AUSTRALIA'S IDENTIFIED MINERAL RESOURCES 2001

AIMR 2001

AGSO
GEOSCIENCE AUSTRALIA

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Front cover Bauxite stockpiles and ship loading facilities, Weipa, Queensland *(courtesy of Comalco Ltd)*

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FOREWORD

Foreword

AGSO – Geoscience Australia provides information on the nation's future capacity to produce mineral resources. Australia's Identified Mineral Resources (AIMR) is a nation-wide assessment of the ore reserves and mineral resources base, conducted annually, for all major and a number of minor mineral commodities mined in Australia. It includes international rankings, summaries of significant exploration results, brief reviews of mining industry developments, and an analysis of mineral exploration expenditure across the States and Northern Territory.

AIMR provides governments, industry, the investment sector and general community with an informed understanding of Australia's known mineral endowment and level of exploration activity. An important objective is to monitor whether resources are being discovered and developed for production at rates sufficient to maintain Australia's position as a major supplier of mineral commodities. National assessments of this type are also assuming greater global significance, as issues concerning cost-effective cleaner mining and product stewardship receive closer attention.

In 2001–02, most of AIMR's resources data will accessible through a virtual atlas of Australia's mineral resources, mines and processing centres, to be developed by Geoscience Australia. Ultimately the atlas will have a web-based GIS (geographic information system) format and show the location of mineral and energy resources, mines and production/processing centres, existing and planned. It will also contain links to commodity and environmental data, jurisdictional legislation, and provide information on mining and processing in terms of regional development, employment and decentralisation.

Neil Williams

Chief Executive Officer

AGSO – Geoscience Australia

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Summary

In 2000, Australia's economic demonstrated resources (EDR) of bauxite, brown coal, copper, diamond, magnesite, mineral sands (ilmenite, rutile, and zircon), nickel, phosphate, tantalum, uranium and vanadium increased, while those of black coal, gold, iron ore, manganese ore and lithium decreased. EDR of zinc, lead and silver were maintained at levels similar to those reported in 1999. The reductions in EDR were due mainly to ongoing high levels of production; commodity prices were a subsidiary factor.

EDR of bauxite, diamond, magnesite, nickel and tantalum increased by over 15% following reviews of resources information that became available during the year. EDR of nickel again reached record levels and at 20 Mt is now 45% of total identified resources for this commodity. Gold EDR decreased by just over 1% to 4959 t. This along with the continued declining trend in net growth in non-EDR for gold and other factors, lead AGSO – Geoscience Australia to suggest that increased exploration expenditure is required to ensure a sustainable sector in Australia.

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

Mineral exploration expenditure fell by 19% to $676.3 million in 1999–2000, which was marginally higher than the low point registered in the last cyclical downturn in 1992–93. Spending for calendar year 2000, based on the sum of ABS four-quarter figures, was down by $42.9 million to $676.4 million — essentially the same as for 1999-2000.

Production of many mineral commodities reached record levels in 1999–2000, and overall mine production is projected by ABARE to rise by around 8% in the five years to 2005–06. Growth in mine output over this period is expected for nickel (55%), copper (7%), zinc (9%), bauxite and alumina (6% and 9%) and iron ore (15%). The high level of investment activity in the minerals industry since the early 1990s, is expected to continue to fall in coming years, according to ABARE and ABS.

INTRODUCTION

Introduction

This report presents the third annual assessment of Australia's identified mineral resources by AGSO - Geoscience Australia (previously the Australian Geological Survey Organisation). It continues a series of national mineral resource assessments that have been published by the Australian Government since 1975.

The assessment is undertaken as input into Government policy decisions relating to the sustainable development of mineral resources. The report examines trends in resources of all major and some minor mineral commodities, and comments on Australia's world ranking as a resource nation. In addition, it comments on exploration expenditure (in current dollars) in 1999–2000 and the previous five fiscal years. The current level of expenditure is put into perspective by comparing it in real terms to expenditure over the preceding 30 years.

Estimates of Australia's identified resources of all major and several minor mineral commodities are reported for 2000 (Table 1). The estimates are based on published and unpublished data available to Geoscience Australia up to the end of December 2000. Data on petroleum resources were provided by Geoscience Australia's Petroleum Engineering and Identified Resources Project. World data have been obtained or calculated from data in various sources, but mainly in publications of the United States Geological Survey (USGS).

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

Geoscience Australia 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 1999). In this publication these estimates are reported under the corresponding resource categories of the national classification scheme. A correlation of the national and OECD/NEA schemes is given in the review of uranium resources.

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

TABLE 1. (TO THE RIGHT)

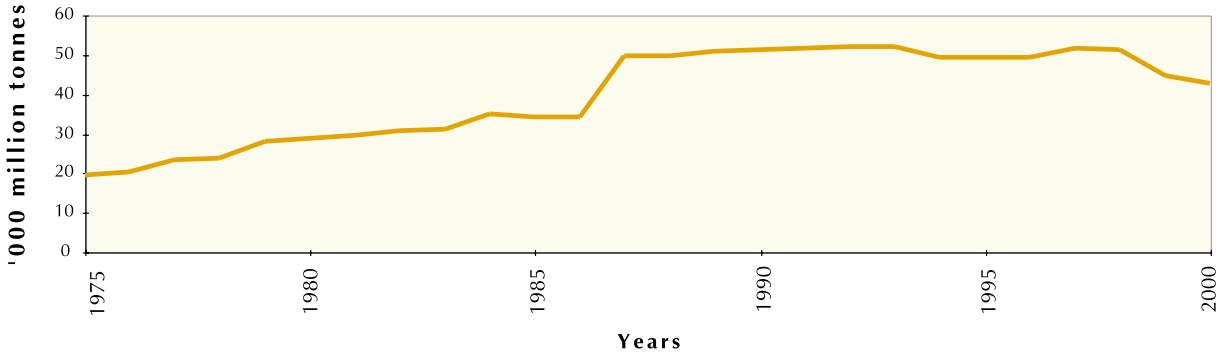
Australia's resources of major minerals and fuels, and world figures for 2000

COMMODITY	UNITS	AUSTRALIA							WORLD	
		Demonstrated			Inferred			Mine production(a)	Economic Demonstrated Resources (b)	Mine Production (c)
		Economic	Sub-economic		Eco-nomic	Sub-economic	Undiff-erentiated			
			Para-marginal	Sub-marginal						
Asbestos										
Chrysotile ore	Mt	-	46	-	-	-	75	-	large	
Crocidolite fibre	Mt	-	0.4	-	-	-	2	-	large	1.9(d)
Bauxite	Gt	4.4	2.6	1.7	-	-	1.4	0.05	25	0.1(b)
Black coal										
in situ	Gt	62.6	1.4	12.5	-	-	very large			
recoverable	Gt	42.6	1	8.3	-	-	very large	0.301(e)	770(f)	3.5(f)(g)
Brown coal										
in situ	Gt	42	43.4	18.1	-	-	113.6			
recoverable	Gt	37.7	39	16.3	-	-	102.2	0.066	189(f)	0.9(f)
Cadmium	kt Cd	108.7	6.7	21.8	19.6	0.8	2.9	na	600	19.3
Cobalt	kt Co	1,286	122	162	-	-	1,534	1.1	5,106	32.3
Copper	Mt Cu	24.1	14.4	1.2	1	2.2	11.8	0.83	340	12.9
Diamond										
gem & near gem	Mc	92.6	225	0.1	1.2	20	1.1	26.6	-	56.5
industrial	Mc	96.1	233	0.3	-	35.1	0.4		580	58.6
Fluorine	Mt F	-	0.2	23.2	-	-	59.1	-	107(h)	2.2
Gold	t Au	4,959	1,021	117	-	-	2,717	296.4	48,959	2,445
Iron ore	Gt	13.6	2.1	1.4	-	-	14.2	0.168	135.6	1.01
Lead	Mt Pb	14.6	3.4	9.6	6.2	15.3	0.8	0.7	64	2.98
Lithium	kt Li	157	78	26	-	-	7	81.9 (p)	3,400	13.3(i)
Magnesite	Mt $MgCO_3$	267	27	35	-	-	1,080	0.35	8,900	10.9(i)
Manganese ore	Mt	128	23	167	-	-	198	1.6	1,871	21.7
Mineral sands										
Ilmenite	Mt	196	51	0.1	-	-	97	2.2	671	7.16(i)
Rutile	Mt	22	12	0.1	-	-	19	0.2	49.3	0.43(i)
Zircon	Mt	28	19	0.2	-	-	23	0.4	69.3	0.90(i)
Molybdenum	kt Mo	-	6.3	3.2	-	-	379	-	5,500	112
Nickel	Mt Ni	20.0	3.1	1.6	-	-	20	0.17	58.2	1.23
Niobium	kt Nb	29	29	132	-	-	1,996	-	3,500	23.6
Petroleum (recoverable)(j)										
Crude oil	GL	227	-	37	-	-	-	33.3		
Natural (sales) gas	10^9m^3	2,219	-	1,027	-	-	-	31.1		
Condensate	GL	282	-	62	-	-	-	7.4		
LPG naturally occur.	GL	262	-	88	-	-	-	4.2		
Phosphate rock	Mt	77	981	-	-	-	1,155	0.806	12,000	139
PGM (Pt,Pd,Os,Ir,Ru,Rh)	t metal	22.6	5.3	20.3	11.9	94.6	2.4	1	71,000	355(k)
Rare earths										
REO & Y_2O_3	Mt	0.9	2.8	10.1	-	-	5.5	-	100	0.08
Shale oil	GL	4.6	197.5	3,719	-	-	41,425	0.006	16,373(o)	na
Silver	kt Ag	32.1	11.1	11.5	15.8	12.3	2.7	2.1	280	17.9
Tantalum	kt Ta	29	30	0.23	-	-	60.4	0.6(q)	32.3	0.62
Tin	kt Sn	107.4	24.2	166.1	3.1	324.7	8.9	9.1	9,600	200
Tungsten	kt W	7	44	28	6	43	-	-	2,000	31.5
Uranium (l)	kt U	654	13	30	185	49	-	7.612	1,570(m)	34.8(n)
Vanadium	kt V	188	1,736	491	81	3,550	-	0.28(r)	10,000	42.0(i)
Zinc	Mt Zn	33	8	17	9	11	2	1.42	190	8

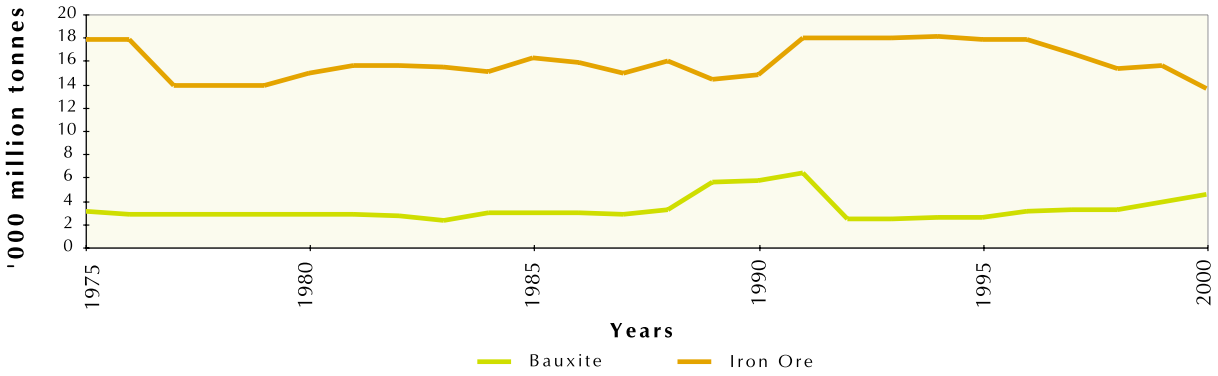
Abbreviations: t = tonne; m^3 = cubic metre; L = litre; kt = 10^3t; Mc = 10^6 carat; Mt = 10^6t; Gt = 10^9t; GL = 10^9L; na = not available.

(a) Source: ABARE
(b) Based on Geoscience Australia, USGS and other sources
(c) World mine production for 2000, mostly USGS estimates
(d) Includes crocidolite production
(e) Raw coal
(f) Geoscience Australia estimate
(g) Saleable coal
(h) Excludes Morocco
(i) Excludes USA
(j) Source: Petroleum Resources Branch, Geoscience Australia (as at 31 December 1997)
(k) Platinum and palladium only
(l) Refer to text for comparison of resource categories in the national scheme with those of the international scheme for classifying uranium resources
(m) Source: OECD/NEA & IAEA (2000). Compiled from the most recent data for resources recoverable at <US$40/kg U. Data for USA and France not available for this category
(n) Source: NUKEM Market Report, 04/2001
(o) WEC Survey of Energy Resources, 1996
(p) Li_2O
(q) Ta_2O_5
(r) Source: Vanadium Australia Pty Ltd

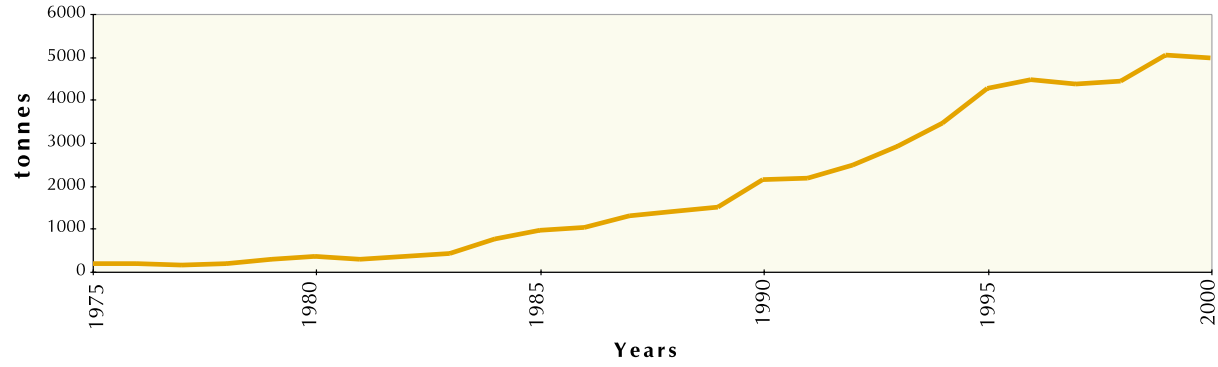
BLACK COAL



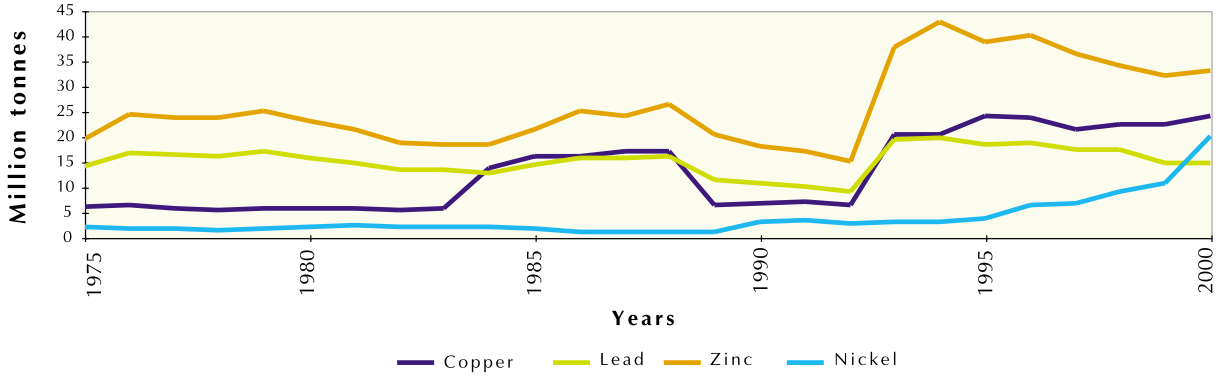
BAUXITE, IRON ORE



GOLD



COPPER, LEAD,ZINC, NICKEL



RUTILE, ZIRCON, ILMENITE

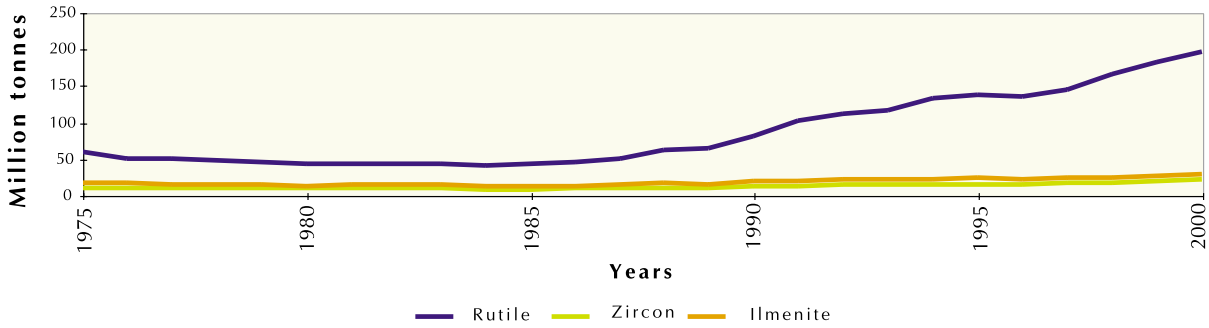


FIGURE 1.
Trends in economic demonstared resources (EDR) for major commodities since 1975

COMMODITY REVIEWS
Commodity reviews

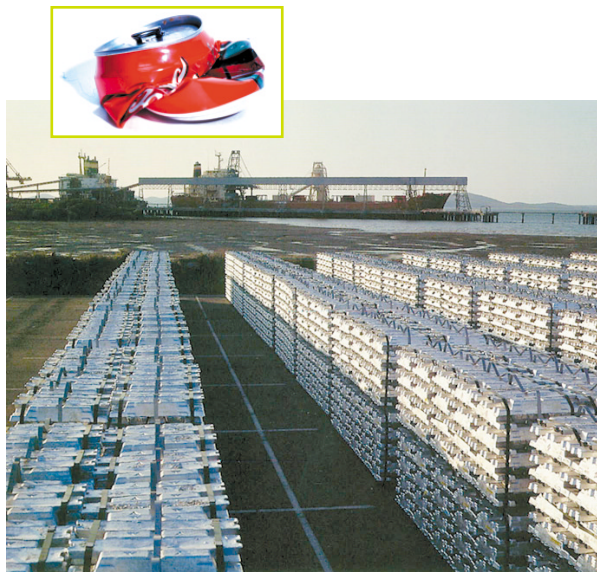
All mining operations and most of the mineral deposits referred to in this section, are shown in the 2nd edition (April 2000) of the map of 'Australian mining operations and significant mineral deposits' (1 to 5 & 10 million-scale). This is available from the Minerals Council of Australia for the cost of postage and handling.

BAUXITE

Bauxite is a heterogeneous naturally occurring material from which alumina (Al_2O_3) and aluminium are produced. The principal minerals in bauxite are gibbsite ($Al_2O_3.3H_2O$), boehmite ($Al_2O_3.3H_2O$) and diaspore (which has the same composition as boehmite but is denser and harder).

Over 85% of the bauxite mined globally is converted to alumina for the production of aluminium metal, an additional 10% goes to nonmetal uses in various forms of specialty alumina, and the remainder is for nonmetallurgical bauxite applications. In nearly all commercial operations, alumina is extracted (refined) from bauxite by a wet chemical caustic leach process known as the Bayer process. Alumina is smelted using the Hall-Heroult process to produce aluminium metal by electrolytic reduction in a molten bath of natural or synthetic cryolite ($NaAlF_6$).

When exports of bauxite, alumina and aluminium are taken into account, the aluminium industry is Australia's second largest commodity exporter behind coal, with export earnings approaching $7 billion in 1999–00.



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

Resources

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

EDR continued its rising trend in 2000 with an increase of 0.6 Gt (16%) over the previous year. On-going successful exploration programs at and near existing mines resulted in resource upgrades from the subeconomic and inferred categories. At Weipa a new orebody model was developed that incorporates additional drilling data. This, together with a detailed economic assessment conducted by Rio Tinto, led to an increase in ore reserves at that site.

Sub-economic demonstrated resources decreased by just over 1 Gt (20%) as a consequence of reclassification of some resources to EDR.

Inferred resources increased by approximately 0.4 Gt (40%) as resource-extension drilling was completed in Queensland and Western Australia.

Exploration

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

Production

Preliminary data published by ABARE shows that in 2000, Australia produced 52.4 Mt of bauxite, 15.7 Mt of alumina and 1.8 Mt of primary aluminium. Australia is the world's largest producer of bauxite and alumina (36% and almost 30% of world bauxite and alumina respectively in 1998–99). In 1999, it was the third largest exporter of aluminium after the Russian Federation (no. 1) and Canada.

World Resources

Australia's demonstrated bauxite resources of 8.7 Gt are the largest in the world, ahead of (according to USGS data) Guinea (8.6 Gt), Brazil (4.9 Gt), Jamaica (2.5 Gt), India (2.3 Gt) and China (2.0 Gt).

Industry Developments

In 2000, Rio Tinto acquired the publicly held (27.6%) share of Comalco, a major Australian-based supplier of bauxite, alumina and primary aluminium to world markets. Approximately 90% of Comalco's bauxite from its Weipa mine is shipped to alumina refineries in Gladstone (Qld) and Sardinia (Italy). Weipa's bauxite production increased by over 3% in 2000.

The final feasibility study for a proposed new $1.4 billion-plus alumina refinery, based on Weipa bauxite and to be located at Gladstone, continued during 2000. Rio Tinto in its 2000 annual report announced that Comalco and its partners in Queensland Alumina are examining prospects for an expansion of their existing Gladstone refinery, which is the world's largest. Comalco has also begun studies of modest expansions of the Boyne Island (at Gladstone, Qld) and Tiwai Point (near Invercargill, NZ) smelters.

In the period under review, CSR advised that the due diligence process had advanced in regard to a non-binding heads of agreement for Billiton Australia to offer to acquire CSR's interest in the Gove bauxite mine and alumina refinery. Under the Gove joint venture agreement, Swiss Aluminium Australia has pre-emptive rights to purchase the CSR stake on the same terms as offered by any potential buyer within a six-month period following the receipt of a formal offer.

During 2000, Alcoa of Australia Limited achieved record production at its two Darling Range bauxite mines in Western Australian — Huntly and Willowdale. Ore production of 20.2 Mt at Huntly was the highest ever recorded by a single bauxite mine and 8.6 Mt at Willowdale a record for that mine. These production levels were attained in response to demand from each of Alcoa's three mine-associated alumina refineries — Kwinana, Pinjarra and Wagerup. Alcoa reduced its total mined and yet to be rehabilitated area in the Darling Range by 222 hectares during 2000. Water management and conservation also continue to be a key focus for the company, which has embarked on series of detailed water audits (to be completed in late 2001) for all its Australian facilities.

In the latter half of 2000, Billiton's Worsley alumina refinery expansion was completed at a capital cost of $800 million. Production capacity has been increased by 1.25 Mt, bringing total capacity at the refinery to 3.4 Mtpa and making it the second largest in Australia (just behind Comalco's 3.6 Mtpa Gladstone operation).

BLACK COAL

Black coal is primarily utilised for electricity generation and the production of coke, which is integral to the production of iron and steel. It is also used as a source of heat in the manufacture of cement and food processing. It occurs in all Australian States and the Northern Territory. Queensland and New South Wales have substantial resources of high quality black coal, which underpin a major export industry. Small but locally significant resources occur in Western Australia, South Australia and Tasmania. The value of Australian black coal exports in 2000 was $9.3 billion.

Resources

In-situ and recoverable EDR decreased by 3.5% and 4.1% respectively during the review period due mainly to production and company reassessments of resources. Both in-situ and recoverable subeconomic resources also decreased following reassessments by industry geologists.

Queensland (61.6%) and New South Wales (35.1%) have the largest share of recoverable EDR. Up to 11% of recoverable EDR (mainly in New South Wales) is likely to be unavailable for mining due to other land use needs, which include conservation, urban development and agriculture.

Exploration

Data published by ABS show that exploration expenditure on coal in 2000 totalled $35.1 million, down from $39.6 million in 1999. Expenditure in Queensland made up 65% of the total.

Production

In 2000, Australia produced 301.2 Mt of raw coal (293.7 Mt in 1999), which yielded 244.6 Mt of saleable coal (231.0 Mt in 1999). Black coal exports in 2000 were 100.8 Mt of coking coal and 85.5 Mt of steaming coal. Australia's thermal and coking coal exports are projected by ABARE to grow to 105.7 Mt and 112.6 Mt respectively by 2006.

World Ranking

Australia has 6% of the world's recoverable black coal EDR and ranks sixth behind USA (27%), Russia (19%), China (12%), India (9%) and South Africa (7%). Australia produced about 7% of the world's black coal in 2000, ranking it fourth largest producer after China (30%), USA (26%) and India (8%).

Industry Developments

Approvals, developments and expansion programs at open cut operations in New South Wales during 2000 included:

- Coal and Allied Operations' commitment to spend up to $20 million developing the 6 Mtpa Carrington mine as well as $17.5 million to redevelop the newly acquired Ravensworth East operation;
- extension of the Bulga mine to incorporate the Whybrow pit, which will maintain coal production at 6 Mtpa;
- startup of the Cullen Valley mine near Lithgow, which will supply 0.6 Mtpa of coal to the Mount Piper power station;
- completion of a box-cut at the Whitehaven mine near Gunnedah with full scale mining commencing at about 0.6 Mtpa in mid-2000;
- Coal Operation Australia's request for State planning approval to develop the $600 million 15.0 Mtpa Mount Arthur North mine, construction of which is scheduled to commence in mid-2002;
- granting of a development consent for the $400 million Mount Pleasant mine near Muswellbrook, which will produce coal at a rate of up 7 Mtpa.

The Dartbrook Joint venture lodged an EIS and Development Application to expand its underground operation. The proposed project includes extension of the underground operation, increased production from 3.5 to 6.0 Mtpa, a new surface access point and extension of the existing rejects emplacement area. BHP is investigating the development of a new coal mine in the Illawarra, which if progressed would be the first in the region for over 20 years. It is proposed that the Dendrobium Project replace the Elourea Colliery as it approaches the end of its economic life. Approval of a lease extension at the Ulan operation makes it possible to increase underground production as open cut reserves are exhausted.

In Queensland, the integration of the Blackwater and South Blackwater mines has created one of the largest coal mining operations in the southern hemisphere with a strike length of 45km. Six draglines have a targeted overburden removal schedule of 120 Mbcm per year, with 13.5 Mtpa of saleable coal to be produced from three preparation plants. In June 2000, the world's largest operating dragline (a 2570WS from Bucyrus International with rated suspended load of 362 t) was commissioned at the Peak Downs mine. At Goonyella, the exploration adit was completed while the final feasibility study is scheduled for completion in the later half of 2001. At Grasstrees, Anglo Coal are developing a 4.0 Mtpa underground longwall mine, which will extend the life of the German Creek mine to 2016.

Intergen's $1.4 billion Millmerran Power Project, under construction 200 km west of Brisbane, is expected to commence generation in late 2002. The $950 million Kogan Creek coal fired power station project was granted a generation authority by the Queensland Government. Tarong Energy is proposing to mine coal at the Glen Wilga and Haystack Road deposits near Chinchilla to blend with coal from the Meandu mine at the Tarong North power station currently under construction. New Hope Coal Australia plan to develop a 1.5 to 2.0 Mtpa open-cut thermal coal operation at Acland on southern Queensland's Darling Downs in the first half of 2002, subject to sales contracts and environmental and mining lease approvals.

TABLE 2.

Australian coal assets/operations: changes in ownership 1999 to Feb 2001

ASSET	Divester	Purchaser	EQUITY SOLD (%)	Date
Blair Athol Mine	Arco Resources Ltd	Rio Tinto	31	Jan '99
Gordonstone Mine	Arco Resources Ltd	Rio Tinto	80	Feb '99
New Wallsend Mine	Oakbridge	New Wallsend Coal	100	Apr '99
Oceanic Coal	HIH Insurance	Glencore International	100	Jun '99
Novacoal	Rio Tinto	Coal & Allied	100	Jul '99
Pasminco coal assets	Pasminco	Glencore International	68	Jul '99
Moura Mine	BHP	Peabody Group	80	Aug'99
Burton Mine	Portman Mining	RAG	95	Dec'99
Cyprus Australia Coal	Phelps Dodge	Glencore International	100	Mar'00
Curragh Mine	Arco Resources Ltd	Westfarmers	100	May'00
Shell Coal	Royal Dutch Shell	Anglo American	100	Jul'00
QCT coal assets	QCT	BHP	100	Nov'00
Lemington Mine	Exxon	Coal & Allied	100	Nov'00
North Goonyella Mine	Sumitomo	RAG	60	Nov'00
Peabody coal assets	Peabody Group	Coal & Allied	100	Dec'00
Springvale Mine	GC Coal	Centennial Coal	50	Jan'01
Ulan Mine	Exxon/Mitsubishi	Glencore International	90	Feb'01

Over the past two years there has been significant consolidation of ownership in the Australian coal industry (Table 2). Currently, five companies (BHP, Rio Tinto, Glencore, MIM and Anglo American) are responsible for over 60% of Australia's black coal production, which includes close to 50% of in-situ EDR.

The Australian coal industry is responding to environmental and greenhouse challenges by instigating a sustainable development strategy. This initiative, Coal in a Sustainable Society, involves various elements including life cycle analysis, clean coal technology and community consultation.

The Commonwealth Government provided a $6 million repayable grant to the Ultra Clean Coal Project, which has the potential to reduce greenhouse gas emissions by 10%. UCC technology involves chemical cleaning of coal to remove ash. The end product is potentially a cost-effective substitute for natural gas and heavy fuel oil in power generation. Its greatest economic potential arises when it is direct fired into a gas turbine power station with combined cycle.

At Chinchilla in Queensland, CS Energy and Linc Energy are investigating the use of underground coal gasification to produce gas for a 30 – 50 MW demonstration plant. Currently any gas produced is being flared. Austral Coal Ltd is planning to use waste methane gas from the Tahmoor Colliery in New South Wales to power 5x1 MW generators. In the Hunter Valley of New South Wales, a 120 MW power station is under construction. The Redbank power station owned by National Power will be fuelled by coal tailings.

A $35.5 million expansion of the Dalrymple Bay Coal Terminal in Queensland has commenced and is expected to be completed in early 2002. The expansion will increase capacity from 40 to 44 Mtpa. In New South Wales, the $345 milllion Port Waratah expansion will increase export throughput capacity from the present 77 to 89 Mtpa by the end of 2001.

Internet based business-to-business procurement and marketing of coal is now available. The global coal e-marketplace is designed to benefit industry participants by reducing transaction costs, increasing price transparency and generating a forward price curve. Currently the coal e-marketplace is mainly servicing global producers and consumers of thermal coal. The sale of coking coal continues to be dominated by long term contracts.

BROWN COAL

Australian brown coal deposits are Tertiary in age and range from about 15 to 50 million years old. The main deposits are in Victoria, which is the only State that mines brown coal mainly for the generation of electricity. Smaller deposits occur in South Australia, Western Australia and Tasmania.

Resources

EDR increased slightly and sub-economic demonstrated resources went down marginally due to a reassessment a number of deposits in Victoria. Victoria accounts for over 95% of Australia's total resources of brown coal and all EDR is within that State, with about 89% in the La Trobe Valley.

Exploration

Data relating to exploration for brown coal specifically are not available nationally.

Production

In 2000, Australian brown coal production was about 66 Mt, up slightly on 1999. The La Trobe Valley produces about 98.5% of Australia's brown coal.

World Ranking

Australia has about 20% of the world's recoverable brown coal EDR, and ranks second behind Germany (22%). It produced 8% of the world's brown coal in 2000, placing it third after Germany (20%) and USA (10%).

Industry Developments

Hazelwood Power plans to develop its future mining operation to the west of existing operations. The development program, known as the Hazelwood West Project, is designed provide a smooth transition once coal mining from the current southeast coalfield begins to wind down in 2004. The development allows Hazelwood Power access to its total allocated coal reserves. Existing dredgers will be used in the new area. Initial pre-stripping, however, will be done by truck and shovel methods, which could start as early as 2001.

Strategic planning at the Loy Yang mine includes lengthening the pit from 2000 to 2400m by 2006, and deepening it from 160m to 180–200m from surface to recover the M2B seam. This optimisation of the mine plan will ensure recovery of as much coal as possible. The 50-year mine plan involves the mine 'heading' out some 7 km from the power stations and then 'returning' towards them to create a total mined width of 5km.

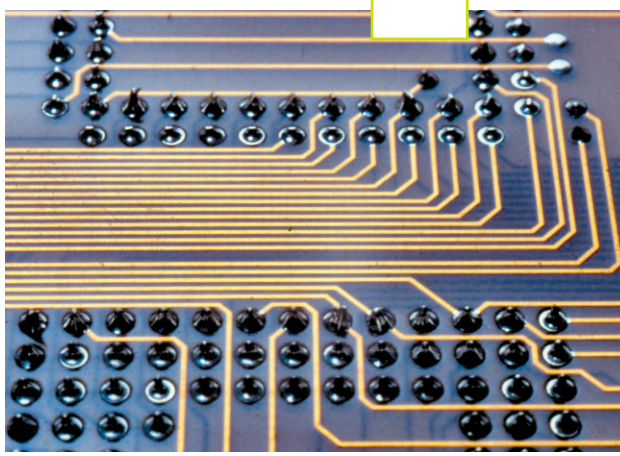
Eastern Star Gas Ltd intends to explore Victoria's eastern Otway Basin for coalbed methane reserves, which may have derived from the extensive brown coal deposits in the region. At the O'Sullivans lignite deposit in Western Australia, Australian Power and Energy Corporation Ltd are conducting a feasibility study into the gasification of the lignite as feedstock for a 280 MW gas fired power station and an oil production plant.

COPPER

Australia's major copper mining and smelting operations are at Olympic Dam (SA) and Mount Isa (Qld). Other significant copper producing mines are at Northparkes, Cadia Hill (NSW), Ernest Henry, Osborne, Mt Gordon (Qld), Golden Grove and Nifty (WA).

Resources

In 2000, EDR increased by 8.6% to 24.1 Mt. This was largely due to an increase in ore reserves at the Olympic Dam mine in South Australia.



Exploration

Exploration expenditure for copper is not recorded separately but is aggregated with base metals (as copper, lead, zinc plus silver, nickel and cobalt).

Production

In 2000, Australia produced 829 kt of primary copper, 13% higher than 1999. This increase reflected the first full year of expanded production at the Olympic Dam mine. The value of copper concentrate and refined copper exports exceeded $1.9 billion, an increase of 36% over 1999. ABARE forecast the long-term demand for copper to increase with the accelerating worldwide trend to upgrade and expand electricity and communications infrastructure, the increasing prevalence of electronics and the on-going use of copper for plumbing, construction, and in vehicles (the average car contains about 20 kg of copper).

World Ranking

Australia has the third largest EDR of copper (7%), after Chile (25%) and USA (13%). As a copper producer, Australia ranks fourth (6%) in the world after Chile (35%), USA (11%) and Indonesia (7%).

Industry Developments

A major expansion of the Olympic Dam copper/uranium/gold/silver mine in South Australia, completed by WMC in 1999 at a cost of $1.94 billion, is now reflected in copper production of 200 ktpa from the previous base of 85 ktpa. This was achieved despite disruptions in the copper solvent extraction plant following a fire in December 1999.

At Mount Isa, the Enterprise underground mine has been developed beneath existing operations at a cost of $370 million. It commenced production in July 2000 and is Australia's deepest mine, with an internal shaft to a depth of 1800m connecting with an existing shaft to the surface. The Enterprise Mine has an average grade of over 4% copper and will provide feed for the Mount Isa copper smelter beyond the next decade, as production from the 1100 orebody declines.

During 2000, the Selwyn mine (150 km southeast of Mt Isa) was re-opened by Selwyn Mines, a newly floated company. A scoping study for a possible expansion program was under way in late 2000.

At Mt Gordon (formerly Gunpowder, 125 km north of Mt Isa), major modifications to the processing plant were completed. Western Metals Limited has applied for a global patent on the "Mt Gordon process", which incorporates pressure oxidation/ferric leach technology for processing copper sulphides to produce copper that is well suited to high technology applications and the oxygen-free copper market. Mt Gordon produced and sold 34 kt of copper cathode during 2000, and is well placed to expand production capacity to 50 ktpa.

In Western Australia, operations ceased at the Telfer mine. Work on two possible development projects at Telfer is continuing. At Nifty, an expansion of solvent extraction and electrowinning (SX-EW) copper production from 16.5 to 23 ktpa was completed and a further expansion to 25 ktpa was in progress at year-end. At Bodddington, expansion of the processing plant was completed permitting a larger throughput of 20 Mtpa from an in situ resource of 440 Mt (av. grade 1.1g/t Au, 0.11% Cu). At Golden Grove, copper resources increased by 2 Mt to over 11 Mt as a result of drilling at Gossan Hill, and resources in two newly identified high-grade mineralised zones (Amity and Catalpa) are to be delineated in 2001.

In New South Wales, Cadia Hill continued to build on its commissioning and production ramp up, producing 26 kt of copper in its first full year of operation. The nearby Ridgeway project commenced initial production using the Cadia Hill concentrator to treat 196 kt of development and trial mining ore. The Ridgeway underground mine, with a design capacity of 4 Mtpa, is expected to be completed by the end of 2001.

At Northparkes in central NSW, construction commenced on a second block cave operation (Lift 2). It will develop the lower orebody and is scheduled to start production in 2003 and to totally replace Lift 1 in 2004. With Lift 2 and the development of another orebody (E48), the mine has a planned life of 15 years at current production rates. At Girilambone, mining ceased in May 2000 as reserves were exhausted. Leaching of remaining heap inventory will continue in 2001.

Gunson Resources embarked on a deep drilling program at their Elaine Prospect, 100 km south of Olympic Dam. At the Mineral Hill mine in central New South Wales, significant high grade copper intersections were encountered at Parkers Hill and resource estimation was in progress at the end of the review period.

DIAMOND

Diamond is composed of carbon and is the hardest known substance. It occurs naturally but is extremely rare compared to other minerals. Diamonds are formed deep in the earth and are carried to the surface or near surface by volcanic rocks in narrow cylindrical-like bodies called 'pipes'. Most pipes are barren and only a very small proportion have significant diamond content. When pipes are eroded, liberated diamonds may accumulate in alluvial deposits.

Diamonds may be located some distance from their source pipe(s) as their hardness allows them to survive multiple episodes of erosion and deposition. A large proportion of industrial diamond is manufactured and it is also possible to produce synthetic diamonds of gem quality.

The quality of diamonds is split broadly into gem, near gem, industrial and boart categories. In rare cases, up to about 90% of diamonds in a deposit can be of gem quality but most economic deposits contain around 20 to 40% gem quality diamonds. Uses for diamond include jewellery, computer chip manufacture, drill bit facing, stone cutting and polishing.

Resources

Australia's total identified resources for both gem/near gem and industrial diamond showed a net increase (allowing for production of 26.5 Mc) of 11% in 2000. EDR for gem/near gem diamond was 92.6 Mc and industrial 96.1 Mc, both up by 11% over 1999. The increase was largely the result of delineation of new resources at the Argyle diamond mine in Western Australia.

Exploration

In 2000, expenditure on exploration for diamond in Australia was $29.4 million, down 14% compared to 1999.

Production

Diamond (gem/near gem, industrial) production in 2000 was 26.6 Mc, a decrease of 4.2 Mc on the previous year. Most of this decrease resulted from lower mining grades at Argyle diamond mine. Waste rock stripping, associated with expansion of the open pit, is expected to limit production over the next few years.

Australia's diamond production is the largest in the world for natural industrial diamonds and second largest (after Botswana) for gem/near gem diamonds. Production is mostly from the Argyle AK 1 pipe with lesser contribution from the nearby Argyle Alluvials operation. Minor production was also recorded at Merlin (NT) and Copeton (NSW).

World Resources

Australia's EDR of industrial diamond ranks third (15%), after the Republic of Congo (26%) and Botswana (22%). Detailed data are not available on world resources of gem/near gem diamond but Australia has one of the largest stocks for this category.

Industry Developments

Further development of the open pit at Argyle (AK1 pipe) continued in 2000 and mine life, including proposed underground development, is projected to extend to 2018. Deep delineation drilling of the Argyle pipe confirmed extension of the central vent to depths greater than previously inferred.

Drilling at Merlin (80km south of Borroloola, NT), aimed at testing extensions at depth of diamond-bearing pipes, showed that two of the main pipes merged into one at about 120m below surface. Ashton Mining Ltd recovered a 42 ct diamond at Merlin, the second largest ever found in Australia. Diamonds were also identified in bulk sampling of drainage from one of its tenements near the Merlin mine.

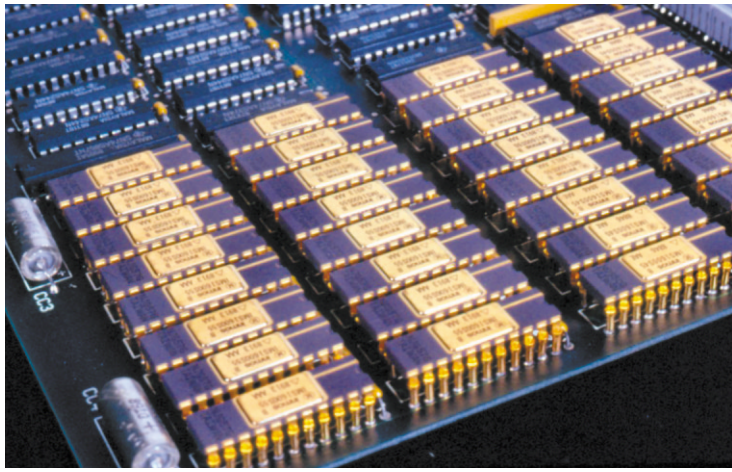
Striker Resources Ltd announced a pre-feasibility study into mining of its Ashmore Pipes (1, 2, 4), 180 km northwest of Wyndham (WA), and continued to focus on exploration of the North King George and Beta Creek Joint Venture areas. The company entered into an agreement with BHP to fly the BHP Falcon airborne gravity gradiometer over its prospects. Early results have been reported as encouraging in identifying kimberlite bodies.

Kimberley Diamond Company NL recovered more diamonds in bulk sampling of gravels in palaeochannels at its Blina project in the West Kimberley region (WA). Thundelara Exploration Ltd reported the discovery of microdiamonds and chromite from drilling near the Aries pipe in the Phillips Range, 160km north of Fitzroy Crossing (WA).

GOLD

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

The low US dollar price for gold continued to attract much attention internationally. Within Australia a further fall in exploration expenditure was cause for concern. Although total identified resources increased by 100 t there was a fall in demonstrated resources, the category from which production is drawn. Production remained high at just under 300 t but well below record levels. Australia maintained its world standing in terms of both production and resources.



Resources

Australia's gold resources occur, and are mined, in all States and the Northern Territory. Total Australian resources rose by 100 t (3.2 Mozs) in 2000. After allowing for replacement of resources lost to production, total newly delineated resources added to the national inventory in 2000 was 396 t (12.7 Mozs). Increases in inventories occurred in Queensland, New South Wales, South Australia and the Northern Territory.

Australia's EDR fell by 59 t (1.9 Mozs), a reduction of just over 1% to 4959 t. EDR is the sum of the JORC Code reserves categories and those resources from the measured and indicated resource categories assessed by Geoscience Australia as likely to be economic. Some 55% of the EDR fell into the JORC reserves category in 2000, an increase on the 52% recorded in 1999.

Western Australia continued to dominate EDR with almost 60% of the national total but its share fell by 178 t in 2000 to 2959 t, 5.7% lower than its 1999 EDR. South Australia had the second largest and with Western Australian accounted for over 78% of Australia's EDR. In New South Wales, EDR rose by almost 18 t to 470 t (a rise of 4%). The Northern Territory had the fourth largest EDR at 257 t and increase of 5.3%. Queensland remained the state with the fifth largest EDR and its stocks rose by 34.8 t to 232 t. Victoria's EDR fell by 4.8 t (7%) to 66 t and in Tasmania the fall was 8 t (17%) to almost 37 t.

Just over 81% of demonstrated resources occur in EDR compared with 82% in 1999.

Subeconomic demonstrated resources increased slightly to 1138 t. The increase was due to a small growth in paramarginal resources more than offsetting a decline in the submarginal category. Western Australia clearly dominated paramarginal resources with 636 t and its share rose from 60% to 62%. Paramarginal resources fell in all other states and in the Northern Territory. New South Wales recorded the largest fall with 14 t. Other reductions recorded were Queensland down by almost 5 t, and Victoria, Tasmania, South Australia and the Northern Territory all by less than 1 t.

Only minor movements occurred in the submarginal demonstrated resource category, where there was an overall reduction of almost 9 t. In Western Australia, a reduction of 9 t occurred and there was a reduction of almost 2 t in Tasmania. In the Northern Territory there was an increase of just over 2 t but in all other States the movement was of 1 t or less.

Inferred resources rose by 149 t (6%) to 2717 t in 2000. Increased inferred resources were recorded in all states, except Western Australia, and in the Northern Territory. Queensland's inferred resources rose by almost 92 t (57%) to 253 t due mainly to the publication of revised resources at Selwyn. In New South Wales, inferred resources rose by 47% to 238 t largely because of new resource estimates from the Cadia project. Inferred resources in South Australia increased by18% with the release of revised information on the Olympic Dam deposit. In Western Australia, inferred resources fell by 5% (85 t) to 1651 t. Despite this reduction, Western Australia held 61% of Australia's inferred resources.

The ratio of demonstrated to inferred resources fell from 2.4:1 to 2.2:1. In comparison to the ratio for the last decade this is still toward the top of the range.

Exploration expenditure

At Australia's 2000 rate of production, its EDR are sufficient for an average 16 years production. However, resources in the JORC Code reserves categories are adequate for only 9 years at the 2000 output rate. It should be remembered that these are average figures and that there are some operations that may continue longer than 16 or 9 years and others that will cease operation before these times. The figures clearly illustrate the need for ongoing successful exploration.

Spending on gold exploration for the year, $371.7 million, also based on ABS quarterly statistics, was $32.3 less than in 1999.

The 1999–2000 spending on gold exploration was $374.8 million and was the lowest recorded since 1992–93. The sharp downturn in exploration spending in recent years shown in Figure 2 reflects the world situation.

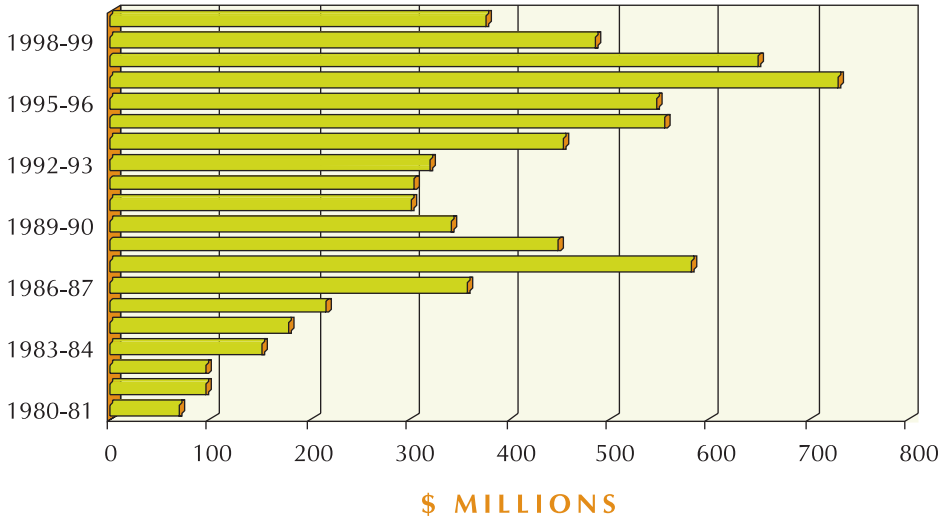


FIGURE 2.
Australian gold exploration expenditure over the 20 years to 1999–2000 (Source ABS).

Given the lag that occurs between exploration expenditure and new resources being delineated or a new mine coming into production, the impact of this reduction may not be fully felt for some years. Exploration success can be achieved by the addition of new resources at known deposits and by the discovery of new deposits. Both outcomes are critical to Australia's ability to maintain a healthy gold industry in the long term.

In concert with the reduction in exploration spending has been a reduction in the rate of growth of the industry's resource base. In 2000 net resource growth[1] for total resources was at its lowest level since 1984 and was substantially less than production (Figure 3). In the last decade all but two years saw net resource growth in excess of 600 t of gold.

The resource inventory did continue to grow in 2000 but the rate of growth was considerably reduced and, apart from an increase in 1999, continued the slowing trend commenced in 1997. Although the situation is still healthy from a total resource perspective, the fact that growth is slowing in a time of falling exploration spending is cause for concern. If exploration continues to decline it is possible that in the near future Australia will enter a phase of resource depletion. If this happens and production stays at about the 2000 level, resource life will be reduced.

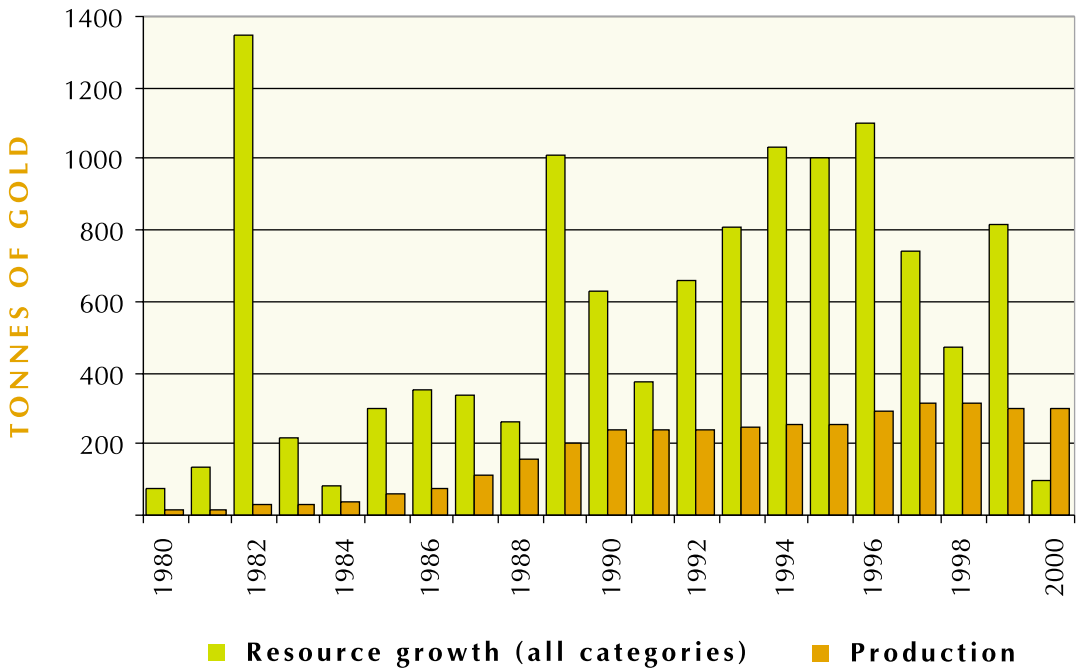


FIGURE 3.
Net resource growth for Australian gold resources since 1980

More detailed analysis of gold's resource trends illustrates the situation more specifically. Net resource growth in non-EDR[2] has declined steadily since 1996 (Figure 4). These categories are the base from which resources would normally move into the EDR category. Consequently, any reduction in their growth has the potential to adversely impact on future EDR levels. It is desirable, therefore, to arrest and reverse the falling growth rates but whether this can be achieved without increased exploration spending is far from certain. Again, it should be stressed that while growth in this category of resources is still positive, it is the slowing rate of growth that is of concern.

In the last 21 years there have only been three years, 1981, 1997 and 2000 in which EDR has fallen. The fact that two of those years have occurred in the last four years combined with very low growth in a third year (Figure 5) is again cause for concern.

1 Net resource growth is the increase in resources including the replacement of resources lost to production.
2 Non-EDR includes paramarginal and submarginal resources and inferred resources.

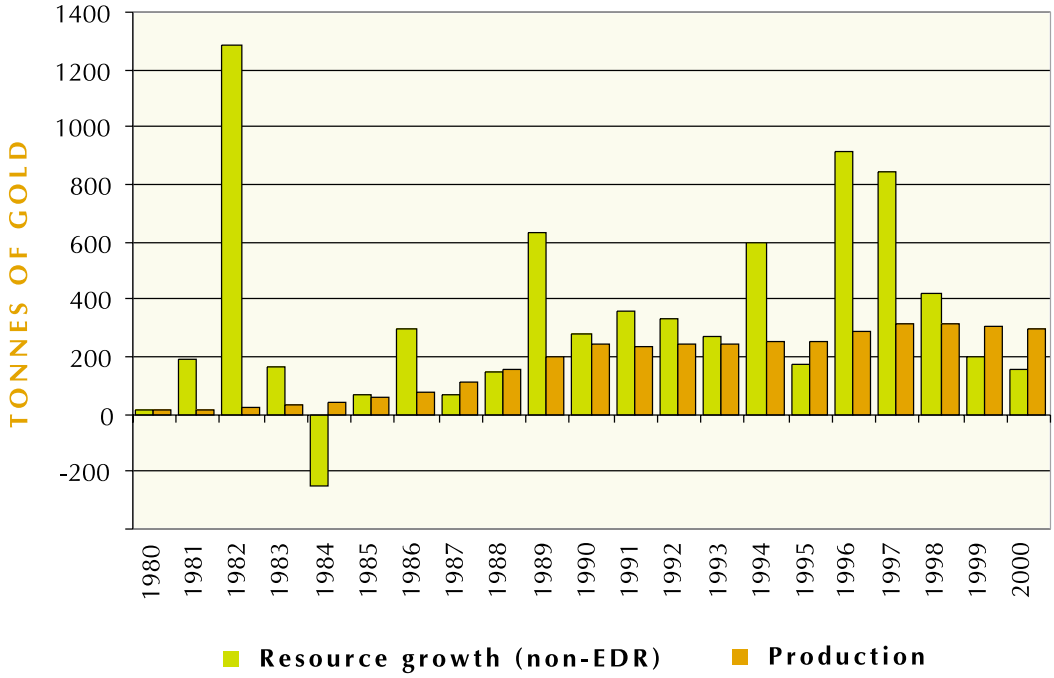


FIGURE 4:
Net resource growth for Australian non-EDR of gold since 1980

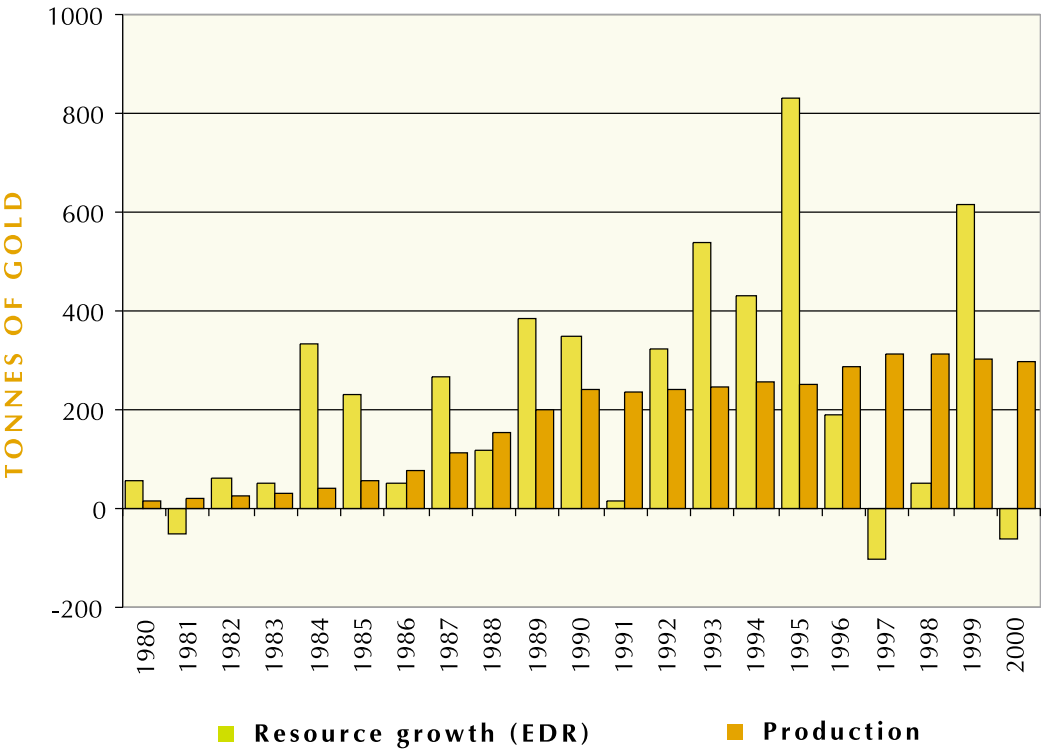


FIGURE 5.
Net resource growth for Australian EDR of gold since 1980

The strong growth in EDR in 1999 was due to a combination of factors. The first was that in excess of 10% of the growth was caused by the reclassification of known resources in one deposit to EDR from non-EDR categories. The second was a combination of reclassification from non-EDR to EDR and the delineation of new resources at one deposit. This suggests that, to a large extent, Australia has relied in recent years on sporadic events to make major advances in EDR. Without such limited events, growth would have been negative or limited. A more stable growth rate is desirable but in an era of depressed exploration spending there is doubt that it can be achieved, making it difficult to maintain the present strong level of EDR into the future.

While Australia's gold resource base is sound currently, there are warning signs emerging from trends in resource levels that suggest increased exploration spending is required to ensure a sustainable Australian industry.

Production

Preliminary data from ABARE indicate that Australia's gold production in 2000 fell by just under 2% to 296.4 t. Western Australia continued to dominate production with 203.7 t, 4% lower than in 1999, and accounting for 69% of Australian production compared to 71% in 1999. Queensland remained the second largest producer and increased its output by over 3 t to 36.9 t. Other production (in rounded amounts) was: Northern Territory 23 t, New South Wales 19 t, Tasmania 6.8 t, Victoria 4.4 t and South Australia 2.3 t.

World Ranking

Based on figures published by the USGS and modified to incorporate the Australian resources reported here, Australia has the third largest EDR after South Africa and the USA. For 1999 the USGS reported that Uzbekistan had more EDR than Australia but they did not report the Uzbekistan figures for 2000 suggesting that the original figures may have been considered unreliable

World EDR in 2000 was estimated at 48 959 t of which South Africa accounted for 39%, slightly higher than in 1999. The USA's share was steady at 11%. Australia maintained its share of world EDR at 10% for the year. Russia again followed Australia and had 6% of the total EDR.

The USGS report total world gold production in 2000 at an estimated 2445 t. Production rankings remained unchanged with South Africa being the largest producer with 18% (440 t) of world output slightly, less than in 1999. It was followed by the USA (330 t), whose share fell by 1 percentage point to 13.5%. Australia's share was down slightly to just over 12%. The USGS estimate that China produced 170 t, which was higher than the Canadian production of 150 t and saw China become the fourth largest producer ahead of Canada.

Industry developments

Successful gold exploration continued in the Eastern Goldfields of Western Australia where, despite production and exploration for over a century, important discoveries continue to be made. The Raleigh gold discovery, reported by Goldfields Ltd to have over 1 Mozs at an average grade of 41.7 g/t Au, is only 22 km from Kalgoorlie. Other prominent discoveries were WMC's Belleisle discovery near its St. Ives operations and Dalrymple Resources and Lionore Mining International's Thunderbox deposit near Leinster.

The Archaean greenstones of Western Australia's Eastern Goldfields continued to yield an impressive array of new shallow mineralisation. And, successful deep drilling (Kanowna Belle and Wallaby for example) in the same region highlighted its depth potential. Deeper resources are likely to be an important factor in the industry's long term future in the Eastern Goldfields and also elsewhere in Australia, which is generally under-explored at depth. The importance of applying new geological models and improved understanding of the geological environment resulted in new mineralisation being located at some existing deposits, for example, the Palaeozoic slate-belt deposits at Bendigo in Victoria.

Some of the interesting exploration results reported in 2000 include:

- WMC Resources Ltd announced results at its **Belleisle** discovery (WA) that indicate potential to add substantial resources to the global resource of the St Ives system which exceeds 11 Mozs. Results include: 43.1 m at 18.41 g/t Au, 4.8 m at 15.01 g/t Au and 34 m at 2.20 g/t Au. Belleisle is on Lake Lefroy, 12 km north of the St Ives processing plant and 7 km from the heap leach facility now being built
- Dalrymple Resources N.L.(40%) and Lionore Mining International Ltd (60%) announced the first resource estimate for the **Thunderbox** deposit 60km south of Leinster (WA). An initial resource of 30 Mt at 2.2 g/t Au for 2.1 Mozs (1.78 Mozs in the indicated category) was reported. It occurs over 1800 m strike length and to a depth of 450 m, has not been closed off in two directions and high grade zones are open at depth.
- Goldfields Ltd announced discovery of the **Raleigh** high-grade gold deposit, 2.5 km south of its Kundana (WA) operation near Kalgoorlie. Combined indicated and inferred resources are 0.668 Mt at 35.2 g/t Au. An 800 m by 50 m anomaly 2 km south of Raleigh yielded results including: 2 m at 10.24 g/t Au, 2 m at 17.73 g/t Au, 1 m at 10.90 g/t Au and 1 m at 2.77 g/t Au.
- Bendigo Mining N.L. reported that drilling at **Bendigo** (Vic) to test its theory that mineralisation repeats at depth intersected unmined ribbons below the Deborah and Sheepshead line of reefs and, 6 km away and 200 m below previous workings, on the New Chum line of reef. Traditionally gold has been sought in anticlinal crests at Bendigo but attention has also focussed on synclines following the Swan Decline intersecting a gold bearing reef in the Deborah Syncline between the Deborah and Sheepshead Anticlines. Sampling of this reef yielded values up to 1.3 m at 7.6 g/t Au.
- At the **Colonial** prospect, 120 km northeast of Kalgoorlie (WA), Gutnick Resources N.L. reported 16 m at 3.1 g/t Au. Colonial occurs beneath 30 m of cover and has no surface expression but, reportedly, a distinctive magnetic signature which has resulted in identification of other targets in the area. Colonial adjoins Pacmin's Carosue Dam operation.
- Croesus Mining N.L. reported good intersections from its **Giles** Prospect 25 km northwest of the Davyhurst mine (WA). These included: 24 m at 14.6 g/t Au, 15 m at 22.1 g/t Au, 15 m at 3.37 g/t, 40 m at 4.10 g/t, 6 m at 25.8 g/t and 32 m at 9.9 g/t Au. Croesus also announced a final feasibility study into the commencement of mining at Davyhurst.
- Good intersections were made in deep drilling at several mines including: **Kanowna Belle** (WA) where Delta Gold Ltd reported 13 m at 11.2 g/t Au and 6 m at 4.9 g/t Au from 1300 m below surface and **Wallaby** (WA) with 5 m at 7.1 g/t Au from 949 m and 5 m at 8.2 g/t Au from 986 m.
- Resources were upgraded by Gindalbie Gold N.L. for its **Minjar** (WA) project to 0.44 Mozs delineated in four deposits - M1, Silverstone, Winddine Well and Bugeye. A bankable feasibility study was commissioned and six more prospects targeted for exploration.
- Successful exploration drilling at the **Frog's Leg** project, 20 km west of Kalgoorlie (WA), has increased the potential for expansion of the 0.314 Mozs inferred resource. Dioro Exploration N.L. reported new intersections including 10 m at 22.4 g/t Au, 1 m at 26.4 g/t Au, 10 m at 2.1 g/t au and 15 m at 2.58 g/t Au.
- Highlighting the value of ongoing exploration in established mineral fields, Gympie Gold Ltd discovered a new orebody at its **Monkland** Mine at Gympie (Qld). Intersections include: 27 m at 8.8 g/t Au, 19 m at 19.5 g/t Au, 14 m at 8.0 g/t Au and 13 m at 6.2 g/t Au.
- At **Stawell** (Vic), Mineral Project Investors Pty Ltd and Pittston Mineral Ventures discovered a new mineralised zone (the Golden Gift lodes) beneath the South Fault, previously considered the base of the Magdala mineralised system. This discovery has the potential to greatly expand the life of the operation.
- Johnson's Well Mining N.L. completed technical assessment of the **Rand** (NT) project which examined the application of the Witwatersrand exploration model to the Amadeus and Ngalia Basins. The investigation identified several priority targets for study.
- Initial drilling by Giants Reef Mining Ltd at its **Thrace** prospect , 40 km north of Tennant Creek (NT), yielded encouraging results. An 11 m (from 254 m) intersection assayed 16.5 g/t Au and included 2 m at 80 g/t Au. The hole also encountered 5 m at 1.26% Cu from 253 m. Mineralisation is in a hematite, carbonate, chalcopyrite, quartz and chlorite zone.
- Triako Resources Ltd reported encouraging results from its **Pearse** Prospect near the Mineral Hill mine 60 km north of Condobolin, New South Wales. Gold intersections were recorded over a strike of 100 m in a 650 m long gold-arsenic anomaly that is open to the north and south. Gold intersections included: 22.5 m at 3.36 g/t Au and 24 g/t Ag and 15 m at 2.83 g/t Au and 25 g/t Ag.
- Newcrest Mining Ltd. reported an initial inferred resource of 0.35 Mozs in 1.1 Mt grading 11 g/t Au, from the Royal Shoot at **Klondyke** epithermal deposit, near Cracow, Queensland. Drilling immediately to the north of the Klondyke workings returned 4 m at 5.7 g/t Au and 5.5 m at 12 g/t Au.
- Following up on a gold in calcrete anomaly, Adelaide Resources N.L. defined a mineralised corridor at the **Barns** Prospect on the Eyre Peninsula in South Australia. The 100 m wide corridor is open to the north and south. Intersections ranged from 1 m at 1.01 g/t Au to 1 m at 5.52 g/t Au and 1 m at 2.52 g/t Au.
- Pacmin Corp. Ltd. reported a new high grade zone of gold mineralisation at the **Galahad** prospect immediately south of its Tarmoola South pit (WA). Mineralisation occurs in a shear zone and has been defined over at least 150 m and to a depth of about 80 m. Intersections include 3 m at 9.35 g/t Au, 5 m at 18.45 g/t Au, 3 m at 21.86 g/t Au and 8 m at 42.92 g/t Au.
- In the **Laverton** region (WA), Metex Resources N.L. reported new gold mineralisation 5km north of the Wallaby deposit. Results include 3 m at 3.7 g/t Au, 4 m at 1.7 g/t Au, 5 m at 2.6 g/t Au and 1m at 23.7 g/t Au, all in weathered rock.

IRON ORE

Iron ore is the source of primary iron for the world's steel industries. Almost all iron ore (98%) is used in steel making. It occurs in all States and the Northern Territory with about 90% of identified resources in Western Australia. Over 80% of resources occur in the Pilbara region of Western Australia.

Resources

EDR decreased by 12.2% to 13.6 Gt in 2000, mainly as a consequence of the major producers reassessing resources in accordance with the JORC Code. Paramarginal demonstrated resources and inferred resources decreased by 55.9% and 11.3% respectively for similar reasons.

Exploration expenditure

Exploration expenditure for iron ore in 2000, annualised from quarterly ABS data, totalled $26.1 million down from $32.1 million in 1999.

Production

Preliminary data released by ABARE shows that Australia's iron ore production in 2000 was 167.9 Mt (cf. 155.0 Mt in 1999) with exports of 157.3 Mt (cf. 139.6 Mt in 1999) valued at $4400 million. Production is projected by the ABARE to increase to around 194.5 Mt and exports to 181Mt by 2005-6.

World ranking

Australia has some 10% of world EDR of iron ore and is ranked fourth after China (18%), Ukraine (16%) and Russia (15%). In terms of contained iron, Australia has about 12% of the world's EDR and is ranked third behind Ukraine (18%) and Russia (16%). Australia produces around 15% of the world's iron ore and is ranked third behind China (21%) and Brazil (19%).

Industry Developments

In 2000, Rio Tinto acquired North Ltd, which owns 53% of Robe River Iron Associates. This is expected to realise capital cost savings of about $300 million on the rail system for the West Angelas Project and an estimated 5% reduction in operating costs through synergy gains from combining the Robe River and Hamersley Iron operations. With attributed production of over 80 Mtpa, Rio Tinto is now the world's second largest iron ore producer after Brazil's Companhia Vale do Rio Doce.

Prior to the takeover the Robe partners approved construction of a second mine processing plant at a cost of $27.4 million, the benefits of which will be increased mineable reserves, reduce stripping ratio and an extension of the Mesa J mine life by 1.5 years.

Hamersley Iron received approval from the Western Australian Government to expand its Yandicoogina iron ore mining operation from 15 to 20 Mtpa. In another development Rio Tinto are investigating the possibility for an 800 ktpa HIsmelt plant in Western Australia. The proposed plant could produce pig iron on a merchant basis as a supply for steel producers.

In late 2000, BHP announced that it would continue to operate its Western Australian Hot Briquetted Iron (HBI) plant. The announcement followed a 9-month technical and economic review of the plant that determined continued operation was economically viable. The company invested $66 million during trials to implement technical modifications within the plant. Continued operation over the next 18 months requires an additional $110 million capital investment to implement technical modifications across the plant.

At Yandi, BHP are investigating the introduction of a lump product. The company has undertaken mine planning and minor modifications at the mine and port to extend Yandi lump production trials in 2001. It is also planning to lift Yandi ore output from 25 to 30Mtpa. In early 2001, BHP signed a letter of intent with Korean steelmaker Pohang Iron and Steel to enter into a joint venture which will underpin development of the Mining Area C project.

Portman Ltd announced that dredging of the port at Esperance now allowed Panamax-class vessels to be fully loaded. Additional storage facilities at the port have also made it possible for a 3-train-64-car rail system to achieve iron ore transportation in excess of 3.2 Mtpa from the Koolyanobbing mine.

At Cockatoo Island, Portman completed the removal of BHP's low grade stockpiles in May 2000. The company also entered into agreement with BHP to mine a remnant resource of high-grade iron ore in exchange for the removal of all of BHP's old mining infrastructure from the island and completion of some rehabilitation. The first shipment of premium fine ore (51,000 t) was to China's Kunming Iron and Steel Corporation.

The Hope Downs Iron Ore Project in Western Australia is the focus of a bankable feasibility study, which is expected to be completed in the first half of 2002. The scope of the study has been broadened to assess the viability of a new $1-billion-plus railway and associated port infrastructure. Approximately $300 million would be needed for mine development.

In late 2000, Austeel released a public environmental review of its $5 billion iron ore mining and downstream processing project in Western Australia's Pilbara region. The project involves development of a new 22.4 Mtpa iron ore mine on the Fortescue deposit, 80km south of Karratha. Ore is to be processed on-site by concentration, pelletising and direct reduction to produce 4.7 Mtpa of HBI, with end product transferred by conveyor to a new port at Cape Preston. Austeel plan to ship HBI to Newcastle as feed for a 3.8 Mtpa electric arc furnace steel plant to be built in the Hunter region.

Kingstream Steel Ltd has been granted a one year extension by the Western Australian Government on the deadline to submit detailed proposals on its $2 billion Mid-West Iron and Steel Project near Geraldton.

At Whyalla, a demonstration plant for the South Australian Steel and Energy (SASE) Project was completed and produced its first pig iron in late 2000. The plant uses Ausmelt's patented top-submerged-lance direct smelting system known as AusIron. The fourth and final stage of the demonstration process is scheduled for completion in 2001, and will use coal from AuIron Energy's Ingomar deposit in the Phillipson coalfield (SA) as fuel/reductant in the AusIron smelter.

During 2000, Ivanhoe Mines Ltd acquired ABM Mining Ltd, owner of the Savage River mine in Tasmania. A planned upgrade of the concentrator will increase capacity from 2.2 to 2.9 Mtpa. Diamond drilling has defined magnetite resources at the South Deposit, where mining of ore is scheduled to commence in June 2001.

The Commonwealth Government granted Major Project Facilitation Status to Boulder Steel's US$425 million Hunter Specialty Steels project. The project entails construction of a steel mini mill with capacity to produce up to 260 kt of stainless and specialty steel products per annum. The plant is expected to be operational by 2004.

LITHIUM

Lithium is a silvery grey metal with a density about half that of water. Sons of Gwalia's Greenbushes mine in southwest Western Australia is the world's largest and highest grade deposit of spodumene ($Li_2O.Al_2O_3.4SiO_2$). It is also the largest producer of lithium minerals. Greenbushes' products have a range of uses that include production of specialty glasses, glass bottles, ceramics and ceramic glazes. Its ore is also a feedstock for the production of lithium carbonate in the chemical industry.

Resources

Australia's identified lithium resources are in Western Australia and all EDR is contained in the Greenbushes deposit. EDR decreased slightly in 2000 to just over 156 000 t, through depletion of resources to production.

Following reassessment of resources at a number of deposits in Western Australia, submarginal demonstrated resources increased substantially in 2000. Inferred resources are unchanged from the previous period.

Exploration

There are no statistics available on exploration expenditure for lithium. In view of the continuing oversupply of lithium worldwide, particularly in the form of lithium-rich brines from Chile, it is unlikely that there will be any substantial expenditure on exploration in Australia in the near future.

Production

Sons of Gwalia remained the world's largest producer of lithium minerals in 2000. Production for the year was 81 891 t, a rise of 8% over 1999, and sales of lithium minerals increased by 20%. The improvement in sales reflected a recovery in some niche markets within the larger lithium industry. Oversupply of lithium carbonate from brine operations in Chile and Argentina, however, is continuing to dampen demand and prices for lithium minerals on international markets.

World Resources and Production

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

World production of lithium in 2000 is estimated by the USGS to be 13 000 t of contained lithium, unchanged from 1999. However, information on USA production is withheld by the USGS for commercial reasons. Chile with 42 % remained the world's largest producer, followed by China (15%), Australia (15%) and Russia (14%).

Industry Developments

There were no significant developments in Australia's lithium sector in 2000.

MAGNESITE

Magnesite (magnesium carbonate, $MgCO_3$) is marketed in three main forms: — crude magnesite, primarily for use in chemicals and agriculture; dead-burned magnesia, a durable refractory additive for cement, glass, and steel and which is used in metallurgical industries; and caustic calcined magnesia, for use in making oxychloride and oxysulphate cements for flooring and wallboards, mouldings and acoustic tiles, and various environmental and chemical applications.

Resources

EDR of magnesite increased by just under 23 % to 267 Mt in 2000. All of the increase was in South Australia, which has the largest EDR. In South Australia, SAMAG (80% owned subsidiary of Pima Mining NL) has identified a global resource of 579 Mt magnesite in the Willouran Ranges, northwest of Leigh Creek. About 180 Mt of this resource is classified as EDR, which is in the Mount Hutton and Witchelina deposits.

Queensland has the second largest inventory of magnesite EDR. The bulk of this is at Kunwarara (70 km northwest of Rockhampton), where Australian Magnesium Corporation has an inferred global resource of 1200 Mt of magnesite-bearing material. Within this, the company has an inferred resource of 500 Mt magnesite, containing several high-grade zones totalling 41.8 Mt, which are classified as EDR. The Kunwarara deposit contains substantial accumulations of very high-density "bone-type" magnesite, characterised by nodular and cryptocrystalline structure and low iron content.

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

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

Subeconomic demonstrated resources, which account for around 4% of total identified resources, fell by nearly a third during the year. The decrease followed reassessment of resources within this category grouping (para- and sub-marginal) and was mostly in South Australia and Queensland.

Inferred resources rose by nearly 60% to a record level of 1080 Mt with Queensland accounting for 52% followed by South Australia (32%) and Tasmania (14%).

Exploration

Data relating to exploration for magnesite are not available nationally.

Production

In 2000, Australian Magnesium Corporation mined 3.5 Mt of crude magnesite ore at Kunwarara, which was beneficiated to produce 348 554 t magnesite. This in turn produced 106 416 t deadburned magnesia, about 42 800 t calcined magnesia and 27 096 t electrofused magnesia. The only other recorded production of magnesite in 2000 was 1,380 t from South Australia.

World Resources and Production

According to Geoscience Australia and USGS data, Australia has about 3% of the world's EDR of magnesite. China, Russia and North Korea, together, account for nearly 75% of the world's EDR of magnesite. The Kunwarara deposit is the world's largest known resource of cryptocrystalline, nodular magnesite, a high-quality ore.

Australia accounted for 3% of the world's production in 2000. USGS data show that China and Turkey (both 23%) were the world's largest producers, followed by North Korea (10%), Russia and Slovakia (both 8%).

Industry Developments

During 2000, a number of planned projects for magnesium plants continued to progress towards development. In November, the Federal and Queensland governments jointly committed $100 million to infrastructure and research activities associated with Australian Magnesium Corporation's (AMC) Stanwell Magnesium Project. AMC also reached agreement with power utility Stanwell Corporation Limited (SCL) on energy, water, land and service arrangements for the next 30 years. With negotiations finalised and a bankable financial study nearing completion, AMC expects to commence construction of its 97 000-tpa magnesium metal plant at Stanwell, which will be adjacent to SCL's 1400-MW power station (23 km southwest of Rockhampton), in mid-2001 with commissioning to start in 2003.

In late 2000, Pima Mining NL, through SAMAG Limited, signed an offset agreement for 100% of its magnesium metal production with ThyssenKrupp Metallurgie, a German engineering company. Pima Mining is seeking a major partner for this project, which involves the building of a 52 500-tpa magnesium metal plant (near Port Pirie), based on its magnesite resource in the Willouran Ranges, northwest of Leigh Creek.

Mt Grace Resources NL signed an agreement with MINTEK (a South African research group) to use their DC-arc furnace technology. The company already has access to plasma-arc furnace technology, which involves the continuous reduction of magnesium oxide with aluminium in a DC-plasma-arc furnace. Mt Grace Resources NL plan to construct a 50 000-tpa magnesium plant, based on magnesite from its Batchelor deposit in the Northern Territory, using either of the above technologies.

In Tasmania, Crest Magnesium NL is seeking a joint venture partner for its magnesite project based on the Arthur River deposit. Golden Triangle Resources NL continued evaluation of its magnesium project based on asbestos tailings at Woodsreef, near Armidale in northern New South Wales. This project plan would use dehydration, cell and electrowinning technologies developed by Alcan and Noranda.

MANGANESE ORE

Over 90% of world manganese production is utilised in the desulphurisation and strengthening of steel. In Australia, manganese ore is mined at Groote Eylandt (NT) and Woodie Woodie (WA). Resources at these mines are the basis of an important export industry.

Resources

EDR of manganese ore decreased by 4.8% to 127.8 Mt in 2000, mainly as a result of new resource data becoming available for both Groote Eylandt and Woodie Woodie. Both paramarginal and submarginal demonstrated resoureces remained unchanged. Inferred resources increased to 197.8 Mt in light of the new data.

Exploration expenditure

Data relating to exploration for manganese are not available nationally.

Production

In 2000, Australia produced 1.6 Mt of manganese ore with a manganese content of 0.8 Mt. According to preliminary figures published by ABARE, exports of ore and concentrates totalled 1.3 Mt with a value of $212 million.

World ranking

Australia has 7% of world EDR of manganese ore, placing it fourth behind South Africa (46%), Ukraine (24%) and China (11%). In terms of contained manganese, Australia has 9% of world EDR placing it third after South Africa (53%) and Ukraine (19%). Australia is the fifth largest producer (9%) of ore behind China (25%), South Africa (16%), Ukraine (14%) and Gabon (10%).

Industry Developments

During 2000, Consolidated Minerals completed an exploration program at Woodie Woodie utilising geophysical and geochemical data gathered since 1990. Drilling identified three significant mineralised zones that are being evaluated in more detail.

HiTec Energy's proposed Electrofuel Project at Port Hedland (WA) was granted Australian Government Major Project Facilitation status. The $237 million project involves construction of a plant to produce electrolytic manganese dioxide for use in alkaline batteries and manganese sulphate in feedstock and fertiliser production. Construction of a demonstration plant has commenced at Murdoch University in Perth and HiTec have been granted a 50-hectare site for the production facility near Port Hedland.

MINERAL SANDS

The principal components of mineral sands are zircon ($ZrSiO_4$) and the titanium minerals rutile (TiO_2) and ilmenite ($FeTiO_3$). Rutile and ilmenite are used mainly in the production of titanium dioxide pigment with a small portion, less than 4% of total titanium mineral production and typically rutile, used in making titanium sponge metal. Zircon is an opacifier for glazes on ceramic tiles and is utilised in refractories and the foundry industry.

Resources

EDR of ilmenite continued its increasing trend in 2000, up from 180.9 Mt in 1999 to 196.0 Mt, an increase of 8.4%. A reassessment of resources in Queensland, which has the second largest EDR (28%), was the main the reason for the increase.

In Western Australia, which has the largest ilmenite EDR (68%), most of the increase was on the Northern Swan Coastal Plain and reflected successful infill drilling programs.

In New South Wales, which has about 3% of total ilmenite EDR, the increase was threefold and followed successful infill and extension drilling carried in the Murray Basin.

EDR of rutile (which includes leucoxene in Western Australia) rose by nearly 11% from 19.8 Mt in 1999 to 21.9 Mt in 2000. Western Australia and New South Wales were the main beneficiaries, with most of the increase (80%) within the Murray Basin in New South Wales. Queensland and Western Australia together have just over 80% of Australia's EDR of rutile. In South Australia, there was a marginal increase in rutile EDR in the Murray Basin.

EDR of zircon rose by nearly 6% from 26.3 Mt in 1999 to 27.9 Mt in 2000. Most of the increase was in the Murray Basin within New South Wales. In Western Australia, EDR increased by 3%, with most of this in the northern section of the Swan Coastal Plain. In Victoria, EDR increased slightly and decreased in Queensland. Western Australia and Queensland together have 90% of zircon EDR.

Some 19%, 26% and 30% 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 Shoalwater Bay area in Queensland; and Yuraygir, Bundjalung, Hat Head and Myall Lakes National Parks in New South Wales.

Australia's subeconomic demonstrated resources of ilmenite, rutile and zircon decreased substantially to 51 Mt, 12 Mt, and 19 Mt, respectively in 2000. The bulk of the decrease, in the paramarginal category, reflected reassessment of the WIM deposits in the Murray Basin within Victoria. The WIM deposits also contain over 14 Mt of leucoxene, which was included with rutile resources in 1999.

Inferred resources of ilmenite fell by over 13% to 97 Mt in 2000. Decreases in New South Wales and Queensland, resulted from reclassification of resources. Victoria has the highest level of inferred ilmenite resources (46%), followed by Western Australia (31%) and Queensland (12%).

Inferred resources of rutile and zircon fell by 44% and 10%, respectively. Most of the decrease was in Victoria and Queensland, which offset small increases in rutile in South Australia and Western Australia and in zircon in South Australia. Victoria has the highest levels of rutile and zircon inferred resources with 69% and 67%, respectively. Victoria has some 9 Mt of inferred leucoxene resources, which were previously incorporated in its rutile resource figures.

Exploration

According to quarterly ABS figures, expenditure on exploration for mineral sands in 2000 was $23.2 million. This is an increase of about 27% over the previous year. Comprehensive State-by-State data are not published by ABS, but it is likely that most of the expenditure was in the Murray Basin, which has an extensive coverage of exploration leases.

Production

In 2000, Australia produced 2.2 Mt of ilmenite, 237 kt of rutile and 352 kt of zircon. The bulk of Australia's rutile and zircon production is exported compared to about 53% for ilmenite. The remaining ilmenite is upgraded to synthetic rutile, which contains about 92-93% TiO_2.

World Resources and Production

According to AGSO and USGS data, Australia has the world's largest EDR of ilmenite, rutile and zircon with 29%, 44%, and 40%, respectively. Other significant rankings are South Africa (16%) and Norway (11%) for ilmenite; South Africa (18%) and India (14%) for rutile; and South Africa (32%) and Ukraine (9%) for zircon.

In 2000, world production of ilmenite increased by 2% to 7.2 Mt, rutile 11 % to 431 kt, while zircon decreased by 3% to 902 kt. Australia produced about 30%, 55% and 39% each of world production of ilmenite, rutile and zircon, respectively and is the leading producer of all three minerals as well as the largest exporter. South Africa (from dune sands) and Canada (from hard rock) mine similar quantities of ilmenite to Australia, and upgrade it to titanium slag prior to export.

Industry Developments

The main focus of industry activity during 2000 continued to be on the strandline deposits in the late Miocene-Pliocene marine sand sequences of the Murray Basin (within NSW, Vic and SA). New deposits were delineated as a number of projects progressed feasibility studies. In Western Australia, strandlines near Shark Bay were identified as having potential for substantial resources.

Basin Minerals upgraded its resource estimates for the Douglas project near Horsham, Victoria. Total inferred resources rose to 20.8 Mt of concentrates containing 11.31 Mt of ilmenite, 1.26 Mt of rutile and 1.62 Mt of zircon. A bankable feasibility study was in progress at year-end, with plans to commence production in 2004. Resource definition drilling, totalling 60 000 m on two deposits at Douglas, is designed to outline a measured resource for an initial 5-year production period and is expected to be completed in the first half of 2001.

At the Wemen project near Robinvale (northwest Vic), mine development is underway as is construction of the separation plant at Mildura. Commissioning is scheduled for the first quarter 2001. The project, jointly owned by RZM Pty Ltd and Sons of Gwalia Ltd, has an initial mine life of about 6 years and will have an average annual production of 10 kt of zircon and 40 kt of rutile.

Elsewhere in Victoria, the WIM 100 and WIM 150 (fine-grained) mineral sands leases near Horsham (relinquished by Rio Tinto), were put out to tender by the Victorian Government. The WIM 100 leases were secured by Basin Minerals and WIM 150 by a joint venture between Austpac Resources and Ticor.

In New South Wales, Bemax Resources announced that resources at its Gingko deposit (120 km north of Mildura) totalled 258 Mt at 2.8% heavy minerals (cut-off grade of 1% heavy minerals). The deposit has a high grade core of 123 Mt grading 4.2% heavy minerals comprising 47% ilmenite, 13% rutile, 10% zircon and 10% leucoxene. A bankable feasibility study of Gingko is progressing with a decision on its findings expected in late 2001. The company has also identified a potentially significant resource at the Snapper prospect (10 km southwest of Gingko), which is likely to increase the potential of the area.

In South Australia, resources at Basin Mineral's Mindarie project (150 km east of Adelaide) were increased to 65.6 Mt at 3.35% heavy minerals. A feasibility study into development of this project is progressing.

On North Stradbroke Island, east of Brisbane, Consolidated Rutile commenced detailed drilling of its Herring-Enterprise lease with the aim of upgrading ore reserve confidence from probable to proven. Mining is expected to commence in 2004, when reserves at its Ibis mine are exhausted.

Further north, increased resources were delineated at Monto Minerals' Goondicum project (110 km south of Gladstone). Ilmenite resources increased by 0.2 Mt to 3.9 Mt with an increase in grade to 5% and the titano-magnetite resources rose by 0.14 Mt to 2.24 Mt at 2.8%. The company plans to produce about 275 ktpa of ilmenite (commencing in 2002) as feedstock for titanium dioxide pigment using the sulphate process.

In Western Australia, Iluka Resources commissioned its North Capel mine (south of Perth) and North mine near Eneabba to take over from the West Eneabba operation, which closed in late 1999. The company now has six operating mines. Exploration by Iluka continued during the year around its existing operations and on deposits scheduled to mined in the near future. Additional resources were identified at the South Capel and Tutunup mines (south of Perth) and at two new deposits — Red Gully and North Dandalup, to the north and south of Perth respectively.

North of Eneabba, near Dongara, Magnetic Minerals Limited carried out infill drilling of the Zeus 1 and 2 strandlines, where it identified an inferred resource of 20 Mt averaging 6.6% heavy minerals. Drilling of magnetic anomalies along the strandlines indicates there is a strong correlation between the anomalies and high-grade mineralisation.

Further north, Gunson Resources announced the discovery of the Amy prospect at its Coburn project near Shark Bay on the central coast. The zone is reported to be 14 km long, on average 1.1 km wide and up to 33 m thick, with mineralisation open along strike. Broad zones (20–30 m thick) of low-grade mineralisation (0.9% heavy minerals) with higher grade zones (up to 7m thick) containing 5.2% heavy minerals were intersected.

South of Perth, Cable Sands received approval to mine the Yarloop deposit (45 km northeast of Bunbury) and is seeking approval to mine the Gwindinup mineral sands deposit (25 km southeast of Bunbury). The latter consists of four orebodies, which are estimated to contain about 16 Mt of ore, with ilmenite the dominant mineral. The deposits would be dry-mined using loaders, scrapers and bulldozers to a maximum depth of 28 m. Heavy mineral production would range between 130 and 170 ktpa over the project's 10-year mine life.

NICKEL

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

Resources

Total identified resources of nickel rose by over 10 Mt (30%) in 2000. Most of this occurred in Western Australia with minor increases in New South Wales and Tasmania.

EDR increased by nearly 90% from 11 Mt to a record 20 Mt, representing 45% of total identified resources. Most of this was in Western Australia and mainly reflected industry reassessments of resources at existing deposits.

Western Australia remains the largest holder of nickel resources with 94% of total EDR. At WMC's operating sulphide mines (Kambalda, Leinster and Mount Keith), measured and indicated resources decreased slightly reflecting a loss of resources to production. Jubilee Mines' resources increased following a successful drilling program that located the Cosmos Deep orebody below the Cosmos open cut. Significant increases in laterite ore reserves were reported by Anaconda Nickel for its Mount Margaret Project, which incorporates the Marshall Pool, Lawlers and Murrin Murrin deposits. An increase and upgrade of laterite resources was also reported by Heron Resources for its Goongarrie project.

Company reassessment of the Marlborough deposits in Queensland contributed a slight increase to EDR.

Subeconomic demonstrated resources, which accounted for about 10% of total identified resources, fell by around 3 Mt with most this being in the submarginal category and attributable to Western Australia. This followed further drilling and upgrading of some resources, notably lateritic resources to EDR

Inferred resources rose by nearly 24% to a record level of close to 20 Mt (following an increase of 26% in 1999). Most of the increase was in Western Australia and associated with Western Metals' Eucalyptus project, Heron Resources' Scotia and Yerilla projects, Anaconda Nickel's Weld Range and Yerilla projects and Acclaim Exploration's Wingellina project.

Additional exploration in the Young-Thuddungra region and at Syerston (NSW) and at Avebury (Tas), resulted in minor additions to inferred resources in these States.

Exploration

Expenditure on nickel exploration (and inclusive of cobalt) for 1999–2000 totalled $73 million and is the first release of separate figures for this commodity by ABS. About a third of expenditure was in Western Australia.

Production

In 2000, some 799 kt of nickel concentrate (approx 166 kt contained nickel) was produced from Western Australia.

World ranking and production

According to Geoscience Australia and USGS data, world EDR of nickel increased by 22.6% (47.5 Mt in 1999 to 58.2 Mt in 2000). Australia's share of EDR increased to 34.3%, up from 22.3% in 1999, making it the largest holder of EDR followed by Russia and Canada (both 11%) and Cuba (10%).

Australia produced about 14% of estimated world nickel output of 1.23 Mt. Russia was again the largest producer with 265 kt (22%) followed by Canada 194 kt (16%), Australia 166 kt and New Caledonia 120 kt (10%).

Industry Developments

Australia has seven operating nickel sulphide mines: — WMC's Kambalda, Leinster and Mount Keith; Outokumpu Oy's Silver Swan; Titan Resources' Radio Hill; Tectonic Resources' RAV8; and Jubilee Mines' Cosmos. RAV8 and Cosmos commenced in 2000. Three laterite nickel mines are now in production in Western Australia: — Preston Resources' Bulong; Centaur Mining & Exploration's Cawse; and Anaconda Nickel's Murrin Murrin. Australia has a nickel smelter at Kalgoorlie and two refineries — one at Yabulu (Qld) and the other at Kwinana (WA).

Production from all of WMC's operations increased during 2000 with concentrate production totalling 703 kt (cf. 578 kt in 1999). The Rocky's Reward underground mine at Leinster shut down and production was taken up by the Harmony open cut. WMC sold a number of its leases to a joint venture headed by Mincor Resources. These leases include the Miitel, Redross and Mariners mines. As part of the divestment agreement, WMC will purchase concentrate produced by the joint venture and treat it at the Kambalda Nickel plant. Negotiations on the sale of WMC's Coronet, Otter Juan and Wannaway mines was continuing at the end of the review period.

WMC's nickel smelter at Kalgoorlie achieved a record level of production (103 kt of nickel-in-matte) in 2000 following shutdown to rebuild the furnace hearth last year. The company announced plans to upgrade its Kwinana nickel refinery, which will lift capacity by close to 10% (61 to 67 ktpa).

In May 2000, WMC announced the discovery of massive and disseminated nickel-copper-cobalt-gold mineralization within layered mafic-ultramafic intrusions in the Musgrave Complex near the South Australian / Northern Territory border. Three prospects have been identified - Nebo, Babel and Gerar, with the following drilling intersections reported for Nebo: 26.55m @ 2.45% Ni, 1.78% Cu, 0.74g/t PGEs+Au; and Babel: 148.9m @ 0.3% Ni, 0.42% Cu, 0.29g/t PGEs+Au.

Outokumpu Australia commenced operations at its 18-ktpa Cygnet mine, northeast of Kalgoorlie. Ore from this mine is blended with high-grade ore from the adjacent Silver Swan deposit and the nickel-in-concentrate output is exported as feed for the company's smelter in Finland.

At Radio Hill in the west Pilbara some 45 kt of concentrate was converted to nickel-in-matte at WMC's smelter. Ore reserves at this mine are expected to be exhausted by mid-2002. Following successful laboratory testing of its patented BioHeap process last year, Titan Resources conducted a pilot-scale metallurgical trial to recover nickel from disseminated mineralization in low-grade stockpiles at Radio Hill. After five months of heap irrigation and leaching of a 5000 t stockpile, 78 % nickel recovery was achieved.

Two new sulphide mines commenced operation in 2000. The first was RAV8, which started in March. Situated near Ravensthorpe, the mine has a 2-year life during which an estimated 48 kt of concentrate averaging 16 to 20 % nickel is expected to be produced. The concentrate is processed at WMC's Kalgoorlie smelter.

The second mine (Cosmos with ore reserves of 420 kt grading 7.52% nickel; 31 kt of contained nickel metal) shipped its first nickel concentrate (8 kt with 16% nickel) to Inco in Canada in August. Situated 700 km north of Esperance, the mine with a projected mine life of 3 years is operated by Jubilee Mines on a fly-in/fly-out basis. During 2000, additional high-grade massive and semi-massive mineralization was discovered (Cosmos Deeps) some 450 m below the surface and has the potential to extend mine life a further four years.

In late 2000, LionOre Australia (Nickel) Limited announced that it was developing the Emily Ann underground mine in the Lake Johnston greenstone belt (200 km southwest of Kalgoorlie). The operation will utilise an on-site conventional nickel-sulphide-concentrate plant with throughput of 250 ktpa producing an average 6.7 ktpa of nickel, over an initial five-year period. The concentrate is to be shipped to Inco's smelter in Canada under a life-of-mine offtake agreement. Production is scheduled to commence by the end of 2001.

Australia's three laterite operations (Bulong, Cawse and Murrin Murrin) continued to experience commissioning difficulties throughout 2000 and were operating below design production capacity. At year end, Bulong had achieved 78% of its capacity (9 ktpa of nickel), Cawse 80 % (9 ktpa of nickel) and Murrin Murrin about 40% (45 ktpa of nickel). Murrin Murrin is expected to achieve 85% capacity within the next twelve months.

Development of the Ravensthorpe 'second generation' lateritic nickel deposit by Comet Resources and QNI / Billiton is being undertaken in conjunction with a major expansion of the Yabulu refinery in Queensland. The nickel refinery is to be expanded from its current capacity of 28 ktpa to 63 ktpa.

A number of other projects were the focus of feasibility studies during 2000. These included a new 20-ktpa plant at Syerston (NSW) and a 25-ktpa plant expansion at WMC's Mount Keith operation. Owners of the Cawse and Bulong lateritic nickel operations were also investigating the feasibility of increasing plant capacity at these facilities.

PHOSPHATE

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

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

DAP and MAP have different ratios of phosphorous and nitrogen, and have slightly different applications. DAP is used on broad-acre crops such as cereal, legume, fodder, horticultural and row crops, and dairy and newly-established pastures. MAP assists with early crop growth and enhances phosphorous uptake in broad-acre crops.

Resources

EDR of phosphate rock increased by approximately 13 Mt (20%) in 2000 after adjustment to reflect WMC's reporting of mineral resources as inclusive of ore reserves at Phosphate Hill. A similar adjustment should also have been made for the previous year, which results in a revised EDR figure (as published) for 1999 of 64 Mt. All EDR is sedimentary phosphate rock (phosphorites), with an average grade of about 23% P_2O_5 at Phosphate Hill.

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

The bulk of Australia's inferred phosphate resources are in phosphorites in the Georgina Basin, and these are distributed between Queensland, Western Australia and the Northern Territory. There is no publicly available information on Christmas Island's current phosphate resources.

Exploration

Data relating to exploration for phosphate are not available.

Production

In 2000, WMC produced just over 326 kt of DAP (from 0.8 Mt of rock phosphate) at Phosphate Hill. In 1999–2000, Phosphate Resources Ltd (PRL) shipped 612 kt of phosphate rock from Christmas Island.

World ranking

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

Industry developments

Construction of WMC's integrated mine and fertilizer manufacturing facilities in Queensland was completed in late 1999. Commissioning of the complex manufacturing plant during 2000 was not without problems, which were mainly due to mechanical difficulties, particularly with the ammonia and phosphoric acid plants. At the end of the period under review WMC reported that the plant, which is designed to produce 975 ktpa high-analysis ammonium fertilizers, was operating at an equivalent annualised production rate of 615 ktpa.

Some Phosphate Hill ore has high iron levels that affect product quality. This is being addressed in the short term by selective mining until an iron-removal step can be incorporated into the process.

In 2000, Phosphate Resources Limited's (PRL) operation on Christmas Island:

- successfully introduced a new product, CIRP 3 (Christmas Island Rock Phosphate averaging 30% P_2O_5), into the Malaysian and Indonesian markets;
- maintained its position as the major supplier of phosphate rock into Malaysia; and
- continued to supply all major Australasian manufacturers of MAP against robust competition from Chinese suppliers.

In its 1999–2000 annual report, PRL advised that it would ensure that all reserves of phosphate rock are removed from areas identified for possible construction of a satellite launching facilitity on Christmas Island. The company is cooperating with the Commonwealth Government and the Asia Pacific Space Centre to facilitate the transfer of land for this project.

SHALE OIL

Organic rich shale that yields substantial quantities of oil by heating and distillation is commonly referred to as oil shale. One tonne of oil shale may contain over 200 litres of oil. The organic material in oil shale is kerogen, which can be a precursor to conventional oil reservoirs given sufficient heat in the crust. Australian oil shale deposits of commercial interest are predominantly in a series of narrow and deep extensional-basins near Gladstone and Mackay (Qld). These are thick Tertiary lacrustine (lake-formed) deposits that are relatively easy to mine. They contrast with generally harder carbonate bearing oil shales (marls) found elsewhere in the world that are more difficult to mine and process.

Resources

To accord with the JORC Code, Southern Pacific Petroleum and Central Pacific Minerals (SPP/CPM) systematically reviewed in-situ mineralisation in all ten oil shale deposits held by them (solely or with joint venture partners) in the Gladstone-Mackay region. The latest reserve and resource estimates reported by the companies are incorporated in this assessment.

Australia has 4.6 GL of shale oil EDR. However, this could increase significantly if the research and development demonstration-scale processing of shale oil moves into commercial production at SPP/CPM's Stuart deposit. Trials at the $300 million demonstration plant commenced in August 1999 and continued throughout 2000. Paramarginal and submarginal demonstrated resources are 197.5 GL and 3,719 GL respectively.

Production

The Stuart demonstration plant had produced 5.6 million litres of oil products by the end of 2000. The oil products are naphtha 50% and medium shale oil 50%. The naphtha has a low sulphur content (less than 1 ppm).

World Resources and production

According to the World Energy Council's 1998 survey of energy resources, Australia, Morocco and Jordan have the largest estimates of 'proved oil shale in place'. In the same survey, the Council reported that production of oil from shale in 1996 was recorded in Estonia (421 million litres), Brazil (184 million litres) and China (74 million litres).

Industry Developments

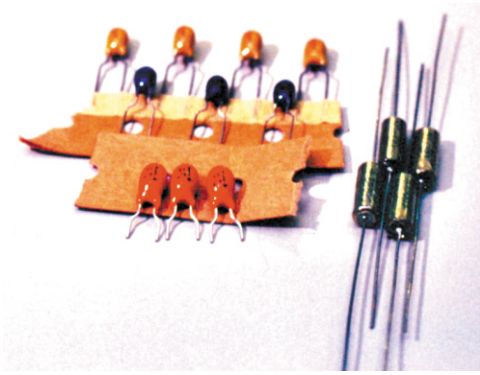
The status of development trials of the Stuart demonstration plant is noted above. In early 2001, Stage 1 of the project was moving into longer test-production runs. Results from research and development at the Stage 1 plant are being incorporated into the design for commercial scale-up (Stage 2). If Stage 2 proceeds it is expected to cost over $350 million.

Early in 2001 SPP/CPM acquired Suncor Energy's 50% interest in Stuart, with Suncor retaining 5% royalty rights in Stuart Stage 1. SPP/CPM's long-term goal is to achieve, through progressive plant expansion, production of 200 000 barrels per day. This would be similar to Bass Strait's current oil production (now in decline) and would deliver a balance of payments benefit to Australia of about $4 billion annually at current oil prices.

TANTALUM

Increased use of portable electronic devices such as mobile phones, computers and video cameras has maintained strong growth in demand for tantalum capacitors in recent years. Australia, through of Sons of Gwalia's operations, is the world's largest producer of tantalum in the form of tantalum concentrates. The company's Greenbushes and Wodgina (WA) deposits are the largest of their type that are commercially mined.

Resources



Despite increased production of tantalum pentoxide (Ta_2O_5), EDR increased by 19% in 2000 to 29 345 t tantalum (Ta). This was largely due to reassessment of resources in the Greenbushes deposit. Sons of Gwalia reported that resources at Greenbushes increased from 75.2 to 98.1 Mlbs of Ta_2O_5 (34.1 to 44.5 kt Ta_2O_5), while the those at Wodgina remained unchanged at 30.1 Mlbs Ta_2O_5 (13.7 kt Ta_2O_5). In assessing EDR for the Greenbushes resources, a recovery factor of 55% (the current metallurgical recovery reported for Greenbushes) was applied. EDR elsewhere in Western Australia and the Northern Territory is relatively small compared to those at Greenbushes and Wodgina.

A significant increase in subeconomic demonstrated resources (SDR) stemmed from reassessment of resources at Greensbushes and the Toongi deposit near Dubbo (NSW). At Toongi, tantalum metal together with zirconia, rare earths, and niobium is associated with an alkaline intrusive complex.

Inferred resources decreased by 14% to 60 391 t Ta in 2000. This resulted from the resource upgrade at Toongi. The bulk of inferred resources are associated with a carbonatite at Mt Weld (26 km southeast of Laverton, WA).

Exploration

Data relating to exploration for tantalum are not available.

Production

In 2000, Sons of Gwalia produced 737 516 lbs (335 t) of Ta_2O_5 from the Greenbushes operation and a further 569 045 lbs (258 t) from its Wodgina mine.

World Resources and Production

The increase in resources at Greenbushes and Wodgina consolidated Australia's position as the world's largest holder of tantalum resources. Based on world estimates published by the USGS and modified by Geoscience Australia to take account of recent discoveries, Australia has over 90% of the world's EDR of tantalum. Canada has the second largest resource base.

World production in 2000, based on USGS estimates modified to account for later Australian data amounted to 628 t Ta. Production was dominated by Australia, with 485 t in 2000 (about 77% of world output). According to the USGS, minor producers of tantalum metal were Brazil (90 t), Canada (50 t), and Nigeria (3 t).

Industry Developments

During 2000, the new processing plant at Wodgina operated above its design capacity of 650 000 tpa. Over the next two years, the plant is to be expanded to 1.8 Mtpa at a capital cost of about $35 million. Commissioning of this expansion is scheduled for first quarter 2002.

At Greenbushes, Sons of Gwalia completed a feasibility study into the development of an underground mine below the Cornwall open cut. The processing plant at Greensbushes is to be expanded to 2.75 Mtpa and should in operation by first quarter 2002.

Sons of Gwalia produce approximately 25 % of the world's tantalum metal. The planned expansions outlined above will ensure that the company continues to be the primary supplier of ore to the tantalum industry.

URANIUM

Resources

Geoscience Australia prepares estimates of Australia's uranium resources within categories defined by the OECD Nuclear Energy Agency (OECD/NEA) and the International Atomic Energy Agency (IAEA) (OECD/NEA & IAEA, 2000). In Table 1, these estimates are reported under the corresponding resource categories of the national classification scheme. The resource categories of both schemes are correlated as closely as possible in Table 3.

TABLE 3.

Comparison of resource classification schemes for uranium

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

The <US$40 category was introduced into the NEA/IAEA scheme in recent years to reflect a production cost range that is more relevant to uranium market prices which prevailed during the 1990s. This assessment is the first in which Geoscience Australia has reported estimates of Australia's resources in the <US$40 category (Table 1). To date, not all countries have reported resource estimates for this category (OECD/NEA & IAEA, 2000).

In 2000, Australia's RAR recoverable at <US$80/kg uranium (U) increased by 96 kt U (17%) to 667 kt U. This was mainly due to reassessment of the ore reserves and mineral resources for the Olympic Dam deposit by WMC. The increases for Olympic Dam reflect the discovery of additional resources, and changes resulting from increases in long-term copper prices, lower exchange rates for the Australian dollar, and the recently completed expansion of the operations.

Approximately 95% of Australia's total uranium resources in RAR recoverable at <US$80/kg U are within the following six deposits:

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

World ranking

Australia's resources in RAR recoverable at <US$40/kg U (equates to EDR) are the largest of those countries which have reported resources in this category. Because all countries have reported their resources in the <US$80 category, the world ranking of the various countries (as follows) is based on the <US$80 figures. Australia has the world's largest resources of uranium in RAR recoverable at <US$80/kg U, with 29% of world resources in this category. Other countries that have large resources in this category include Kazakhstan (19%), Canada (14%), South Africa (10%), Brazil (7%), Namibia (6%), Russian Federation (6%), and United States (5%) (OECD/NEA & IAEA, 2000).

Exploration

Total expenditure on uranium exploration in Australia for 2000 was $7.59 million, 21% lower than for 1999. The main areas for exploration, and deposit types targeted were:

- Arnhem Land (NT) - unconformity-related deposits in Palaeoproterozoic metasediments below a thick cover of Kombolgie Sandstone,
- Frome Embayment (SA) - sandstone type deposits in Tertiary sediments,
- Mount Painter region (SA) - uranium and gold mineralisation in hematite-rich granitic breccias.

Annual expenditure on uranium exploration in Australia has declined progressively since 1997. Respondents to the annual survey (conducted by Geoscience Australia) of uranium exploration and mining companies attribute this to:

- low market prices for uranium in recent years,
- uranium mining policies of State governments in Western Australia, Queensland, New South Wales, Victoria and Tasmania,
- difficulties in accessing prospective areas because of Native Title issues.

Production

Uranium oxide was produced at the Olympic Dam and Ranger operations. Commercial operations commenced at the Beverley in situ leach operation in November. Australia's total production for 2000 was a record high of 8937 t U_3O_8 (7579 t U; U=0.848 x U_3O_8), of which Olympic Dam produced 4500 t U3O8 and Ranger produced 4437 t U_3O_8. Nil production was reported from Beverley for the year. Australia's total production for 2000 was 27% higher than in 1999.

Industry Developments

Olympic Dam. Production from Olympic Dam was 41% higher than for 1999, and in terms of annual production, it is now the world's second largest uranium mine. This increase in production resulted from a major expansion of the project, which was completed in 1999 at a final cost of $1.94 billion. Annual production capacity is now 200 000 t of refined copper, 4600 t U_3O_8 with commensurate increases in gold and silver output.

WMC announced plans to further increase production to an annual rate of 245 kt refined copper by optimisation of operating processes within the metallurgical plant. Associated increases in uranium production were not reported. This expansion should be completed by 2003.

Ranger. Mining of the Ranger No. 3 Orebody open pit continued throughout the year with 2.4 Mt of ore and 4.5 Mt of overburden being mined. Energy Resources of Australia (ERA) Ltd reported that mining of the No. 3 Orebody is expected to be completed in 2007, which will meet the requirements for this open pit to be utilised as a tailings repository from 2008. It is anticipated that processing of Ranger ore will be completed by 2010.

In January 2000, the new Authority to Operate at Ranger came into force. New environmental requirements (ERs) for Ranger were imposed as conditions of this Authority. The ERs reflect the changes in technology and build upon the knowledge gained from mining in the region over the past 20 years. They will enable continuation of the existing high level of environmental protection.

The company's performance at both Ranger and Jabiluka continues to be closely monitored by the Supervising Scientist and the Northern Territory Government. The Supervising Scientist reported in his 1998–1999 Annual Report for the Alligator Rivers region:

'Assessments showed that the environmental management regime at Ranger continues to operate in a way that poses no immediate nor long-term substantial threat to the surrounding environment of Kakadu National Park'.

In August 2000, Rio Tinto Ltd gained majority ownership of ERA Ltd through the take-over of North Ltd.

Jabiluka. Construction of the decline, interim water management pond and surface facilities was completed in 1999. During 2000, the Jabiluka site was on stand-by and environmental maintenance.

ERA reported revised estimates of the mineral resources and ore reserves for Jabiluka based on mapping of underground exposures and drilling of the upper eastern section of the orebody during 1999 (Table 4). Previous estimates, based entirely on surface drill hole data, assumed a high degree of grade continuity between drill intersections within the same lithological units of the mine sequence. The new underground exposures revealed a much greater degree of structural control of the mineralisation, and a lesser degree of grade continuity. This has resulted locally in higher grades and lower tonnages when compared to previous estimates.

TABLE 4.

Jabiluka ore reserves and mineral resources as at June 2000 (cut off grade 0.2% U_3O_8)

Ore Reserves	Ore (Mt)	Grade (% U_3O_8)	Contained U_3O_8 (t)
Proved	6.8	0.57	39 000
Probable	7.0	0.45	32 000
Total Proved & Probable Ore Reserves	13.8	0.51	71 000
Mineral Resources *			
Total Measured & Indicated Resources	15.3	0.57	88 000
Inferred	15.7	0.48	75 000
Total Resources	31.1	0.53	163 000

* Includes resources modified to produce the ore reserves

Beverley. Commercial production of uranium commenced at the Beverley mine in late 2000. Beverley is Australia's first in situ leach (ISL) operation to mine uranium. Annual production is planned to be approximately 1000 t U3O8, and ion exchange technology is used in the uranium recovery plant.

Development of the project was approved by both the Commonwealth and South Australian Governments in 1999, following a joint assessment of the Environmental Impact Statement. As part of the assessment process the Commonwealth Environment Minister required the company to carry out further work to confirm that there was not a hydraulic connection between the Beverley aquifer and other surrounding aquifers, including the Great Artesian Basin aquifer. This was necessary in order for approvals to be granted for the disposal of liquid wastes by re-injection into the Beverley aquifer.

Honeymoon. The draft Environmental Impact Statement for the proposed development of the Honeymoon project (SA) was released in June 2000. Southern Cross Resources proposes to develop a commercial ISL uranium operation, based on the Honeymoon and East Kalkaroo deposits. Production is planned at a rate of 1000 tpa U_3O_8 with uranium to be recovered in the processing plant using solvent extraction technology.

The commercial ISL operation will produce considerable quantities of liquid wastes made up of:

- 1% bleed from the leach solutions after uranium recovery, estimated at 376 m^3/day,
- plant wash-down and process discharge water, estimated at 115 m^3/day,
- wellfield development water, estimated at 113 m^3/day, and
- brine solutions discharged from the reverse osmosis plant (these solutions contain salts remaining after purification of ground water drawn from the Upper Sands aquifer. Estimated volume 60 m^3/day).

The various options for disposal of these liquid wastes were outlined in the draft EIS. The company's preferred method for disposal is to re-inject the liquid wastes into the Basal Sand via disposal wells. It claims that return of these liquids to the Basal Sands will have negligible impact on the ground water because of its already high natural levels of salinity, and contamination with uranium and radium.

To assist Environment Australia in the assessment of the proposal, Geoscience Australia prepared a technical review of the liquid waste disposal methods currently used by ISL uranium operations worldwide. This review also summarised the environmental issues relating to each of the various disposal methods.

Salinity levels in the palaeochannel aquifer are high. Total dissolved solids (TDS) vary from 10,000 to 20,000 mg/litre, and the salinity levels increase with depth. On the basis of TDS alone, the ground water in the palaeochannel is generally not suitable for watering livestock. The TDS of the water in the Basal Sand aquifer is beyond the tolerance for stock watering. The water in the Upper Sand is generally unsuitable for stock watering and is near the upper limit for sheep on dry feed.

In November 2000, Southern Cross released a Response Supplement to the Environmental Impact Statement, which contained the company's considerations and responses to the issues raised by government agencies and the public.

The draft EIS and the Response Supplement were assessed jointly by the South Australian State Department of Transport, Urban Planning and the Arts, and the Commonwealth Department of Environment and Heritage (Environment Australia).

In February 2001, the Environment Minister announced that before he could make a final decision on the proposal, further detailed information would be required on the hydrology of the Honeymoon aquifers. With reference to the disposal of waste liquids by re-injection into the Basal Sands aquifer, the Minister stated that he must be confident about the characteristics of any migration of re-injected waste, and also that detrimental environmental consequences would not occur. This will require further testing of aquifer boundaries, their associated ground water chemistry, and the effectiveness of monitoring wells.

Geoscience Australia and the Bureau of Rural Sciences provided technical advice to Environment Australia in preparing the terms of reference (released in March 2001) for the additional work to be completed by the company. It was recommend that the company:

- carry out pump tests and stratigraphic drilling to assess the hydrogeological boundaries and characteristics of the aquifer and confining beds, including any leakage between the aquifers;
- characterise the chemical processes, which may occur in any liquid waste plume, to determine the chemical and physical changes and the probable rate of return to values comparable to the natural groundwaters in the aquifer; and
- demonstrate the effectiveness of the monitoring system to detect possible excursions as a result of ISL operations, and liquid waste injection into the Basal Sand aquifer and groundwater extraction from the Upper Sand aquifer.

VANADIUM

Vanadium is used in metal alloys, principally to strengthen steel.

Resources

EDR of vanadium increased by 4% to over 188 kt during 2000. The Windimurra deposit (WA) contains more than 95% of Australia's EDR.

Windimurra, Australia's only vanadium mine, commenced production in February 2000. Other vanadium deposits in Western Australian are in the Yilgarn Craton at Gabanintha, Buddadoo, Youanmi, and Narndee, and in the Pilbara Craton at Balla Balla and Don Well. These were documented in some detail in AIMR 1999.

Exploration

Commercial development of the Windimurra mine has led to an increase in vanadium exploration activities in recent years. Most of this has been for vanadium-titanium deposits within Archaean layered gabbroic intrusions in the Yilgarn and Pilbara Cratons (WA). WMC is exploring for magmatic Fe-Ti-V deposits in the general area of the recent nickel discoveries in the Musgrave Complex.

The Gabanintha-Yarrabubba vanadium project (45 km southeast of Meekatharra) is currently being evaluated by Greater Pacific Gold. Drilling has outlined inferred resources, in the Gabanintha-Yarrabubba and Flood Plain portions of the project area, of 62.4 Mt grading 1.13% V_2O_5. An additional inferred resource of 31 Mt grading 0.59% V_2O_5 has been estimated for the hanging-wall zone. The company is investigating the possibility of developing a mine and processing plant with capacity to produce 5200 t V_2O_5 per year.

The Youanmi vanadium project (120 km east-southeast of Mount Magnet, WA) was acquired by Centaur Mining and Exploration in mid-2000 following its takeover of Australian Gold Resources (AGR). An inferred resource of 136 Mt averaging 0.42% V_2O_5 has been estimated by AGR and preliminary metallurgical testwork shows moderate to high recoveries of vanadium from bulk samples of oxidised and primary ore.

At the Buddadoo prospect (150 km east of Geraldton, WA), exploration has confirmed the presence of a vanadium-rich titanomagnetite horizon over a strike length of 3.5 km within a layered gabbroic intrusion. Exploration of this prospect is continuing.

During the year, WMC explored for magmatic Fe-Ti-V deposits in Mesoproterozoic layered mafic-ultramafic intrusions in the Musgrave Complex. This identified ilmenite - magnetite horizons that are up to 35 km long. Reconnaissance drilling along these horizons, at 5–10 km intervals, intersected a number of thick but low-grade zones of mineralisation, reported by WMC as 10-50 m thick, with grades of 5-9% TiO_2 and 0.1-0.5% V_2O_5. Several narrow intervals from 4-14 m (within the broader low-grade layers) yielded intersections averaging 11–11.5% TiO_2. Exploration is continuing in this region.

Production

In 2000, Australia produced 2763 t V_2O_5, all of this being from the Windimurra mine in its first full year of production.

Industry developments

At full production, it is anticipated that Windimurra will produce 15.8 million pounds (7200 t) of V_2O_5 per year, which would be approximately 12% of world production.

TABLE 5.

Reserves and resources for Windimurra as at 31 December 2000, cut off grade 0.4% V_2O_5 (Xstrata AG, Annual Report 2000)

	Mt	Grade (% V_2O_5)	Contained V_2O_5
Proven reserves	36.7	0.54	198 180
Measured resources *	67.9	0.48	325 920
Indicated resources	30.0	0.48	144 000

* Includes those resources modified to produce ore reserves

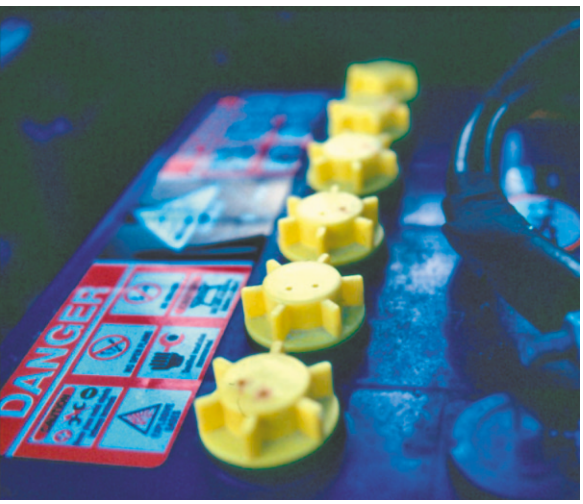
In October 2000, Precious Metals Australia sold its 40% share in the Windimurra operation to Xstrata AG, which is a subsidiary of Glencore International AG, the world's largest vanadium producer.

Renewable Energy Corporation continued investigations into the feasibility of developing the Balla Balla vanadium project (100 km southwest of Port Hedland). It is proposed to mine approximately 1.2 Mt annually by open cut methods. Beneficiation by crushing, grinding and magnetic separation would produce approximately 700 kt of vanadiferous magnetite concentrate for further metallurgical processing. The proposed metallurgical processing would produce V_2O_5 concentrates which would be converted to high-quality ferrovanadium. A comprehensive program of metallurgical test work continued during the year and the company announced the signing of a long-term sales agreement, with a subsidiary of Thyssen Krupp AG, for approximately 75% of the proposed output from the project over an initial period of 5 years.

The deposit is close to existing infrastructure including a power supply and natural gas pipeline. A Notice of Intent (similar to an environmental impact statement) was submitted to the Department of Minerals and Energy (WA) in 1999.

The Don Well vanadium project (16 km northwest of Whim Creek) adjoins the Balla Balla project leases. Dominion Mining reported inferred resources for the Don Well deposit of 40.8 Mt averaging 0.57% V_2O_5 at a cut off grade of 0.3% V_2O_5. Dominion Mining sold the Don Well project in early 2000 to Ashbridge Holdings Pty Ltd.

Fimiston Mining continued metallurgical investigations into the feasibility of recovering vanadium from the Julia Creek oil shale deposits (15 km east of the Julia Creek township). Vanadium occurs in the marine oil shale sediments of the Cretaceous Toolebuc Formation, which outcrops over hundreds of square kilometres in the Julia Creek region.



ZINC, LEAD, SILVER

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

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

The relative scarcity, attractive appearance and malleability of silver has made it suitable for use in jewellery, ornaments and silverware since before ancient Roman times. Its extensive use in coins throughout history has declined over the last forty years. In Australia, the 1966 fifty-cent piece was the last coin in general use to contain silver (80% silver, 20% copper). Silver is mined and produced mainly as a co-product of copper, lead, zinc, and to a lesser extent, gold. Today, photographic paper and film, followed by the electronics and jewellery/tableware industries are the most important users of silver. Demand for silver as an anti-bacterial agent is likely to double over the next few years as its use increases in water treatment (as an ioniser with copper in domestic swimming pools) and for biocide and bacteriostatic activity in plastic and textiles formulations.

Resources

Australia's total identified resources of zinc (79.7 Mt) and lead (50 Mt) decreased by 2% with silver staying steady at (85.4 kt) in 2000. In the same period, EDR of zinc (32.8 Mt), lead (14.6 Mt) and silver (32 kt) remained unchanged as a result of production and reassessment of resources at major mines. Just over 30% of EDR for zinc, 17% for lead and 25% for silver comprise ore reserves as identified by the JORC Code.

Queensland continued to dominate EDR for zinc, lead and silver with almost 60%, 50% and 65% of the national totals, respectively. The Northern Territory had the second largest EDR of zinc (8.1 Mt), lead (4.8 Mt) and silver (4.1 Mt). Although, New South Wales retained its position with the third largest EDR for zinc and lead, it fell by 0.1% and 3.8% respectively. South Australia retained its position with the third largest EDR for silver, rising slightly by 0.2% from 3.4 kt to 3.6 kt.

Mt Isa Mines' lead-zinc-silver ore reserves were maintained with slightly reduced grades for lead and silver. Depletion due to production was matched by additions to reserves of 1.8 Mt. The Enterprise Mine (3000 & 3500 orebodies) had an overall increase (net of production) of 2.8 Mt. The Isa Copper (1100 & 1900 orebodies) had an overall increase (net of production) of 1.5 Mt.

Ore reserves at George Fisher were depleted by 0.2 Mt due to production but this was offset by an increase of 0.3 Mt at Hilton. Underground drilling and development at McArthur River resulted in the addition of sufficient resources to replace 1999-2000 production.

Production from the Century open cut commenced in late 1999. The mine became fully operational in March 2000 and was officially opened on 4 April 2000, ten years to the day after its discovery drillhole was completed. At Dugald River, a drilling program was ongoing to obtain metallurgical samples for a pre-feasibility study.

Noranda Pacific completed a feasibility study into the Lady Loretta Zn-Ag-Pb project. Drilling resulted in a 60% increase in resources with estimates reported as measured 9.1 Mt at 16.7% Zn, 6.2% Pb and 99 g/t Ag; indicated 4.0 Mt at 8.0% Zn, 5.4% Pb and 94 g/t Ag and inferred 0.5 Mt at 15.6% Zn, 5.1% Pb and 91 g/t Ag. Noranda subsequently exercised its option to purchase a 75% share in the project.

At Elura, continuation of the review of mining strategy at depth resulted in a decrease to the overall mineral resource of 3.6 Mt. Proved ore reserves, however, remained unchanged at of 12.1 Mt (8.2% Zn, 4.9% Pb and 48 g/t Ag).

Broken Hill measured and indicated resources (including reserves) were 18.6 Mt (down 30%) with an additional 1.6 Mt of inferred resource. Mine production reported in 2000 was 2.8 Mt. Identified resources in areas considered inaccessible or unlikely to be accessed by future development were also excluded from this year's reported resources. Production from the Potosi open cut ceased in January 2000.

At Rosebery, delineation of new resources during 1999 was not sufficient to offset resources depleted by mining. Exploration recommenced in March 2000 with the focus on defining additional resources in known leases and locating potential repetitions in mineralised lenses along strike.

The Hellyer lead-zinc underground mine closed on 30 June 2000 after production at a rate of about 1.3 Mtpa over the past decade. Western Metals plans to retreat the substantial resource remaining within the tailings dam at Hellyer. The plant is on care- and-maintenance pending a decision to proceed with the retreatment program.

Remaining reserves at Pillara increased from 10.4 Mt at 7.3%Zn and 2.5% Pb in 1999 to 12.9 Mt at 7.8% Zn and 2.7% Pb. Drilling at Fossil Downs (20km north of Pillara), continues to provide encouraging results with a significant number of high grade intersections confirming the existence of a strongly mineralised system.

Exploration

In 2000, Australia's base metals (including copper, nickel, cobalt) exploration expenditure was $135.3 million, down 14% compared to 1999. Exploration expenditure for silver, lead and zinc was $55.8 million, which represents over 40% of total base metal exploration expenditure. Exploration continued to focus on Broken Hill style and Mount Isa province Zn-Pb-Ag deposits. There is also some renewed interest in volcanogenic massive sulphide (VMS) deposits, with increased exploration in the Yilgarn (WA) and the Lachlan Fold Belt (NSW).

Deep drilling beneath the Gossan Hill and Scuddles mines (WA) continues to intersect new mineralisation. Drilling has also intersected significant zinc mineralisation at Amity and Catalpa in a prospective zone between the Scuddles and Gossan Hill mines.

Anomalous zinc values have been reported at the Centennial project (5–10 km northwest of Broken Hill). Encouraging lead, silver and copper values were also reported.

Compass Resources announced a new resource (measured, indicated and inferred) at the Browns-Browns East project (Batchelor, NT) totalling 69.3 Mt at 2.59% Pb and 10 g/t Ag.

Sipa Resources International announced that Outokumpu Zinc Australia would undertake a $3.9 million two-stage bankable feasibility study into development of the Sulphur Springs VMS Zn-Cu deposit in Western Australia's Pilbara district.

Kagara Zinc reported an open pit and underground mineable resource of 2.4 Mt at 6.79% Zn at its Mt Garnet project (105km southwest of Cairns, Qld). Kagara also purchased the Balcooma base metal deposits and is doing a feasibility study on a combined Mount Garnet-Balcooma project.

Production

Mine production in 2000 for zinc, lead and silver was 1.42 Mt, 0.7 Mt and 2.06 kt respectively. Production was mainly from mines at Cannington, Century, George Fisher, Hilton and Mount Isa in Queensland; McArthur River in the Northern Territory; Broken Hill and Elura in New South Wales; Rosebery in Tasmania; and Scuddles, Gossan Hill and the Lennard Shelf deposits in Western Australia. Australia's gold mines are significant contributors to silver production.

World Resources and Production

Australia has the world's largest EDR of lead (23%) and zinc (18%). It has the fourth largest EDR of silver (11%) after Mexico, Canada and the USA. As a producer, Australia ranks first in the world for lead, second for zinc (after China) and fourth for silver after Mexico, United States of America and Peru.

Industry Developments

MIM is conducting a scoping study into bulk mining of the McArthur River lead-zinc mine as a possible option instead of the selective room-and-pillar method currently employed on the main Number Two orebody. Bulk mining could increase the mine's life significantly and potentially increase metal production. It could also reduce mining costs appreciably and increase reserves to more than 46 Mt.

Advanced mineral recovery technology (IsaMill and Jameson Cell), developed and now marketed by MIM Holdings, is set to provide extra revenue from its new George Fisher lead-zinc operation over the life of the mine. Ore mined at George Fisher is trucked 20 km to be processed in the Mt Isa.

MINERAL INDUSTRY PERFORMANCE AND OUTLOOK

According to quarterly preliminary figures, released by ABARE (March 2001), the minerals industry contributed $51.8 billion to Australia's export earnings in 2000, making it the nation's largest export earner.

Production of many mineral commodities reached record levels in 1999–00 and overall mine production is projected by ABARE to rise by around 8% in the five years to 2005-06. Growth in mine output over this period is expected for nickel (55%), copper (7%), zinc (9%), bauxite and alumina (6% and 9% respectively) and iron ore (15%). These increases in production reflect increasing output from new operations and expansion in capacity at others, referred to in the preceding commodity assessments. In summary they include:

- incremental expansions at existing nickel sulphide mines and expansions in output from the mine-to-metal laterite operations in Western Australia;
- further expected expansion at Olympic Dam for copper and the Century mine moving toward full production for zinc;
- expansions at alumina refineries in the Darling Range (WA) that began in the past year or so; and
- iron ore contributions expected from BHP's Orebody 18 and Mining Area C, and Robe River's West Angelas deposit.

Production and exports of selected mineral commodities for 1999–00 are presented in Table 6. Australia's total minerals and energy export earnings in 2000–2001 are forecast to increase by over 23% to $54.9 billion (Waring et al., 2001). After rising to $31.4 billion in 2001–02, ABARE's projection for metals and other minerals is for an easing to $27.5 billion in real terms (2000–01 dollars) by 2005–06.

New capital expenditure on mining (in real terms) fell by over 41% in 1999–00 to $5.3 billion. ABS data indicate that capital expenditure on mining in 2000–01 may be around $5.3 billion (in nominal terms), which would indicate a flattening out in the decline. This decrease in investment spending reflects the completion of a number of large projects over the last 12–18 months. Many of these projects were commissioned in 2000 (refer commodity assessments) and will add significantly to Australian mineral production (as forecast by ABARE) over the next five years.

The high level of investment activity in the minerals industry since the early 1990s, is expected to continue to fall off in coming years, according to analysis by ABARE and ABS. In 2000, the rate of major mineral and energy project completions was about half that of 1999, when a record 35 projects (valued at almost $11 billion) were commissioned. Around nine projects are scheduled for completion in 2001.

At the close of the 20th century, the enormous nation-wide benefits that have accrued from mining were recognised in a feature paper prepared by Geoscience Australia for ABS, entitled The Australian *mining industry: from settlement to 2000.* Australia's Mining History

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

TABLE 6

Australian production and exports of selected mineral products 1999-00

Commodity	Production	Exports	Export value $ million
Aluminium			
Bauxite (Mt)	50.033		166
Alumina (Mt)	14.976	11.655	3,471
Aluminium (Mt)	1.744	1.364	3,302
Coal			
Black raw (Mt)	294.67		
Black saleable (Mt)	237.39	175.78	8,298
Brown	66.00		
Copper			
Ores and concentrates (kt)	2,340	938	768
Refined primary (kt)	478	306	840
Diamond (kc)	29,673	37,289	639
Gold			
Mine production (t)	298.55		
Refined (t) (a)	382.97	329.83	4,803
Iron & Steel			
Ore & Pellets (Mt)	156.440	149.436	3,817
Iron and steel (Mt) (b)	14.248	3.694	1,422
Lead			
Ores and concentrates (kt)	988	437	241
Refined (kt)	234	258	188
Bullion (kt)	165	135	164
Manganese			
Ores and concentrates (kt)	1,755	1,301	185
Mineral sands			
Ilmenite concentrates (kt)	2,163	1,133	151
Rutile concentrates (kt)	221	171	127
Synthetic rutile (kt)	569	380	229
Titanium dioxide pigment (kt)	164	135	404
Zircon concentrates (kt)	354	374	180
Nickel			
Concentrate (kt)	774		
Refined (kt)	199(c)	177	1862(d)
Uranium (t U_3O_8)	8,223	8,025	367
Zinc			
Ores and concentrates (kt)	2,343	1,497	682
Refined (kt)	404	317	550

t = tonnes; kt = 10^3t; Mt = 10^6t; kc = 10^3 carats

Source: *Australian Mineral Statistics, ABARE, December quarter 2000*
Australian Commodity Statistics, ABARE, December 2000

(a) Includes primary and secondary gold of Australian and overseas origin
(b) Includes recovery from scrap
(c) Sum of products in the Intermediate nickel, <99% Ni and >99% Ni categories
(d) Sum of all nickel product export values

MINERAL EXPLORATION IN AUSTRALIA

EXPLORATION

Exploration

Mineral exploration expenditure for a range of commodities is collected quarterly by ABS. The following discussion is based on the survey data for 1999–2000 (year ended 30 June 2000) and the first two quarters for 2000–01. Differentiation of commodity groups prior to 1980 is based largely on a breakdown of ABS totals by Geoscience Australia.

In line with a world-wide trend to reduced exploration spending and continuing the downward trend commenced in 1997–98, exploration expenditure fell in 1999–2000 by 19% to $676.3 million. This was only $45 million higher than the low point registered in the last cyclical downturn in 1992-93.

Spending for calendar year 2000, based on the sum of ABS four quarter figures, was down by $42.9 million to $676.4 million — essentially the same as for 1999–2000.

Gold remained the principal commodity sought and accounted for 55.4% of all exploration spending in 1999–2000. Although gold remained dominant, exploration expenditure on the search for it fell by $111.3 million to $374.8 million (Figure 6), a fall which accounted for just over two-thirds the total expenditure lost in the year. Mineral sands was the only commodity group to have an increase in its spending in 1999–2000 with growth of $2.5 million (Table 7). Major reductions in spending occurred for gold (-22.9%), base metals (-11.4%), diamond (-27.1%) and iron ore (-28.4%). Despite these falls, both base metals and coal increased their share of national spending to 23.2% and 5.2% respectively. Gold and base metals combined accounted for almost 79% of total exploration spending.

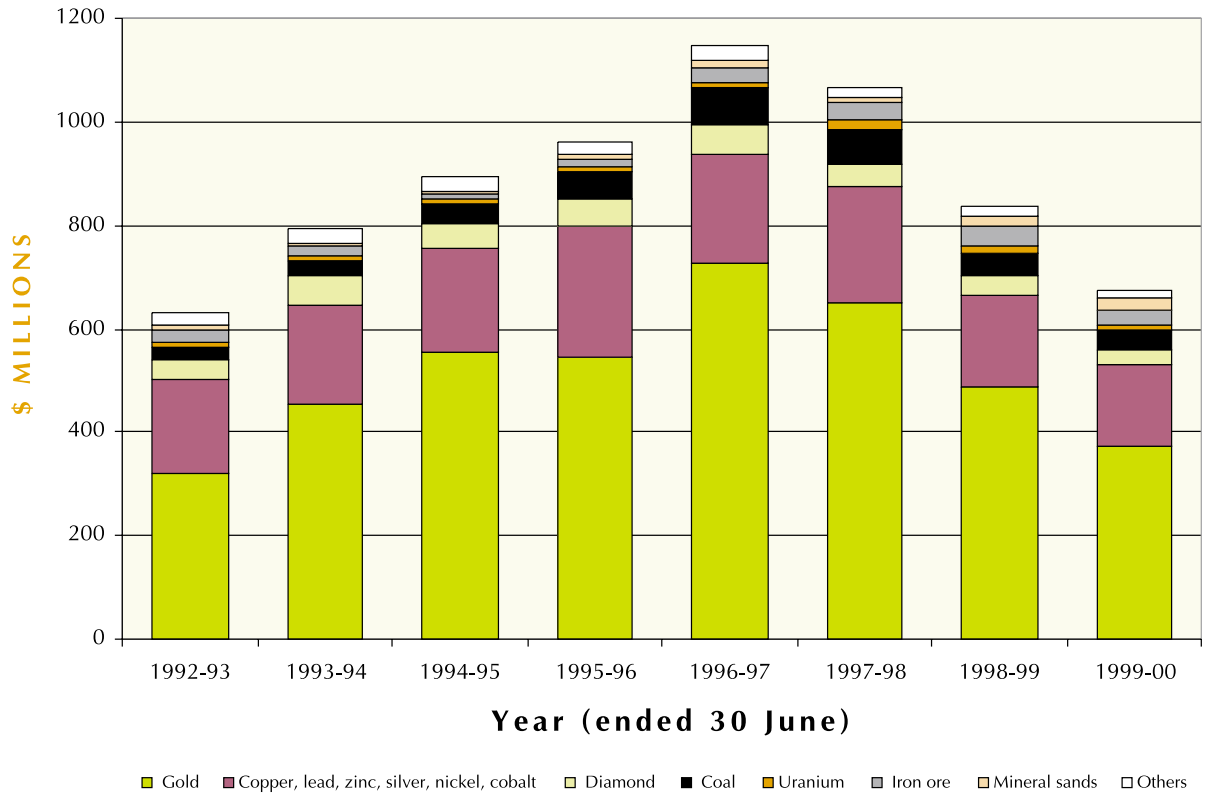


FIGURE 6.
Australian mineral exploration expenditure since 1992–93 (Source: ABS)

ABS has published, for the first time, a breakdown of components of the base metal exploration expenditure. In 1999–2000 base metal expenditure of $156.8 million was composed of $28.4 million directed to copper, $55.4 million for silver-lead-zinc and $73.0 million for nickel-cobalt exploration.

TABLE 7.

Australian mineral exploration expenditure by commodity, 1998–99 & 1999–00

Commodity	Exploration Spending ($ million)		Change ($ million)	Proportion of Australian Total Exploration Spending ($ million)		Change % points
	1998-1999	1999-2000		1998-1999	1999-2000	
Gold	486.1	374.8	-111.3	58.0	55.4	-2.6
Base Metals	176.9	156.8	-20.1	21.1	23.2	2.1
Diamond	40.9	29.8	-11.1	4.9	4.4	-0.5
Coal	39.9	35.4	-4.5	4.8	5.2	0.4
Iron Ore	41.5	29.7	-11.8	5.0	4.4	-0.6
Mineral Sands	19.0	21.5	2.5	2.3	3.2	0.9
Uranium	15.4	11.7	-3.7	1.8	1.7	-0.1
Others	18.1	16.7	-1.4	2.2	2.5	0.3

Exploration spending fell in all States and the Northern Territory in 1999–2000 (Figure 7). Western Australia was the principal destination for exploration with $415.0 million spent, 61.4% of total Australian spending and just over five times higher than in Queensland, the State with the second highest expenditure. Queensland attracted $82.6 million (12.2% of total Australian spending), which was $11.2 million lower than in 1998–99. The Northern Territory surpassed New South Wales to have the third largest expenditure with $57.5 million (8.5% of the total), $7 million lower than 1998–99. Spending in New South Wales fell by $9.5 million to $56.1 million, which was 8.3% of national expenditure. In Victoria, spending fell by $3.2 million to $33.8 million, 5% of the Australian total. South Australian spending almost halved, falling by $19.3 million to $22.6 million with its share of national spending falling to 3.3%. Tasmania had $8.8 million spent on exploration compared to $11.9 million in the previous year and had 1.3% of Australian spending.

Although Western Australia remained the principal target for exploration spending, it suffered a substantial reduction in the amount spent (Table 8) and its share on national spending fell slightly. Although the amount spent fell in all jurisdictions, four saw their share of national spending increase marginally: — Queensland by 1 percentage point to 12.2%, New South Wales by 0.5 percentage points to 8.3%, Victoria by 0.6 percentage points to 5.0% and the Northern Territory by 0.8 percentage points to 8.5%.

The depth of the current exploration recession is well illustrated in constant 1999–2000 dollar terms with 1999–2000 spending the lowest since 1978–79 (Figure 8). This graph also shows changes in the patterns of expenditure with gold increasing from the late 1970s at the expense of other commodities, in particular base metals.

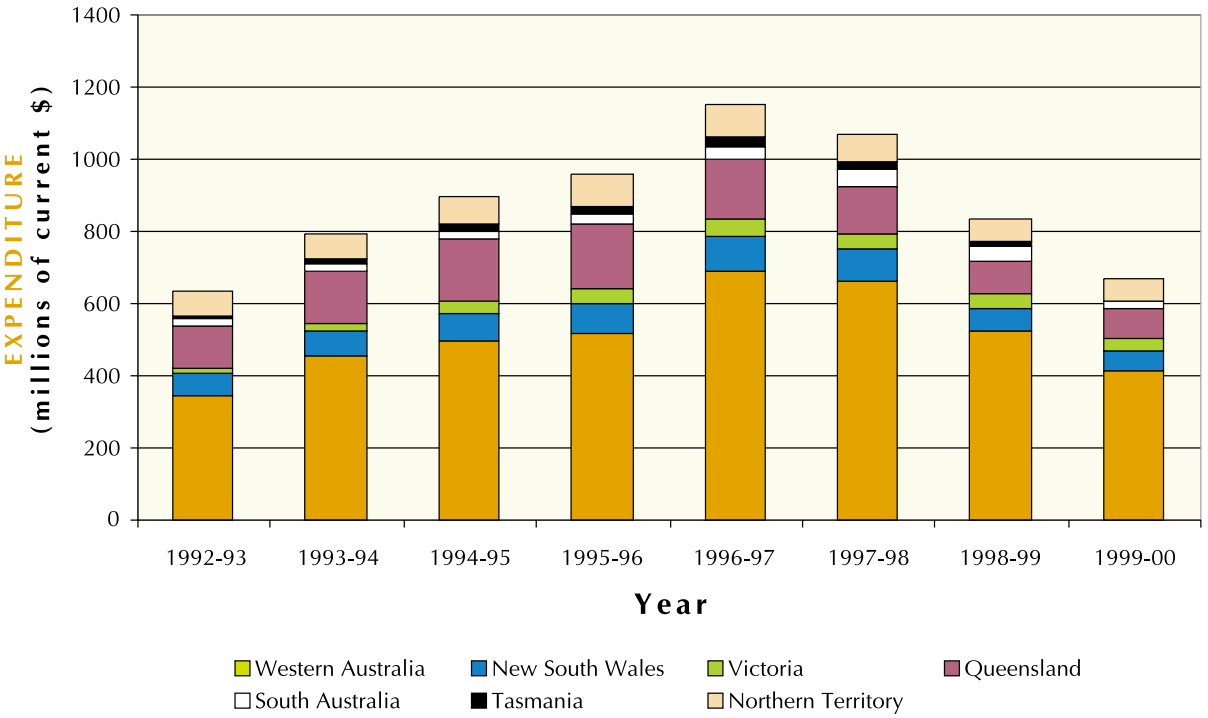


FIGURE 7.
Mineral exploration expenditure in States/NT, 1999–2000

TABLE 8.
Mineral exploration expenditure by State/NT, 1998–99 & 1999–00

State	Exploration Spending ($ million)		Change ($ million)	Proportion of Australian Total Exploration Spending ($ million)		Change % points
	1998-1999	1999-2000		1998-1999	1999-2000	
Western Australia	523.1	415.0	-108.1	62.5	61.4	-1.1
Queensland	93.8	82.6	-11.2	11.2	12.2	1.0
Northern Territory	64.5	57.5	-7.0	7.7	8.5	0.8
New South Wales	65.6	56.1	-9.5	7.8	8.3	0.5
Victoria	37.0	33.8	-3.2	4.4	5.0	0.6
South Australia	41.9	22.6	-19.3	5.0	3.3	-1.7
Tasmania	11.9	8.8	-3.1	1.4	1.3	-0.1

ABS exploration expenditure figures for the September and December quarters 2000 were unchanged, at $357 million, compared to the equivalent period in 1999. Expenditure in the second half of calendar year 2000 was $37.6 million higher than in the first half. In Western Australia, spending rose by $5.7 million compared to the last half of 1999 but this was largely offset by a fall of $4.5 million in the Northern Territory. Variations of less than $1 million occurred in the other States. Actual expenditures for the six month period are as shown with the figures for the corresponding half year of 1999 in brackets: — New South Wales $29.4 million ($29.4 million), Victoria $15.9 million ($16.3 million), Queensland $43.2 million ($42.3 million), South Australia $12.3 million ($13.2 million), Western Australia ($222.4 million ($216.7 million), Tasmania $4.3 million ($5.0 million) and the Northern Territory $29.5 million ($34.0 million).

Since 1981–82 there has been a general trend for the proportion of total exploration spending to increase on Production Leases[3], with a consequent reduction in the proportion spent in all other areas (Figure 9). Although the proportion has been stable over the last three years, the long term trend shows a concerted move away from the higher risk greenfields exploration. In current dollar terms, the 1999–2000 "Other areas" expenditure was the lowest since 1992–93.

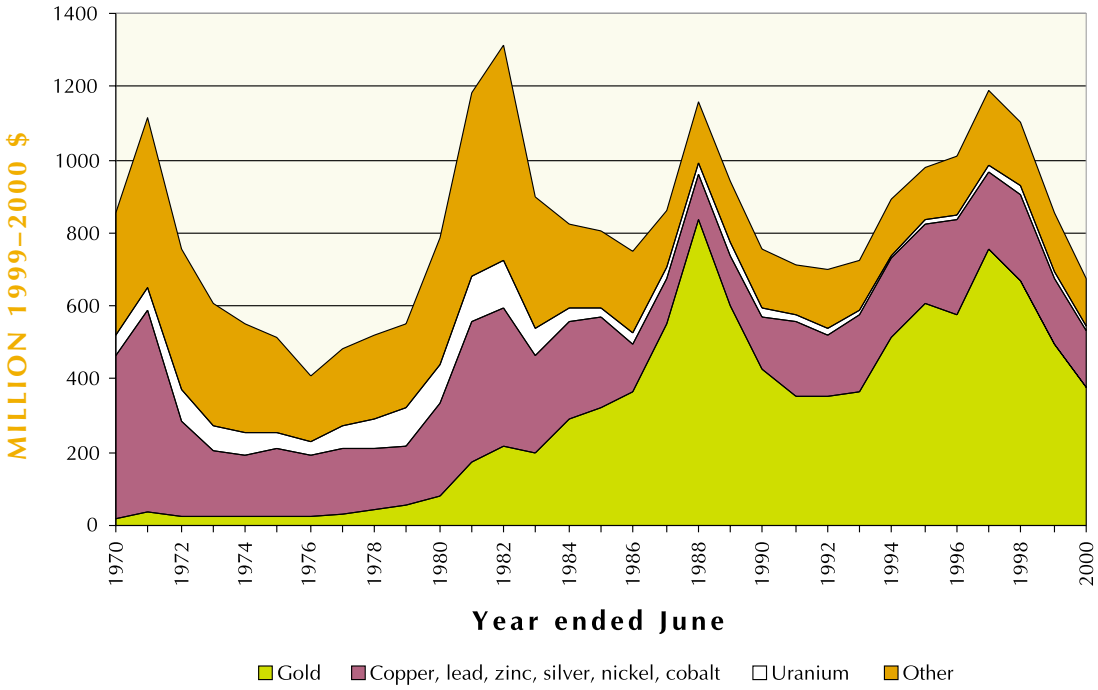


FIGURE 8.
Australian mineral exploration expenditure since 1969–70 (1999-00 $s)

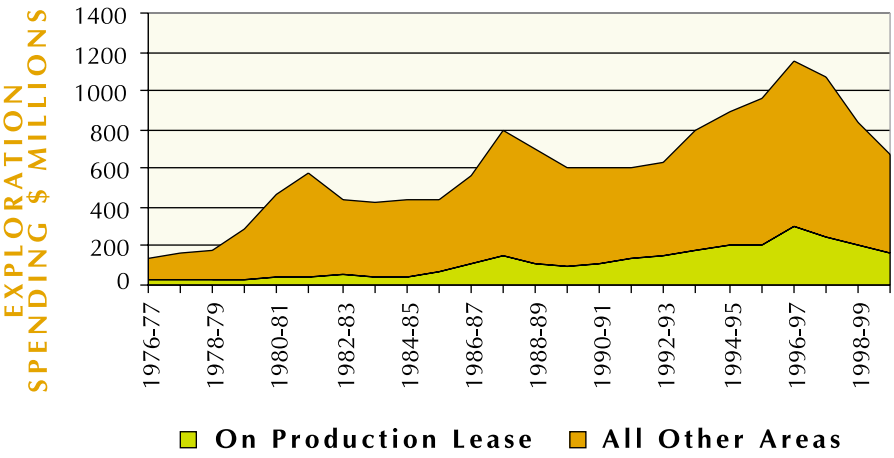


FIGURE 9.
Exploration expenditure on production leases compared to other areas

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

EXPLORATION DRILLING

Exploration Drilling

Geoscience Australia commissioned ABS to undertake a survey of exploration and mining companies to ascertain the amount and type of mineral exploration drilling done in Australia in 1999–2000. The survey was commissioned on behalf of some of the members of the Chief Government Geologists Conference to enable a comparison of expenditure and amount of drilling done throughout Australia for 1999–2000. A summary of the survey results was released by ABS on 20 December 2000 in the ABS publication 8412.0.

Australian spending on exploration drilling in 1999-2000 was $256.6 million, a reduction of $56.4 million (18%) compared to 1998–99. Of total exploration expenditure, 37.9% was directed to drilling which was a slight increase on the previous years 37.4%. There was a wide range in the proportion of exploration spending that went on drilling in the States and Northern Territory (Figure 10). The State-based break down of exploration expenditure, Table 9, shows that in New South Wales just over half was directed to drilling while the Northern Territory had the lowest proportion with 15%.

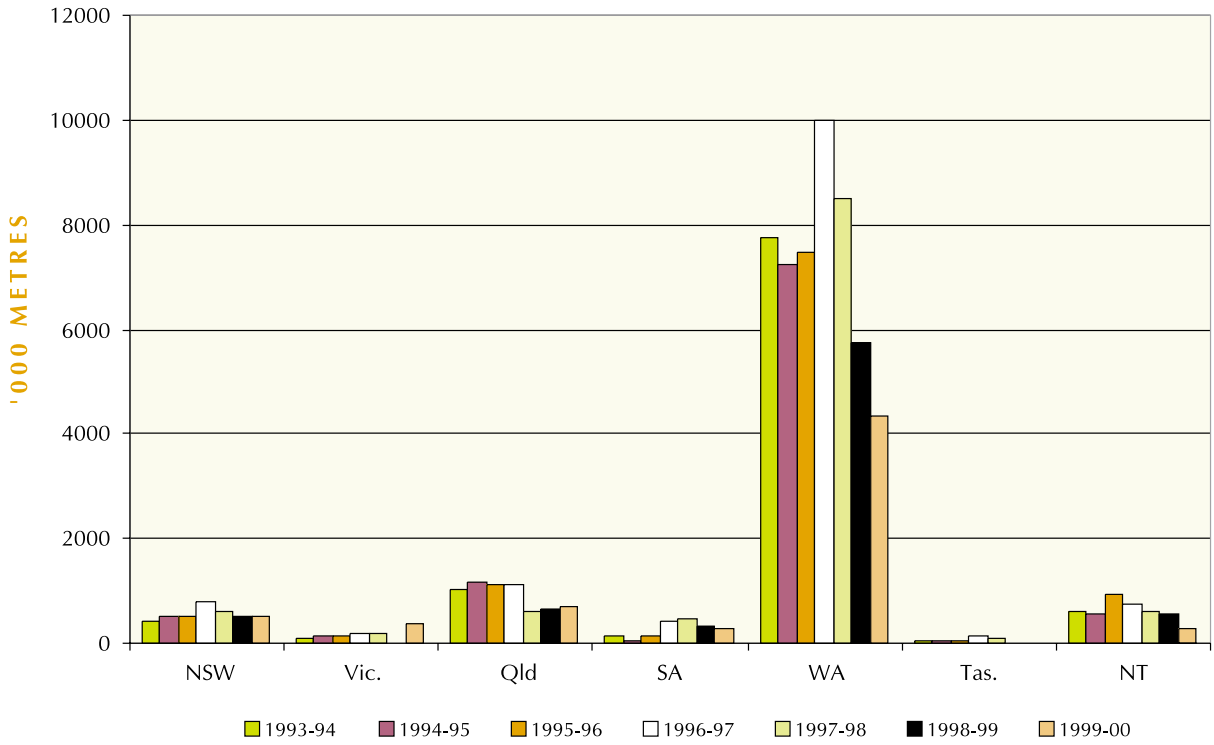


FIGURE 10.
Exploration metres drilled in each State/NT from 1993–94 to 1999–00

In 1999-2000, almost 6.5 million metres of exploration drilling was completed in Australia, a reduction of just under 20% over the previous year. Of the total metres drilled, 28% was in Production Areas (Table 10) slightly lower than in 1998–99. Western Australia was again the leading State with 4.3 million metres drilled, which was almost 67% of the total (Figure 11). Although Western Australia was dominant, its share fell again from 71% in 1998–99 and 77% in 1997–98. In terms of actual spending on drilling, Western Australia accounted for $164.0 million, 64% of Australian expenditure which was five percentage points lower than in the previous year. Queensland had the second highest proportion with 13.4%, followed by New South Wales 11.0%, Victoria 4.6%, Northern Territory 3.4%, South Australia 2.4% and Tasmania 1.3%.

TABLE 9.

Mineral exploration expenditure and exploration drilling, 1999–00

State	Total exploration expenditure ($ million)	Exploration Drilling	
		$ million(a)	'000 metres(a)
New South Wales	56.1	28.327	512.5
Victoria	33.8	11.743	350.5
Queensland	82.6	34.417	706.4
South Australia	22.6	6.100	273.3
Western Australia	415	164.021	4330.6
Tasmania	8.8	3.340	21.4
Northern Territory	57.5	8.633	294.3
Australia	676.4	256.581	6489.0

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

(a) Statistics collected by Australian Bureau of Statistics for Geoscience Australia, on behalf of some members of the Conference of Chief Government Geologists.

TABLE 10.

Exploration drilling in Australia by method and type of area drilled, 1999–00

Drilling Method	Production Areas			Other Areas		
	'000 metres	'000 $	Average $/m	'000 metres	'000 $	Average $/m
Diamond	501.1	43,303	86.42	559.9	60,164	107.45
Reverse Circulation	698.7	29,030	41.55	1,533.2	54,954	35.84
Percussion	70.9	3,040	42.88	68.5	2,262	33.02
Rotary Air Blast (RAB)	341.7	7,036	20.59	1,217.9	17,870	14.67
Air Core/Vacuum	165.7	5,986	36.13	1,208.7	24,397	20.18
Other	11.1	772	69.55	111.6	7,767	69.60
Total	1,789.2	89,167	49.84	4,699.8	167,414	35.62

Drilling Method	Total (production and others)		
	'000 metres	'000 $	Average $/m
Diamond	1,061.0	103,467	97.52
Reverse Circulation	2,231.8	83,984	37.63
Percussion	139.4	5,302	38.03
Rotary Air Blast (RAB)	1,559.6	24,906	15.97
Air Core/Vacuum	1,374.4	30,383	22.11
Other	122.8	8,539	69.54
Total	6,489.0	256,581	39.54

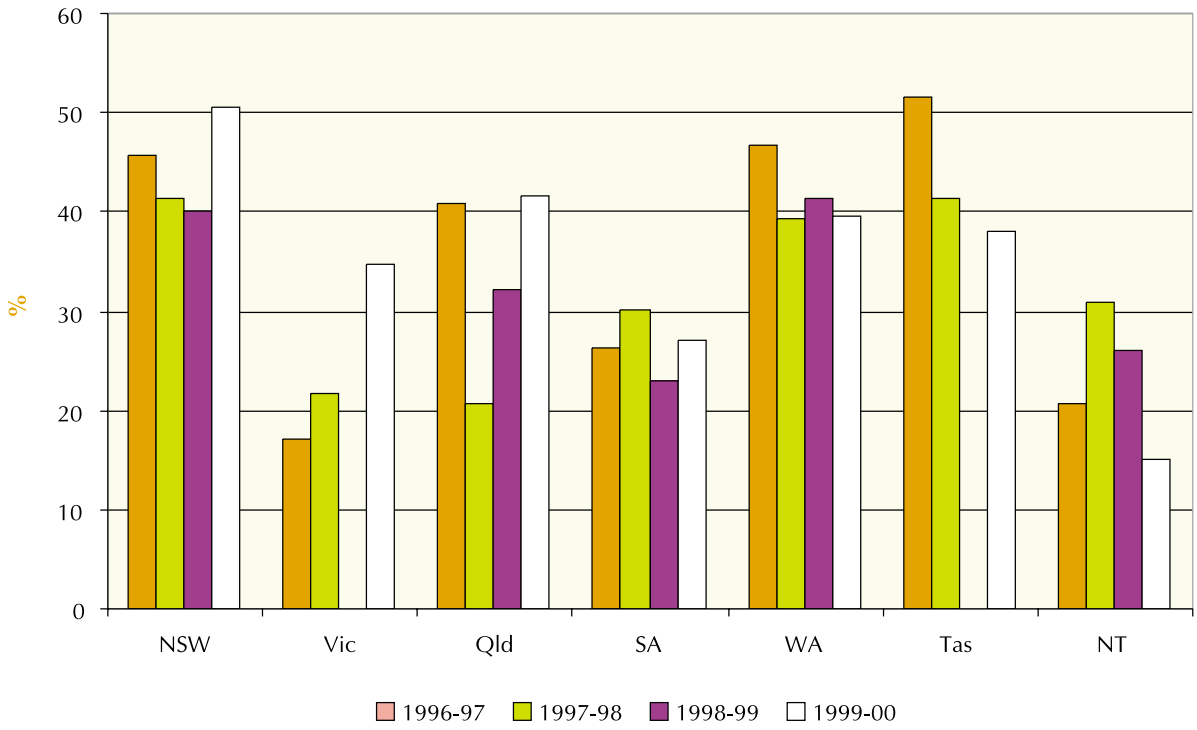


FIGURE 11.
Proportion of Australian mineral exploration expenditure spent on drilling in each State/NT, 1996–97 to 1999–00

Drilling in greenfield areas fell again in 1999–2000 with 4.7 million metres drilled, a reduction of 17% over the previous year. This was about 72% of all exploration drilling and was slightly higher that the 70% achieved in 1998-99. The total cost of greenfield drilling in 1999–2000 was $167.4 million.

The average cost of all drilling undertaken in 1999–2000 rose by almost 3% to $39.54/metre (Table 10). The increase was due to the increased average cost for all categories of drilling except diamond and reverse circulation (RC) drilling which fell by $9.45 and $1.46/metre respectively. These falls were not sufficient to offset reductions in the average cost of all other categories of drilling.

GOVERNMENT PROGRAMS ASSISTING EXPLORATION

Geoscience Australia and the geological surveys of Queensland, New South Wales, Victoria, Tasmania, South Australia, Western Australia and the Northern Territory, have programs that provide geoscientific information and datasets in both proven and greenfield mineral provinces. These activities are enhanced by cooperation in strategically important areas under the National Geoscience Agreement (NGA). Current NGA projects are located in the Yilgarn province, Western Australia, the Carpentaria-Mount Isa belt, Queensland and Northern Territory, the southern Northern Territory, the Gawler Craton, South Australia and the Broken Hill-Olary province, New South Wales and South Australia.

Examples of States and Northern Territory programs include: — Northwest Queensland Minerals Province comprehensive geoscientific data package, part of Queensland's $8 million Prospectivity Plus Package; Exploration New South Wales: Mining Beyond 2000, a $30 million initiative for accelerated geological and geophysical investigations: South Australia's, $10 million Targeted Exploration Initiative South Australia; the Northern Territory Exploration Initiative, a $16 million geoscientific program. In Tasmania, $4.1 million will spent by mid-2002 on a Commonwealth-funded geophysical, geological and database development initiative. Initiatives in Western Australia generated mineral occurrence maps and digital datasets for several regions and, for the Kalgoorlie region, a seamless database covering 38 1:100 000 geological maps has been compiled. Details of State/Northern Territory programs can be found on their web sites.

The Commonwealth and States/Northern Territory have committed to the establishment of a geoscience web portal to improve access to Australian geoscience data and information. Scheduled to be operational in 2001, it will initially provide information and links to the various geological surveys as well as acting as a facility for promulgating nationally agreed standards for the management of geoscience data. Online access to national geoscience datasets and databases is currently available via Geoscience Australia's website www.agso.gov.au.

Three Cooperative Research Centres (CRC) focusing on mineral exploration technologies, a predictive environment for mineral discovery and coal research are to receive Commonwealth Government funding totalling $52.6 million. The two non-coal CRCs are: — Landscape Environments and Mineral Exploration, whose aims include providing research to aid mineral exploration in areas of substantial cover; and Predictive Mineral Discovery, whose aim is the prediction of the location and quality of ore deposits.

OUTLOOK FOR EXPLORATION

ABS mineral exploration figures for the September and December quarters 2000 suggest that the decline in spending has been arrested. However, ABARE cautions that an upturn in exploration spending over one six month period "does not necessarily signal the beginning of a broad based recovery" (Mineral and energy outlook to 2005–06, Outlook 2001 Minerals and Energy, p39). ABARE note that the parlous state of gold prices and the uncertainty surrounding central bank gold sales and loans will not encourage increased gold exploration. For base metals, ABARE considers the outlook for prices to be an important driving force for exploration as will company rationalisations and uncertainty regarding land access. ABARE forecasts gold prices to average US$260/ounce in 2001 and for base metals they suggest that there will be a marginal increase in copper price in 2001, while lead prices will be virtually unchanged and zinc prices will be lower.

The outlook for junior companies has improved with successful listings of more than a dozen new mineral floats on the Australian Stock Exchange during 2000. These companies have concentrated on base metals and nickel with gold, mineral sands and PGMs also of interest. There is renewed interest in greenfields exploration by major companies, particularly as a consequence of the scarcity of advanced projects. Further strategic alliances between junior companies and larger overseas companies are expected to boost exploration.

While exploration is likely to continue to be focussed on the major mineral provinces — Yilgarn, Mount Isa, Lachlan Fold Belt, Broken Hill-Olary — emerging provinces like the Tanami-Arunta and Murray Basin will see increased activity. Main interest is expected to continue to be on gold, nickel, zinc, copper, mineral sands and diamond in both extensions of known provinces under cover and in greenfields areas. High palladium prices should generate continued interest in PGMs. WMC's West Musgrave discovery highlights the potential of Australia's under-explored frontier provinces to host significant mineralisation.

OFFSHORE MINERAL EXPLORATION IN COMMONWEALTH WATERS

The Commonwealth *Offshore Minerals Act 1994* regulates exploration for and mining of minerals, other than petroleum, over the continental shelf three nautical miles beyond the territorial baselines (generally the low water mark) of the States and Territories.

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 $3,000. The application must be made in the approved manner and must specify details such as:

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

The initial term of a 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 a 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 16 May 2001, a total of 65 offshore MEL applications had been received since February 1990. Currently there are two active licences (Table 11). One of the active licences is in the Joseph Bonaparte Gulf in the northwest of Australia. This exploration is directed at discovering economic deposits of alluvial diamonds in offshore palaeochannels and tidal shoals. To date no diamonds have been discovered in Commonwealth waters, however, gem quality diamonds have been discovered adjacent to WA-1-MEL and WA-7-MEL in State waters. In Ringarooma Bay, Tasmania, previous exploration has identified an inferred resource of 23 million cubic metres at a grade of 149g tin metal per cubic metre.

TABLE 11.

Active offshore exploration licences in Commonwealth waters as at 30 December 2000

MEL	Granted	Location	Commodity
WA-1	20-Jul-90	120km north of Wyndham, (Ord Prospect)	Diamond
T-2	30-Mar-98	Ringarooma Bay, Tasmania	Tin

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APPENDIX 1

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 & 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
SDR	Subeconomic demonstrated resources
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

APPENDIX 2

NATIONAL CLASSIFICATION SYSTEM FOR IDENTIFIED MINERAL RESOURCES

Introduction

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

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

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

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

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

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

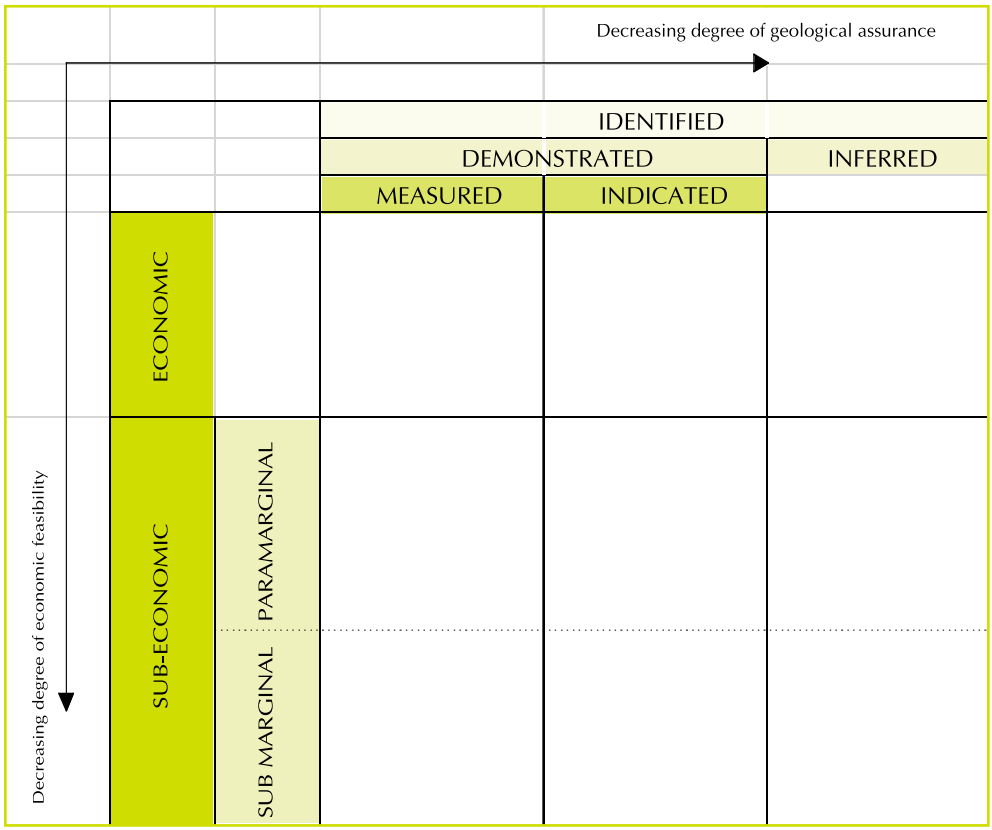
Classification principles

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

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

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

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



Terminology and definitions

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

Categories of resources based on degree of assurance of occurrence

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

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

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

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

INFERRED - Resources for which quantitative estimates are based largely on broad knowledge of the geological character of the deposit and for which there are few, if any, samples or measurements. The estimates are based on an assumed continuity or repetition for which there is geological evidence. This evidence may include comparison with deposits of similar type. Bodies that are completely concealed may be included if there is specific geological evidence of their presence. Estimates of inferred resources should be stated separately and not combined in a single total with measured or indicated resources (see guideline ii).

Categories of resources based on economic considerations

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

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

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

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

Geoscience Australia's guidelines for classifying mineral resources

(i) Use of the term 'resources' is restricted to material, the extraction of which is generally judged to be potentially economically viable in an arbitrary time frame of about 20 to 25 years. The term includes, where appropriate, material such as tailings and slags. The definition does not intend to imply that exploitation of any such material will take place in that time span, but only that its possibility might reasonably be considered. This guideline attempts to establish a lower limit to what is worth assessing. It should be applied on a commodity by commodity basis to take account of prevailing and prospective technologies. Material falling outside the category of resource should be referred to as 'occurrences'. Unless otherwise stated, the classification system refers to in-situ resources. However, it is possible and in fact desirable to also show recoverable quantities of resources in each category.

(ii) By definition, inferred resources are classified as such for want of adequate knowledge and therefore it may not be feasible to differentiate between economic and subeconomic inferred resources. Where inferred resources are shown as 'undifferentiated', the amount known or judged to be economic may be indicated. Such judgements must take careful account of the commodity being assessed and its mode of occurrence as these factors will have a bearing on the reliability of estimates made. Specifically, grade estimates can be more reliably made for concordant sedimentary and biological deposits than for discordant epigenetic deposits (King et al. 1982, p. 8).

(iii) The definition of 'economic' is based on the important assumption that markets exist for the commodity concerned. All deposits which are judged to be exploitable economically at the time of assessment, whether or not exploitation is commercially practical, are included in the economic resources category. It is also assumed that producers or potential producers will receive the 'going market price' for their production. The classification is therefore based on the concept of what is judged to be economic rather than what is considered to be commercial at any particular time.

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

(a) the resources (published or unpublished) of operating enterprises, whether or not such operations are sustained by long- or short-term, direct or indirect, government subsidies;

(b) resources in a deposit which is being developed for production (i.e., where there is a corporate commitment to production);

(c) undeveloped resources which are judged to be economic on the basis of a financial analysis using actual, estimated, or assumed variables - viz., the tax rate, capital and operating costs, discount rate (such as reflects the long-term bond rate), commodity prices, and depreciation schedules; the values for the economic variables used in an assessment must be realistic for the circumstances prevailing at the time of the assessment;

(d) resources at mines on care-and-maintenance meeting the criteria outlines in (c) above.

(iv) The term 'recoverable' is considered to make allowance for mining as well as processing losses. Where a finer distinction needs to be made, *mineable* is used to take account of mining losses and *metallurgically recoverable* (*saleable* for coal) is used to take account of processing losses.

(v) Some minerals derive their economic viability from their co-product or by-product relationships with other minerals. Such relationships and assumptions must be clearly explained in footnotes or in accompanying text.

(vi) National aggregates of resource estimates should be rounded to the appropriate last significant digit, so as not to create false impressions of accuracy.

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King, H.F., McMahon, D.W. and Bujtor, G.J., 1982. A guide to the understanding of ore reserve estimation. Australasian Institute of Mining and Metallurgy, Melbourne, 21 pp.

USBM/USGS, 1980. Principles of a resource/reserve classification for minerals. US Geological Survey Circular 831, 5 pp.

APPENDIX 3

National Projects and Advice

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AIMR 2001: staff, commodity responsibilities and related projects

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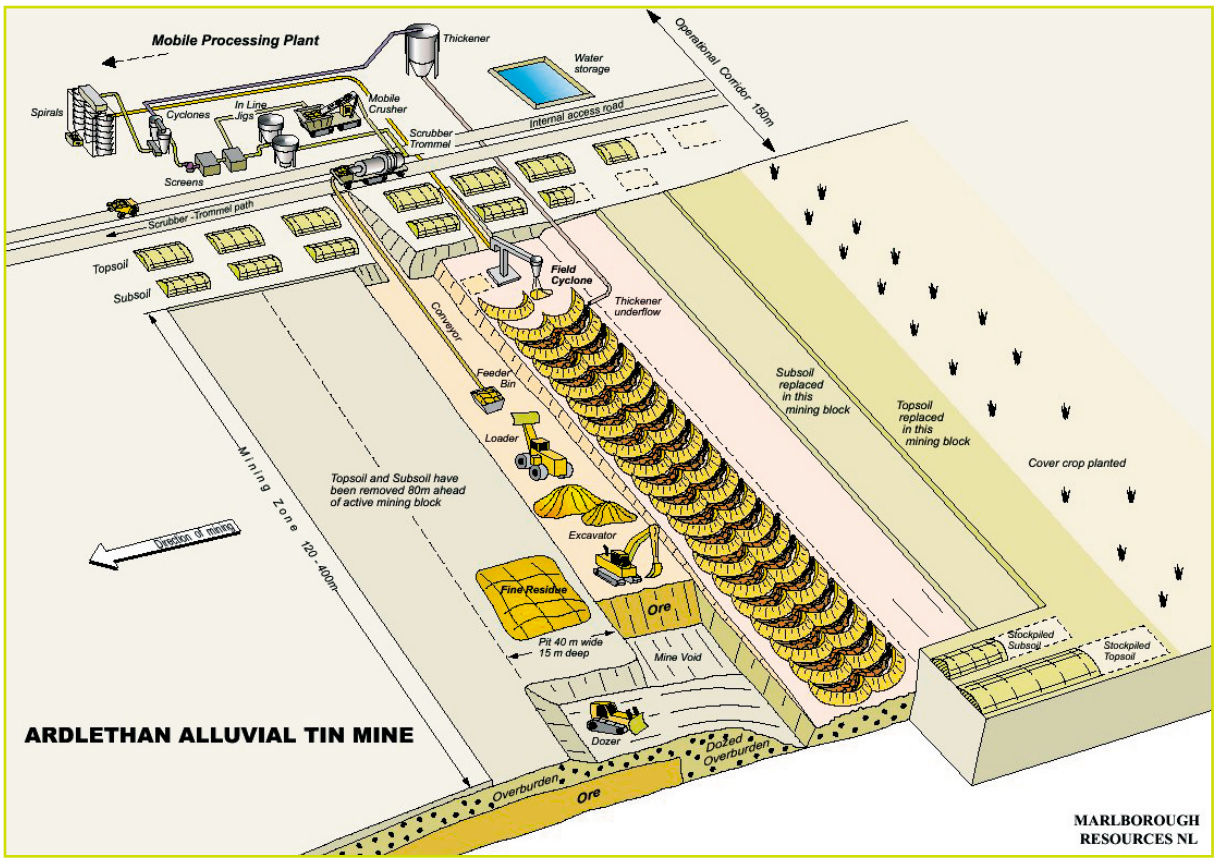

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F/c	Bauxite stockpiles and ship loading facilities, Weipa, Qld	Comalco Ltd
6	Koolyanobbing iron ore open cut (WA) and Australian Stock Exchange	Portman Limited. ASX Operations Pty Ltd. Photos by David Moore and Ray Sharpe; reproduction in whole or part is not permitted without the consent of ASX Operations Pty Ltd.
11	Aluminium ingots for export and a can to be recycled	Australian Aluminium Council
17	Copper tracks on PC circuit board	IMB, Geoscience Australia
18	Diamond abrasive pastes used for high-quality polishing	IMB, Geoscience Australia
20	Gold-plated pins and 'flash' coatings on integrated circuits	IMB, Geoscience Australia
26	Sunscreen/maintenance steel framework and tension cables, AGSO – Geoscience Australia's office, Canberra	IMB, Geoscience Australia
28	Lithium enhances performance and life of batteries	IMB, Geoscience Australia
29	Magnesium alloy car wheel	IMB, Geoscience Australia
31	Woodie Woodie manganese ore open cut (WA)	Consolidated Minerals Ltd
32	Titanium hip joint	Iluka Resources
35	Utensils like stainless steel cutlery have significant nickel content	IMB, Geoscience Australia
37	Phosphate — an important component of fertilisers	IMB, Geoscience Australia
40	Tantalum — used in capacitors and other electronic components	IMB, Geoscience Australia
43	Uranium recovery plant at the Beverley mine (SA). Trunklines carry leach solutions from the plant to the well field and leachates from the well field back to the plant.	Heathgate Resources Pty Ltd
45	Chrome-vanadium tools	IMB, Geoscience Australia
47	Lead plates are widely used in automotive batteries	IMB, Geoscience Australia
47	Silver jewellery	IMB, Geoscience Australia
52	Gravity is a geophysical tool widely used in mineral exploration. Gravity measurements are tied to a common datum, the Australian Fundamental Gravity Network, which is being upgraded by Geoscience Australia to include absolute gravity measurements (portable absolute gravimeter, top right, is being used to take measurements across Australia at sites shown in background image).	Fundamental Gravity Network Project, Geoscience Australia
73	Schematic layout of Marlborough Resources' alluvial tin mining operation at Ardlethan, New South Wales	Marlborough Resources NL


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