
MINERAL INDUSTRY

Geology and Mineral Resources

General geology

Most of the western and central part of the Australian continent consists of basement rocks of Precambrian age. Younger Palaeozoic rocks, mostly of geosynclinal origin, form a discontinuous belt several hundred kilometres wide extending from north Queensland to Tasmania. Mesozoic platform sediments form a broad zone separating the Palaeozoic and Precambrian rocks and extending from the Gulf of Carpentaria to central New South Wales. Cainozoic rocks occur mainly in Victoria, south-western New South Wales and southern South Australia, and as residual basalt cappings over extensive areas of the Palaeozoic and Mesozoic rocks of eastern Australia.

Economic geology

Minerals of economic significance occur throughout Australia, their geological age ranging from Precambrian to Recent. Many of the large deposits such as those at Broken Hill (New South Wales), Mount Isa (Queensland), Olympic Dam (South Australia) and the Kalgoorlie and Pilbara regions of Western Australia and the Alligator Rivers area of the Northern Territory are Precambrian in age. In eastern Australia the major deposits such as the Elura, Cobar, Woodlawn, Hellyer and Rosebery base-metal deposits, the Renison (Tasmania) tin deposit, and most of the gold and black coal deposits, are Palaeozoic in age. The black coals of the Moreton district of Queensland, north-east New South Wales and Leigh Creek, South Australia are of Mesozoic age. Deposits formed in Tertiary times include the brown coal in Victoria, the oil shales of eastern Queensland, the bauxites of Weipa (Queensland), Gove (Northern Territory) and the Darling Range (Western Australia) and the nickeliferous laterites at Greenvale (Queensland).

Mineral resources

Australia is self-sufficient in most minerals of economic importance (and much more than self-sufficient in some). Major minerals with known reserves adequate for domestic demand and exports include bauxite (aluminium), black coal, clays, copper, diamonds, gold, iron ore, lead, manganese, mineral sands (titanium and zirconium), natural gas, nickel, salt, silver, uranium and zinc.

A special article on the development of Australia's mineral industry is included at the end of Chapter 15 of *Year Book* No. 71, pages 592–598. For further details of principal Australian mineral deposits, and notes on principal mineral resources, see *Year Book* No. 61, pages 925–932.

Administration

Mineral rights in Australia are held by the State and Territory Governments and the granting of exploration and development titles is administered by them under the respective

State or Territory legislation. The Commonwealth Government holds rights to minerals in Commonwealth Territories and to certain prescribed substances in the Northern Territory, within the meaning of the Atomic Energy Act (principally uranium). The Commonwealth Government is also able to influence overall development and production activity in the mineral industry by virtue of its constitutional powers with respect to international trade, customs and excise, taxation and foreign investment. Certain specially-formed bodies such as the Joint Coal Board have been given administrative responsibility in defined areas. The Government has also established consultative mechanisms, such as the Australian Coal Marketing and Technology Council, to provide an advisory, rather than administrative, role.

Mineral exploration and development

Onshore

Each State or Territory has its own mining Acts or Ordinances and Regulations governing the prospecting for and working of mineral deposits. These Acts and Regulations, although similar in principle are different in detail. They all make provision for a miner's right to prospect and for small mining leases for mineral production. The principles embodied were established many years ago when mining operations were generally small-scale and labour-intensive. Although amendments have been enacted to modernise the legislation, it is generally inadequate for the large-scale capital-intensive operations often involved with modern mineral development. For this reason, a large enterprise may take the course of acquiring mining titles by negotiations with the appropriate Minister for Mines and having the agreed terms and conditions embodied in an Act of the State Parliament. This method of acquisition has been used in several cases where the leasing company undertook an obligation (such as the erection of a large treatment works) in return for leases over large areas for a long period, and has become more common in recent years (e.g. iron ore in Western Australia, coal and bauxite in Queensland and bauxite in the Northern Territory). Mining legislation enacted in recent years is simpler and more suited to modern conditions.

As a result of the introduction of largescale modern prospecting methods (particularly airborne prospecting), small prospecting areas were found to be unsuitable in some instances, and steps have been taken in the States and Territories to ensure the availability of large areas for prospecting by interested persons. Large areas may be made available by provision within the mining Acts or Ordinances for the issue of authorities to prospect over an area defined by a written agreement which also sets out provisions as to the amount of money to be spent, methods of prospecting, tenure of the agreement, etc.

The tenure of such areas is limited (usually to one or two years) and, if renewed for a further period, is only over an area selected from the larger area (usually 50 per cent) as a result of work done during the life of the initial agreement. It does not give the holder any rights over, or authority to prospect on, land already held under a mining title within the agreed area. Unless specifically stated in an agreement, the discovery of minerals, whether inside or outside an area covered by an authority to prospect, gives the discoverer no legal rights except the right to apply for a mining lease over the area in which the discovery was made. Suitable prospects are converted to mining tenements by making application for lease under the appropriate mining Act.

Offshore

Following the enactment of the *Seas and Submerged Lands Act 1973* the High Court confirmed that the Commonwealth has sovereignty over the territorial sea and sovereign rights over the resources of the whole of Australia's continental shelf. However, in the Offshore Constitutional Settlement between the Commonwealth and the States reached in June 1979, it was agreed that responsibility for mining of the seabed on the landward side of the outer limit of the 3 nautical mile territorial sea should lie with the States, while the Commonwealth should have responsibility for areas beyond.

The *Minerals (Submerged Lands) Act 1981* passed by the Commonwealth Parliament in June 1981 follows the scheme of the offshore petroleum legislation amendments passed in 1980 and provides for joint Commonwealth-State authorities to be responsible for major

matters under the legislation with the States being responsible for day-to-day administration. The legislation came into force on 1 February 1990. Pending enactment of similar legislation by the State's, offshore mining within the outer limit of the territorial sea is administered under the onshore mining legislation of the State's and the Northern Territory.

The mining code under the new legislation provides for a two-stage system of titles: the exploration permit, which covers all forms of exploration, and the production licence, which covers development.

Petroleum exploration and development

Onshore

In Australia, full control of petroleum mining rights is vested with the relevant State or Territory Government. Any organisation or individual proposing to undertake petroleum exploration or development must first satisfy the relevant Government that it has access to the necessary financial and technical resources to undertake the proposed operations.

Three main types of petroleum title are available:

- (i) the exploration title, where the holders are typically given exclusive rights over an area to explore for petroleum by conducting surveys and drilling wells etc;
- (ii) the production title, which is required for commercial production of petroleum and gives the holder the right to produce and sell the petroleum, is granted subject to the payment of a royalty; and
- (iii) retention leases are available in the Northern Territory under the *Petroleum Act 1984* which provide security of tenure over sub-economic discoveries.

Royalty arrangements vary from State to State. Most onshore royalties are determined as a percentage of the well-head value of all petroleum production.

Commonwealth legislation provides for the replacement of all Commonwealth excise on liquefied petroleum gas and crude oil, and State/Territory royalty, with a Resource Rent Royalty (RRR) where the relevant State or Territory Government has negotiated an acceptable agreement with the producers and has agreed upon a revenue sharing formula with the Commonwealth. A RRR applies to the Barrow Island oilfield in Western Australia.

Offshore

As part of the Offshore Constitutional Settlement (OCS) between the Commonwealth and the States, responsibility for administering petroleum exploration and development within the outer boundary of the three nautical mile territorial sea rests with the relevant State or Territory while the Commonwealth has responsibility for the continental shelf beyond the territorial sea. Under the OCS, the States/Northern Territory and the Commonwealth agreed to a common petroleum mining code.

The Commonwealth legislation, the *Petroleum (Submerged Lands) Act 1967* provides for a Joint Authority for the adjacent area (beyond the territorial sea) of each State and the Northern Territory consisting of the relevant Commonwealth and the State/Territory Minister. The Joint Authorities are concerned with major matters arising under the legislation and in the case of disagreement the view of the Commonwealth Minister prevails. Day-to-day administration is the responsibility of the State or Territory Minister as the Designated Authority.

The offshore legislation provides for:

- (i) exploration permits, providing exclusive exploration rights over a specific area;
- (ii) production licences to authorise development and commercial production from discovered fields; and
- (iii) retention leases to allow security of tenure over sub-economic discoveries.

Secondary taxation arrangements vary. In the major production areas of Bass Strait (crude oil/natural gas) and the North West Shelf (natural gas/condensate), a royalty, as well as an excise on crude oil production, is levied on all petroleum production. The Commonwealth shares royalty receipts with the States/Northern Territory under the OCS.

All other offshore projects ('greenfield' projects which had not received a production licence by 1 July 1984) are subject to petroleum Resource Rent Tax, in accordance with legislation introduced by the Commonwealth in 1987.

In order to encourage offshore petroleum exploration, the Commonwealth recently announced a coordinated strategy involving the regular release of exploration acreage, improved collection and dissemination of exploration data to explorers and enhanced company awareness about Australia's title acquisition and taxation agreements. A major feature of the strategy is that explorers are given advance notice of future releases of exploration acreage.

Mineral royalties

The collection by governments of royalties for the production of minerals within their area of authority is an internationally-accepted practice. In Australia, the responsibility for mineral royalties is largely a State concern, and all States currently collect some form of mineral royalty payments.

In recent years there has been an important basic change in the system of establishing royalty commitments, and it is now quite common for the State Governments to negotiate special royalty rates with companies which are seeking mineral leases for large scale developments. These royalty rates may vary, depending on whether production is for export or for domestic processing. The rates for a particular mineral may also vary between producers. Important examples of this type of royalty agreement are the iron ore development agreements in Western Australia and coal development agreements in Queensland. Mineral royalties received by governments in recent years are shown in the following table.

MINERAL ROYALTY RECEIPTS: GOVERNMENTS
(\$'000)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
New South Wales(a)	109,789	109,194	118,569	135,486	97,166	99,387
Victoria(b)(c)	180,585	206,086	213,292	157,991	156,799	109,035
Queensland(a)	107,579	142,533	196,110	176,451	196,013	178,301
South Australia	14,172	27,739	58,352	33,592	36,011	34,914
Western Australia	(d)168,477	131,640	162,208	154,056	162,648	171,972
Tasmania	2,137	1,043	1,507	1,641	3,048	3,800
Northern Territory	3,963	5,483	8,079	7,186	10,642	9,514
Commonwealth Government(c)	103,412	114,299	187,061	119,806	132,346	75,100
Total	690,114	738,017	945,178	786,210	794,673	682,023

(a) Includes royalties on sand and gravel from Crown lands. (b) Includes royalties on brown coal paid by State Electricity Commission. (c) Includes royalties received under the *Petroleum (Submerged Lands) (Royalty) Act 1967-68*. (d) Includes prepaid royalty of \$50 million in respect of diamond royalty agreement.

Government Assistance

The Commonwealth Government and the various State Governments provide assistance to the mineral industry in a variety of ways. These were described in detail in *Year Book No. 73*.

Research

Research investigations into problems of exploration, mining, ore-dressing and metallurgy are conducted by government bodies, universities, private enterprise, or by the combined efforts of all these. A summary of their functions follows, for further information on research *see* Chapter 22, Science and Technology.

Amdel Limited

Analysis, contract research and consulting in a broad range of scientific and technical areas is carried out by Amdel Limited and its subsidiaries. Operations are based in Adelaide, with branches in Perth, Melbourne, Sydney, Darwin and Townsville. Extensive laboratory facilities are available in the fields of analytical chemistry, mineralogy, metallurgy, materials science and petroleum. Mineral process evaluation is carried out at bench and Pilot Plant scale. Services are provided in fields of pollution and environmental control and occupational health and safety. Products are based around nucleonic measurement techniques linked to microprocessors, and include in-stream analysis for the mineral industry, coal slurry analyser, limestone analyser and on-pipe density gauge.

Commonwealth Scientific and Industrial Research Organisation—CSIRO

Minerals research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is undertaken within the Institute of Minerals, Energy and Construction. The objective of the Institute is to increase the international competitiveness, export earnings, gross domestic product and value of services provided by the minerals, energy and construction industries.

Divisions (and their respective headquarters locations) of the Institute engaged in minerals energy and construction research are the Division of Geomechanics at Syndal (Vic.); the Division of Coal Technology at North Ryde (NSW); the Division of Mineral Products at Port Melbourne (Vic.); the Division of Mineral and Process Engineering at Clayton (Vic.); the Division of Exploration Geoscience at Perth (WA); the Division of Fuel Technology at Lucas Heights (NSW), and the Division of Building, Construction and Engineering at Highett (Vic.). The Institute Headquarters is located in Sydney (NSW).

University research

The various universities in Australia carry out research into various aspects of the mineral industry such as geology, ore mineralogy and genesis, mining techniques, mineral processing, extractive metallurgy, and materials and metals technology.

Research by private enterprise

The Australian Mineral Industries Research Association Limited (AMIRA) is a non-profit organisation which was set up in 1959 by the Australian mineral industry to manage jointly sponsored research and development on behalf of the industry. There are 139 members of AMIRA, drawn from all parts of the mineral, coal and petroleum industries. Membership ranges from small exploration companies to large mining houses and includes suppliers of services to the industry. The policy of the Association is determined by a council elected by members.

AMIRA has no research facilities so organisations such as CSIRO, universities, consultants, suppliers or member companies carry out the research as contractors to AMIRA. Research contracts worth approximately \$29 million are being handled by AMIRA.

International Relations

International relations are of considerable importance to the mineral industry. Australia is a large supplier of certain minerals to the rest of the world and the welfare of the

domestic industry depends to a large extent on the maintenance of a high level of exports. The Commonwealth Government takes an active role in international consultations and discussions relating to minerals. The most important international links are shown below.

Association of Tin Producing Countries—ATPC

The ATPC came into being on 16 August 1983. Membership is open to countries which are net exporters of tin. The current members are Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand, and Zaire. Major activities of the ATPC have been directed towards the encouragement of greater consumption of tin through research and development. This resulted in the London-based International Tin Research Institute (ITRI) becoming a subsidiary of the ATPC in 1988. Since 1987, the ATPC has operated a program of production restraint which, with the cooperation of non-members Brazil and China, is aimed at reducing excess tin stocks overhanging the market. The scheme was extended for twelve months from January 1990.

International Lead and Zinc Study Group—ILZSG

Australia has been a member of the ILZSG since its formation in 1959. The following countries are also members: Austria, Belgium, Brazil, Bulgaria, Canada, China, Czechoslovakia, Denmark, Finland, France, Germany (Federal Republic of), Hungary, India, Iran, Italy, Japan, Korea (Federal Republic of), Morocco, Netherlands, Norway, Peru, Poland, South Africa, Spain, Sweden, Thailand, Tunisia, Union of Soviet Socialist Republics, United Kingdom, United States of America and Yugoslavia.

The main objectives of the Study Group are to provide a forum for intergovernmental consultations and to develop to the maximum extent possible transparency in the international lead and zinc markets.

Government and industry representatives meet annually to discuss developments in the international lead and zinc industry. The Group also undertakes special studies of the world situation in lead and zinc and considers possible solutions to problems unlikely to be resolved in the normal development of world trade. Particular attention is given to statistics on lead and zinc. The Study Group also publishes a monthly statistical bulletin and twice-yearly makes a short term forecast of the supply and demand for lead and zinc.

Association of Iron Ore Exporting Countries—APEF

APEF was established in 1975 with the following membership: Australia, Algeria, India, Liberia, Mauritania, Peru, Sierra Leone, Sweden and Venezuela.

Following the receipt in 1988 of notices of intention to withdraw from the Association by Sweden, Peru and Sierra Leone, the 27th session of the Board, held in March 1989, suspended the activities of the Association indefinitely. Venezuela is holding the secretariat pro tempore until the end of 1990 and the statistical function has been transferred to an independent trust fund within UNCTAD.

UNCTAD Intergovernmental Group of Experts (IGE) on Iron Ore

The UNCTAD IGE on Iron Ore was established in 1986 to discuss impediments to the formation of a producer/consumer forum to stabilise the market for iron ore.

Three meetings of the IGE have been held, the most recent in October 1989, with a further meeting scheduled to be held in October 1990.

In view of the IGE's scant progress towards its initial aim, the group has become a more general market transparency forum, and since the suspension of APEF, the only such forum on iron ore.

International Bauxite Association—IBA

Australia joined the IBA as a founder member in October 1974. Other members are Ghana, Guinea, Guyana, India, Indonesia, Jamaica, Sierra Leone, Surinam and Yugoslavia. Members account for about three-quarters of world bauxite production, with Australia accounting for over one-third of world production.

The objectives of the Association are to promote the orderly and rational development of the bauxite industry; to secure for members fair and reasonable returns from the exploitation, processing and marketing of bauxite and its products for the economic and social development of their peoples, bearing in mind the recognised interests of consumers; and generally to safeguard the interests of member countries in relation to the bauxite industry.

The Association consists of a Council of Ministers which meets once a year, an Executive Board consisting of senior officials which meets three times a year and a Secretariat which is located in Kingston, Jamaica.

The IBA provides members with an opportunity to discuss common problems and evolve cooperative policies to facilitate further development of their bauxite/alumina/aluminium industries. The Association's work is mostly concerned with exchanging views and information on a range of industry matters. The commercial and technical aspects of formulating minimum export prices for bauxite and alumina have received particular attention. Australia has indicated that it is not bound by any decision the IBA might make regarding minimum pricing of bauxite and alumina. The Association publishes a quarterly review.

International Nickel Study Group—INSG

The INSG held its inaugural meeting on 25-28 June 1990. Founding members of the group are Australia, Canada, Cuba, Federal Republic of Germany, Finland, France, Greece, Indonesia, Japan, Netherlands, Norway and Sweden. Together these countries account for over 60% of world nickel trade.

The main objectives of the Study Group are to provide a forum for intergovernmental consultations and to develop a statistical and information gathering service to increase transparency in the world nickel market.

The secretariat of the group will be located in The Hague. Member Governments and their industry advisers will meet annually to discuss developments in the international nickel industry. The first of these meetings will be held in the first half of 1991.

Mining Industry Statistics

This section contains statistics of the mining industry in Australia, obtained from the annual census of mining establishments. The mining census is conducted throughout Australia on an integrated basis with other economic censuses, e.g. manufacturing, electricity and gas, retail, wholesale trade, construction, transport and selected services establishments.

The following table titled Mining Establishments, Summary of Operations, shows key items of data for 1988-89 based on the 1983 edition of the *Australian Standard Industrial Classification* (ASIC).

Mineral Production

For details of the scope of mineral production statistics and their relation to mining industry statistics, and the principles for measuring the output of minerals, see *Year Book* No. 61 and earlier issues.

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS, BY INDUSTRY CLASS, 1988-89p(a)

ASIC code	Description	Establishments at 30 June	No.	Employment at end of June(b)	Wages and salaries (c)	Turnover	Stocks		Total purchases transfers in and selected expenses	Value added	Fixed capital expenditure less disposals
							Opening	Closing			
			No.	No.	\$m	\$m	\$m	\$m	\$m	\$m	\$m
	Metallic minerals—										
	Ferrous metal ores—										
1111	Iron ores	13		7,619	286	1,977	280	147	935	909	331
1112	Iron ore pelletising	1									
	Non-ferrous metal ores—										
1121	Bauxite	6		1,936	72	653	19	29	97	567	16
1122	Copper ores	5		2,673	107	684	62	68	179	511	96
1123	Gold ores	156		9,233	340	3,179	304	354	1,469	1,760	906
1124	Mineral sands	12		2,009	56	623	75	85	188	446	94
1125	Nickel ores	4		n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1126	Silver-lead-zinc ores	16		5,434	223	1,124	93	149	438	742	152
1127	Tin ores	9		n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1128	Uranium ores	3		n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1129	Non-ferrous metal ores n.e.c.	6		n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
11	Total metallic minerals	231		31,980	1,202	9,447	1,104	1,093	3,560	5,876	1,874
	Coal, oil and gas—										
1201	Black coal	98		27,973	1,258	6,305	614	576	2,879	3,388	397
1202	Brown coal	2									
1300	Oil and gas	41		4,724	225	3,606	238	241	393	3,216	1,427
12-13	Total coal, oil and gas	141		32,697	1,483	9,911	851	817	3,272	6,604	1,824
	Total metallic minerals, coal, oil and gas	372		64,677	2,685	19,358	1,955	1,910	6,832	12,480	3,698
	New South Wales	85		19,737	855	3,589	286	334	1,530	2,107	253
	Queensland	12		1,507	73	1,616	46	50	140	1,479	268
	South Australia	113		16,339	715	5,188	486	498	2,218	2,983	535
	Western Australia	4		2,232	79	844	154	138	138	706	69
	Tasmania	125		20,156	775	6,465	656	558	2,272	4,095	2,309
	Northern Territory	11		2,500	101	511	34	37	262	253	20
		22		2,206	87	1,144	294	279	273	857	244

(a) The 1988-89 Census of Mining was restricted to the metallic minerals, coal, oil and gas industries. Previous mining censuses also included construction materials and other non-metallic industries. A full census will be conducted in 1989-90 as the reference year. (b) Includes working proprietors. (c) Excludes amount drawn by working proprietors.

More recent tables showing quantities of selected minerals produced and contents of selected metallic minerals produced for 1987-88 and earlier years are contained in *Year Book No. 73*. Additional data for all minerals are available in the annual publication *Mineral Production, Australia* (8405.0).

Foreign Participation in the Mining Industry in Australia

Summary information on foreign participation in the mining industry in Australia is shown in Chapter 26, Foreign Transactions. More detailed statistics are available in *Foreign Ownership and Control of the Mining Industry, Australia 1984-85* (5317.0) and *Foreign Control in Mineral Exploration, Australia 1984-85* (5323.0).

Mineral Exploration (Other Than for Petroleum)

Definition

Exploration consists of the search for new ore occurrences or undiscovered oil or gas and/or appraisal intended to delineate or greatly extend the limits of known deposits of minerals or oil or gas reservoirs by geological, geophysical, geochemical, drilling and other methods. This includes construction of shafts and adits primarily for exploration purposes but excludes activities of a developmental or production nature. Exploration for water is excluded.

Source of statistics

The statistics of private sector exploration are derived from the quarterly mineral exploration census conducted by the Australian Bureau of Statistics (ABS) in each State and the Northern Territory.

Expenditure

The following table shows expenditure by State on private mineral exploration other than for petroleum in Australia during the last six years.

PRIVATE MINERAL EXPLORATION (OTHER THAN FOR PETROLEUM)
(\$ million)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
Expenditure—						
New South Wales	55.6	49.5	51.8	47.6	61.5	50.6
Victoria	11.1	15.2	12.3	15.5	33.9	21.7
Queensland	80.7	79.5	88.6	120.6	159.3	139.8
South Australia	54.4	57.6	48.9	11.0	18.9	16.6
Western Australia	184.7	189.8	205.2	323.3	466.3	387.2
Tasmania	18.0	17.8	10.6	10.9	10.4	13.1
Northern Territory	24.2	28.0	24.6	27.9	48.9	68.6
Australia	428.7	437.3	442.0	556.8	799.2	697.6

The table below shows expenditure on private petroleum exploration in Australia during the last six years.

PRIVATE PETROLEUM EXPLORATION
(\$ million)

	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89
Expenditure—						
Onshore	283.1	419.6	367.8	171.0	271.9	233.6
Offshore	540.6	373.6	398.0	134.1	223.2	405.7
Total	823.7	793.2	765.8	305.2	495.1	639.3

Mineral Processing and Treatment

The extraction of minerals from ore deposits, as in mining and quarrying, is only a part of mineral technology, as few minerals can be directly used in the form in which they are mined. In most cases, minerals must undergo considerable processing and treatment before utilisation.

Principal products

The following table shows particulars of the production of certain important manufactured products of mineral origin during recent years.

PRODUCTION(a) OF PRINCIPAL MANUFACTURED PRODUCTS OF MINERAL ORIGIN

Commodity		1986-87	1987-88	1988-89
METALS(b)				
Non-ferrous—				
Alumina	'000 tonnes	9,840	10,328	10,601
Refined aluminium	"	921	1,074	1,227
Blister copper(c)	"	174	180	191
Refined copper	"	171	186	211
Lead bullion (for export)(c)	"	183	201	181
Refined lead	"	142	183	184
Refined zinc	"	300	305	303
Refined tin	tonnes	784	501	377
Ferrous—				
Pig iron	'000 tonnes	5,783	5,455	5,875
Precious—				
Refined gold(d)	kg	81,856	111,934	169,653
Refined silver	"	270,608	304,426	305,013
FUELS				
Coal products—				
Metallurgical coke	'000 tonnes	3,253	3,727	3,889
Brown coal briquettes	"	811	809	751
Petroleum products(e)—				
Diesel-automotive oil	megalitres	8,198	9,399	9,774
Industrial fuel and marine fuel	"	240	229	175
Fuel oil for burning	"	2,274	2,078	2,272
Automotive petrol	"	15,296	15,995	15,913
BUILDING MATERIALS				
Clay bricks	millions	1,847	1,867	2,142
Portland cement	'000 tonnes	5,920	6,158	6,901
CHEMICALS				
Sulphuric acid	'000 tonnes	1,678	1,816	1,904
Superphosphate(f)	"	2,769	3,194	3,681

(a) Some products exclude production of single establishment manufacturing establishments employing less than four persons and production of establishments predominantly engaged in non-manufacturing activities but which may carry on in a minor way, some manufacturing. (b) Excludes secondary metal with the exception of pig iron and steel ingots. Source: Australian Bureau of Agricultural and Resource Economics (non-ferrous and precious metals only). (c) Metallic content. (d) Newly won gold of Australian origin. (e) Source: Department of Primary Industries and Energy. (f) Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22 per cent P₂O₅ equivalent.

Overseas Trade

Exports and imports

For particulars of the quantities and values of the principal minerals and products exported from and imported into Australia during recent years, see Chapter 26, Foreign Transactions.

REVIEW OF RECENT DEVELOPMENTS IN THE AUSTRALIAN MINING INDUSTRY

(Source: Australian Bureau of Agricultural and Resource Economics)

Major recent developments in the Australian mining industry are reviewed briefly in subsequent parts of this section. Additional information on developments in the industry is available in *Agriculture and Resources Quarterly* (ARQ) and other Australian Bureau of Agricultural and Resource Economics statistical publications.

General review of 1988–89

Australia's Gross Domestic Product (GDP) in 1988–89 was \$335,745 million, of which an estimated \$24,860 million was generated by the mining industry, excluding metal smelting and refining. The addition of metal smelting and refining adds an estimated \$5,841 million to this figure, and at 9 per cent makes minerals including energy and metals the largest primary sector contributor to the GDP.

This broadly defined sector experienced strong growth in 1988–89, as strong world demand for, and lagging supply of, metals fed through to higher prices. The ex-mine value of mine production in Australia in 1988–89 was approximately \$16.5 billion. This was around \$1.3 billion, or 9 per cent more than the 1987–88 value, and equal to the record level attained in 1985–86, in current dollars. While sector performance was mainly attributable to upward movements in metal prices, it also featured some notable improvements in production volumes. These offset generally declining energy prices and (excluding black coal), declining energy production volumes.

Major minerals to realise improved ex-mine production values were copper, diamonds, mineral sands (ilmenite and zircon), nickel and zinc, while the substantial increase in gold production was offset by an easing in gold price. Major minerals to record significant declines in ex-mine values were crude oil and LPG (declining price and production levels) and lead (price decline).

Exports—1988–89

The value of mineral exports rose by 9 per cent to a new record of \$20.5 billion. Major minerals to show gains on their 1987–88 levels included alumina, aluminium metal, copper, diamonds, mineral sands (ilmenite and zircon), nickel and zinc. These improvements generally reflected the world surge in metal prices during the period, but in some cases improvements in export quantities were also significant.

Increased exports of aluminium reflect the continuing trend toward increased value added to resource exports by downstream processing of Australia's raw materials. Diamond export volumes rose significantly (19 per cent) while copper and zircon improved appreciably (10 per cent and 7 per cent respectively). Despite a 29 per cent increase in the quantity of gold exported, the value of gold exports rose by only 2 per cent as a consequence of declining world gold prices.

The energy industries did not fare as well. Decreases in the value of exports were recorded for crude oil, LPG, refined petroleum products, steaming coal and lead. Crude oil, LPG and refined petroleum product revenues fell as a result of both lower world prices and falls in export quantities, while steaming coal revenue fell (in spite of a marginal price improvement) as a result of declining export volumes. The value of lead exports fell by 19 per cent, despite a 7 per cent rise in export volumes, due to falling world prices.

With the sustained global recovery of the steel industry and increased use of steaming coal in electricity generation, black coal, at \$4,630 million, remained Australia's single largest export earner, accounting for about 23 per cent of the value of mineral exports. Aluminium was the second largest earner with \$2,511 million; gold, \$2,456 million;

alumina, \$2,238 million; zinc, \$834 million; and nickel \$770 million. These six minerals together accounted for approximately three-quarters of mineral exports and over one-third of the total value of all merchandise exports.

Imports—1988–89

The value of mineral imports continued to be dominated by crude oil and refined petroleum products, although their prominence weakened further. In 1988–89, the value of crude oil imports fell by 16 per cent to \$1,183 million, despite an increase of 9 per cent in the quantity imported, reflecting the general weakening of world energy prices. The value of imported refined petroleum products increased by 19 per cent to \$747 million, while quantities rose 24 per cent. Crude oil and refined petroleum product imports accounted for almost 70 per cent of the total mineral import bill of \$2,786 million (\$2,772 million in 1987–88).

Other significant mineral imports included diamonds and gold bullion (primarily for re-export), iron and steel, phosphate rock and sulphur. The volume of diamond imports was significantly down, recording a 35 per cent fall, however their value rose by 25 per cent, reflecting a shift to importation of higher value gem diamonds. Gold imports fell by 69 per cent, to less than one-third of their 1987–88 levels, as a result of declining Australian re-export trade. Iron ore imports rose significantly (a ten-fold increase in quantity and four-fold increase in value) from a low base, due to domestic production problems for specific ore grades.

Australia's mineral balance of trade (value of mineral exports minus value of mineral imports) was a record \$17.8 billion in 1988–89 (\$16.1 billion in 1987–88), reflecting the strength of world metal prices, which more than offset the effects of declining energy prices.

Pattern of mineral trade—1988

During 1988, Australia exported minerals to more than 100 countries. Japan accounted for 39 per cent of those exports, up from 37 per cent in 1987, which had been the lowest share since 1965. Principal mineral products exported to Japan included alumina, aluminium, black coal, copper, crude oil, gold, iron ore, lead, mineral sands, nickel and zinc.

The share of mineral exports going to Asian countries other than Japan has increased in recent years, and in 1988 accounted for 28 per cent of the total (24 per cent in 1987). The main country destinations and commodities exported were: Korea (Republic of) (aluminium, black coal and iron ore); Hong Kong (black coal and gold); and Taiwan (aluminium, black coal and iron ore).

These figures continue to reflect the trend of increasing Australian trade within the Asian region, with the Asian countries outside Japan providing major trade stimulus while the role of traditional European markets is diminishing. This trend is expected to continue.

The Middle East supplied 30 per cent of Australia's mineral imports by value in 1988 (38 per cent in 1987), while Indonesia provided a further 13 per cent (20 per cent in 1987). Other major suppliers in 1988 were Malaysia (10 per cent), Canada (6 per cent) and the United States (5 per cent). Middle East, Indonesian and Malaysian mineral imports were made up almost entirely of crude oil, while Canada and the United States were major suppliers of sulphur and fertilizers, with Canada also providing nickel and the United States supplying clays and diamonds.

Bauxite, alumina and aluminium

In 1988–89, production of bauxite increased by 6 per cent to 37.3 million tonnes, alumina by about 3 per cent to 10.6 million tonnes, and aluminium by 14 per cent to 1.2 million tonnes. Australia continues to be the world's largest producer of bauxite and alumina.

The value of exports of alumina and unwrought aluminium and aluminium alloys was a record \$4.7 billion in 1988–89. Alumina accounted for \$2.2 billion of this figure while unwrought aluminium and aluminium alloys comprised the remaining \$2.5 billion. Exports of alumina totalled 8.3 million tonnes.

In Western Australia, Alcoa of Australia owns and operates four bauxite mines, Jarrahdale, Del Park, Huntly and Willowdale, with total annual capacity of 17.8 million tonnes. Worsley Alumina owns and operates an integrated operation with a bauxite mine (capacity 4 million tonnes a year) and alumina refinery at Mt. Saddleback near Boddington. The Gove joint venture, also an integrated facility, operates the Gove mine (5.8 million tonnes a year) and alumina refinery in the Northern Territory, while Comalco owns and operates the Weipa mine (capacity of 11 million tonnes per year) in Queensland.

In Western Australia, all bauxite production is refined at either Alcoa's refineries at Kwinana, Pinjarra and Wagerup (total capacity 5.5 million tonnes a year) or at the Worsley refinery (1.2 million tonnes capacity a year). In the Northern Territory, bauxite not exported is refined at Nabalco's refinery at Gove (1.6 million tonnes capacity per year). Queensland Alumina operates the Gladstone alumina refinery (2.9 million tonnes capacity a year).

There are six smelters in Australia which produce primary aluminium. These are the Kurri Kurri and Tomago smelters in New South Wales; the Point Henry and Portland smelters in Victoria; the Boyne Island smelter in Queensland; and the Bell Bay smelter in Tasmania.

Identified recoverable resources of bauxite at 31 December 1989 were approximately 5,543 million tonnes.

Copper

Australia ranks as the eighth largest mine producer of copper, but accounts for only 3.6 per cent of mine production among the market economies. Nevertheless, copper is an important export earning mineral for Australia. In 1988–89 Australian mine production of copper increased by 21 per cent to 273,000 tonnes, mainly in response to firm prices and strong export demand. The only major new mine capacity to come on stream during 1988–89 was from Western Mining Corporation's Olympic Dam deposit in South Australia.

Refined copper production increased by 14 per cent, to 211,000 tonnes in 1988–89 as smelters, particularly the CRA Port Kembla copper smelter and refinery in New South Wales, increased capacity utilisation rates.

The gross value of copper exports rose by over 40 per cent to \$557 million in 1988–89 in response to high prices, increased shipments to Japan and Korea (Republic of) and a slightly weaker Australian dollar.

Identified recoverable resources of copper at 31 December 1989 were approximately 6.5 million tonnes.

Gold

In 1988–89, Australia's gold production increased for the eighth successive year, reaching 721,281 kilograms, the highest since 1905. Australia is now the Western World's third largest producer. Western Australia continued to dominate Australian production and accounted for approximately 70 per cent of all gold produced in 1988–89.

Australia exported 154,590 kgs of gold during 1988–89 with a value of \$2.456 billion. Even though the quantity exported increased by approximately 30 per cent on the previous year the value was only marginally higher due to lower world gold prices.

Identified recoverable resources of gold at 31 December 1989 were approximately 1,486 tonnes.

Iron ore and steel

Production of iron ore in 1988-89 declined by nearly 5 per cent to 97.4 million tonnes, primarily due to disruptions to production in key mining operations. Exports grew by 6 per cent to 96.0 million tonnes in response to growth in world steel production. Increased exports were facilitated by a large rundown of stocks.

Australia is the world's fourth largest iron ore producer (behind the USSR, China and Brazil) and the second largest exporter behind Brazil. During 1988-89, work proceeded on the Hammersley Iron/China Metallurgical Import and Export Corporation (CMIEC) Mt. Channar Joint Venture. It commenced operation in January 1990 with an initial annual production rate of 3 million tonnes. Production will be increased, as required, to 10 million tonnes per annum.

Identified recoverable resources of iron ore at 31 December 1989 were approximately 14,300 million tonnes.

Silver, lead and zinc

Mine production of both lead (487,000 tonnes) and zinc (769,000 tonnes) increased in 1988-89 by around 1 per cent on the previous year, while mine production of silver fell by nearly 5 per cent to 1,088 tonnes. Lead production rose slightly as world prices remained firm, while silver production, mainly a by-product of lead mining, fell as a consequence of reduced metal content in ore. Zinc production rose slightly, despite a sharp rise in world prices, due to short-term production capacity constraints.

Production of primary refined lead increased slightly to 184,000 tonnes in 1988-89, while production of primary refined zinc fell slightly to 303,000 tonnes due to production capacity constraints at the two domestic smelters at Cockle Creek and Port Pirie.

The gross value of lead exports declined by 20 per cent to \$440 million in 1988-89, mainly due to lower contract prices for lead bullion, while the gross value of zinc exports increased by 43 per cent to \$834 million due to higher world prices. The value of silver exports is confidential. However, the total quantity of silver metal exported in all ores, concentrates, intermediate products and in the refined state decreased by 10 per cent in 1988-89.

Estimated identified recoverable resources at 31 December, 1989 were: lead, 11.5 million tonnes; zinc, 20.4 million tonnes; and silver, 21.8 thousand tonnes.

Nickel

Mine production of nickel in ore and concentrates was 64,000 tonnes in 1988-89, down by 7 per cent on 1987-88 (69,000 tonnes). With increased world production, Australia slipped to being the fourth largest world producer behind Canada, the USSR, and New Caledonia. However, new mining projects and expansion of existing mines should lift Australian production substantially in the near future.

Production capacity in Western Australia has risen with the recent re-opening of the old Agnew, now Leinster mine. Proposed expansions of existing mines, together with other new projects at Forrestania, Mt. Keith and Radio Hill, will further lift Western Australian production. The Radio Hill facility will also have an on-site smelter.

Production of nickel ore in Queensland will decline with the closing of the Greenvale mine in 1991-92. Greenvale presently supplies ore feedstock to the Yabulu hydrometallurgical refinery near Townsville. This refinery is presently undergoing a major expansion and future ore supplies will be sourced from Indonesia and New Caledonia.

The value of Australian nickel exports in 1988-89 was \$770 million, an increase of 45 per cent over 1987-88 (\$530 million). This increase was mainly attributable to the sharp increase in world prices during the period.

Identified recoverable resources of nickel at 31 December 1989 were approximately 1.1 million tonnes.

Mineral sands

Australia is the world's largest producer and exporter of natural rutile, ilmenite, zircon and monazite. Output of concentrates in 1988-89 were: rutile 247,000 tonnes; ilmenite; 1,691,000 tonnes; zircon 513,000 tonnes; and monazite 13,000 tonnes.

Strong demand for mineral sands products resulted in the industry's export earnings rising sharply from \$542 million in 1987-88 to \$786 million in 1988-89, an increase of 45 per cent. This increase was mainly due to additional processing of ilmenite to synthetic rutile, and processing of synthetic rutile and ilmenite to titanium dioxide pigment before export, together with higher prices for zircon. The value added component of export earnings is projected to continue to rise from 35 per cent in 1988-89.

With the development of a number of new projects, Australia will continue to be the world's leading producer and exporter of mineral sands over the medium term. Most of Australia's expanded production capacity will be in Western Australia where the Cooljarloo, Eneabba and Jangardup deposits are being developed. A further deposit, near Beenup, is currently undergoing a feasibility study. Outside Western Australia, potential mines include the Rocky Point and Bayfield deposits in Queensland, the WIM-150 deposit in Victoria and the Newrybar deposit in New South Wales.

Estimated identified recoverable resources of mineral sands at 31 December 1989 were: ilmenite, 64.2 million tonnes; monazite, 360 thousand tonnes; rutile, 9.4 million tonnes; and zircon, 15.2 million tonnes.

Diamonds

Australia is the world's leading volume supplier of diamonds and accounts for around 30 per cent by quantity of the world's natural diamond production. However, by value it is the world's sixth largest producer behind the USSR, Botswana, South Africa, Namibia and Zaire, due to the relatively low proportion of gem quality stones mined.

Australian diamond production in 1988-89 was 35.1 million carats, the bulk of which (34.5 million carats) were produced at the Argyle diamond mine. This mine is currently undergoing a major upgrade which is expected to increase ore throughput from the present 4.5 million tonnes a year to 6 million tonnes. Diamonds from the AK-1 pipe at Argyle comprise 5 per cent gem quality, 45 per cent near-gem quality and about 50 per cent industrial grades.

While the majority of production (72 per cent) is marketed through the Central Selling Organisation, a significant proportion is now independently marketed. A cutting and polishing facility has been established in Perth and a large proportion of higher quality gems are now processed in Australia.

The Bow River Joint Venture near Argyle processed 2.5 million tonnes of ore in 1988-89 to produce 0.58 million carats of diamonds. Diamonds from Bow River comprise 20 per cent gem quality, and 80 per cent industrial quality.

Estimated identified recoverable resources of diamonds at 31 December 1989 were: gem and cheap gem, 179 million carats and industrial, 214 million carats.

Black coal

Raw black coal production in 1988-89 was a record 183.5 million tonnes, 9 per cent higher than in 1987-88. The output of saleable coal rose by 10 per cent to the record level 149.3 million tonnes. Domestic consumption rose to the record level of 49.9 million tonnes in 1988-89, mainly due to the growth in use by the electricity and iron and steel industries. Exports fell by 5 per cent to 96.9 million tonnes in 1988-89 and the value of exports fell to \$4,630 million. Of total exports 46.3 million tonnes were shipped to Japan.

Demand for steaming coal on the international market has remained high. However, Australian exports of steaming coal fell to 40.1 million tonnes in 1988-89. Coking coal exports declined by less than 1 per cent in 1988-89 compared with 1987-88, to 56.9 million tonnes.

Papers dealing with the Australian coal industry have been published in the *Australian Mineral Industry Quarterly*, Vol. 31, No. 1 and Vol. 34, No. 2.

Uranium

During 1988-89, uranium was produced from the Ranger and Nabarlek operations in the Northern Territory and Olympic Dam in South Australia. Total production for the year was 4,506 tonnes U₃O₈. Uranium exports for 1988-89 were 5,060 tonnes U₃O₈ at an average f.o.b. unit value of \$36.12 per pound U₃O₈. The production phase of the Olympic Dam copper-uranium-gold project commenced in August 1988. Although the project has an annual capacity of 1,900 tonnes U₃O₈, production in 1988-89 was 910 tonnes U₃O₈.

Petroleum

In 1988-89 production of crude oil and condensate decreased by 9.6 per cent to 28,255 million litres, LPG production decreased by 4.1 per cent to 3,763 million litres, and total natural gas production rose 3.3 per cent to 15,956 million cubic metres.

Identified recoverable resources of crude oil and condensate at 31 December 1988 were approximately 451,000 million litres, LPG resources were approximately 167,000 million litres and natural gas resources were 2,081 billion cubic metres, of which 1,537 billion cubic metres were located in the Browse and Carnarvon basins off the coast of Western Australia.

Consumption of petroleum products in 1988-89 totalled 40,500 million litres, an increase of 4.4 per cent over 1987-88. Consumption of automotive gasoline (motor spirit) increased by 3.1 per cent to 17,078 million litres, with unleaded gasoline making up 20.7 per cent of total consumption, up from 14.5 per cent the previous year. Consumption of most major products rose in 1988-89, while consumption of industrial diesel fuel, kerosene, heating oil and other minor products all decreased.

Exports of crude oil and other refinery feedstock decreased in 1988-89 by 23.7 per cent to 4,921 million litres, while imports rose 8.7 per cent to 10,409 million litres. The value of net crude oil and other refinery feedstock imports increased by 36 per cent, to \$593 million. LPG exports decreased by 9 per cent in volume and 34 per cent in value, to \$161 million. The volume of refined petroleum product exports increased by less than 1 per cent to 2,761 million litres, while imports increased by 24 per cent to 4,101 million litres. The value of net refined petroleum product imports rose to \$244 million, compared with \$67 million in 1987-88.

Expenditure on petroleum exploration and development in Australia in 1988-89 was approximately \$2.4 billion. The level of onshore exploration activity was depressed in 1988-89. Offshore activity continued to rise both in terms of the number of wells drilled and the amount of seismic surveying undertaken. In the 1988 calendar year, 243 exploration wells were drilled (211 onshore and 32 offshore). Offshore development activity continued strongly in 1988-89, with the completion of the initial liquefied natural gas production and export facilities of the North West Shelf project, to which a total expenditure of \$6.4 billion had been committed by mid 1989. There was further development of fields in Bass Strait, the Timor Sea and elsewhere on the North West Shelf.

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