
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 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) 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 and Rosebery base-metal deposits 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 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, 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 Federal Territories and to certain prescribed substances in the NT, 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 statutory powers with respect to international trade, customs and excise, taxation and loan raisings. 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 large-scale 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 Commonwealth is working with the States to expedite the implementation of the

Minerals (Submerged Lands) Act by all governments. In the meantime administration of offshore mining is carried out under the States' onshore mining legislation on an interim basis.

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 in the government or administration of each State or Territory. Any company, organisation or individual proposing to undertake petroleum exploration or development must first satisfy the government concerned that the necessary financial and technological resources are available to carry out the operation.

There are three main types of petroleum title:

- (i) the exploration title, where the holders are typically given exclusive rights over the area to conduct petroleum exploration, including the drilling and testing of wells;
- (ii) the production title, which is required for commercial production of petroleum and gives the holder the right to produce and sell the petroleum subject to the payment of a royalty calculated as a fixed percentage of the well-head value of the petroleum produced; and
- (iii) the retention licence enacted in the Northern Territory, covering onshore petroleum exploration and production under the *Petroleum Act 1984* and is intended to allow tenure over currently non-commercial discoveries.

Royalty arrangements vary from State to State. All States and the Northern Territory determine royalties derived from onshore production as a percentage of the derived well-head value of all petroleum production.

The Commonwealth has passed legislation that provides for the replacement of all Commonwealth excise on liquefied petroleum gas and crude oil, and State ad valorem royalty, with a resource rent royalty where the relevant State government has negotiated an acceptable agreement with the producers and has agreed upon a satisfactory revenue sharing formula with the Commonwealth.

Offshore

As part of the Offshore Constitutional Settlement between the Commonwealth and the States, responsibility for administering petroleum exploration and production 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. The *Petroleum (Submerged Lands) Act 1967* provides for a Joint Authority for the adjacent area of each State and the Northern Territory (beyond the territorial sea limit) consisting of the Commonwealth Minister 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 and State or Territory officials.

The mining code applicable under the legislation provides for a three stage system of titles: the exploration permit, which covers all forms of exploration including drilling, the retention lease which provides tenure over currently non-commercial discoveries and the production licence, which covers development and production.

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 is levied on

all petroleum production. The Commonwealth shares payments with the relevant States under the Offshore Constitutional Settlement. In addition, the Commonwealth also levies excise on crude oil production.

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

Availability of exploration acreage

As part of the government's aim to encourage petroleum exploration, regular releases of offshore exploration acreage are made.

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 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)

	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88
New South Wales(a)	105,403	109,789	109,194	118,569	135,486	102,569
Victoria(b)(c)	124,861	180,585	206,086	213,292	157,991	145,215
Queensland(a)	89,793	107,579	142,533	196,110	176,451	196,013
South Australia	9,321	14,172	27,739	58,352	33,592	36,011
Western Australia	102,454	(d)168,477	131,640	162,208	154,056	162,648
Tasmania	2,082	2,137	1,043	1,507	1,641	3,048
Northern Territory	2,934	3,963	5,483	8,079	7,186	10,642
Commonwealth Government(c)	83,609	103,412	114,299	187,061	119,806	132,346
Total	520,457	690,148	738,017	945,178	786,210	788,492

(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.

Joint Coal Board

The Joint Coal Board was established in 1946 under joint legislation of the Commonwealth Government and of the State of New South Wales to carry out special functions in regard to the New South Wales black coal mining industry. In summary, the Board's functions are to:

- ensure that coal is produced in the State of New South Wales in such quantities and with such regularity as will meet requirements throughout Australia and in trade with other countries;
- ensure that the coal resources of the State are conserved, developed, worked and used to the best advantage in the public interest;

- ensure that coal produced in the State is distributed and used in such manner, quantities, classes and grades, and at such prices as are calculated best to serve the public interest and secure the economical use of coal and the maintenance of essential services and industrial activities;
- promote the welfare of workers engaged in the coal industry in the State.

Government Assistance

The Commonwealth Government and the various State governments provide assistance to the mineral industry in a variety of ways. The main forms of assistance are discussed on the following pages.

Commonwealth Government assistance

Assistance provided by the Commonwealth Government takes the form of income taxation concessions, subsidies, bounties, and technical assistance, mainly through the work of the Bureau of Mineral Resources, Geology and Geophysics (BMR) and the Commonwealth Scientific and Industrial Research Organization (CSIRO) as well as through the National Energy Research, Development and Demonstration Program.

Income taxation concessions as at 30 June 1989

Income derived from mining, principally for gold, in Australia is exempt from tax. The exemption is also available in respect of income derived from mining principally for gold and copper if the value of the gold obtained is not less than 40 per cent of the value of the total output (excluding the value of pyrites).

Special deductions for capital expenditure incurred in prospecting and mining for petroleum (including natural gas) are allowable to a petroleum mining enterprise engaged in these operations in Australia. Capital expenditure allowable to petroleum mining enterprises includes, broadly, the amount of successful cash bids and the costs of exploratory surveys; access roads; and housing and welfare. The enterprise is entitled to these special deductions against income from any source although in the case of cash bids, the deduction only becomes available if a production licence is granted. While the special deductions for prospecting expenditure are deductible immediately against the net income of the enterprise, the deductions for capital expenditure on mining are allowable over the life of the oil or gas field or over ten years, whichever is the lesser, on a straight line basis.

An enterprise mining or prospecting for minerals other than petroleum and gold may also be allowed special deductions for capital expenditure. Broadly, allowable capital expenditure includes expenditure on exploration and prospecting; preparation of a site for extractive mining operations; buildings; other improvements necessary for those operations; access roads; and housing and welfare.

The allowable capital expenditure of a general mining enterprise, other than costs of exploration, may be deducted against income from any source over the life of the mine or over ten years, whichever is the lesser, on a straight line basis. Expenditure incurred by a general mining enterprise in exploring for minerals is deductible immediately against the net income of the enterprise from any source. Undeducted exploration and development expenditure of general mining and petroleum companies may be carried forward indefinitely, although in respect of such expenditure actually incurred in 1985-86 and subsequent financial years the companies may elect to have such undeducted expenditure treated as carry-forward losses transferable to another company in the same group.

Annual deductions for depreciation on petroleum mining plant or general mining plant are available. The cost of exploration plant may also be deducted under the depreciation provisions of the law. The investment allowance scheme may permit a deduction at the rate of 18 per cent of the cost of certain new plant, provided it was contracted for (or construction commenced) before 1 July 1985 and is the first used for the purpose of producing assessable income, or installed for such use, before 1 January 1988.

Special deductions are allowable for capital expenditure incurred on certain transport facilities for use in Australia primarily and principally, for the transport of raw minerals (other than petroleum or gold) and certain specified products obtained from the processing of such minerals, or for transporting petroleum between the oil or gas field and a refinery or other terminal. The special deductions apply to expenditure incurred on a railway, road, pipeline or similar transport facility and on certain port facilities or other facilities for ships. Allowable expenditure on transport facilities is deductible in equal annual instalments over a period of ten or twenty years at the option of the mining enterprise.

Bureau of Mineral Resources, Geology and Geophysics—BMR

The BMR is the principal geoscientific agency of the Commonwealth Government. Established in 1946, it is a Research Bureau of the Department of Primary Industries and Energy.

The role of BMR is to:

- develop a publicly available, comprehensive and integrated geoscientific knowledge base for the Australian continent, the Australian offshore area and the Australian Antarctic Territory, especially through the provision and coordination of appropriate databases, as a basis for encouraging and improving the effectiveness of exploration for, and assessment of, Australia's endowment of petroleum, mineral, and groundwater resources and for contributing to land-use planning and to the resolution of environmental issues, including the mitigation of natural hazards;
- provide independent and timely scientific and technical assessments, advice and information to government, industry and the public to facilitate the formulation and implementation of policies necessary for the effective management of the land and its petroleum, mineral and groundwater resources;
- provide special national geoscientific capabilities, such as the geophysical observatory functions and seismic monitoring for both earthquake risk and underground nuclear explosions; and
- participate in appropriate multilateral and bilateral geoscientific programs to contribute to Australia's international policy objectives.

In carrying out its role BMR cooperates closely with State and Northern Territory government agencies, CSIRO and other geoscience organisations.

BMR's major programs are directed towards minerals, petroleum, groundwater, the environment, national geoscience databases and international aid and cooperation. Its main products are geoscientific information maps and advice for government, industry and the wider community.

BMR undertakes land, marine and airborne geoscientific surveys and maintains specialist geochemical, geochronological, organic geochemical, palaeomagnetic and electronic design laboratories in Canberra. BMR's Australian Seismological Centre (ASC) maintains an Australian seismological network which includes observatories at Mundaring (WA), Kowen Forest (ACT), Macquarie Island and Mawson (Antarctica). The ASC is involved in earthquake studies, detection of nuclear explosions and geomagnetic research.

At 31 August 1989, BMR comprised 558 staff including 254 research and other scientists, 178 technical and cartographic staff and 126 administrative and other support staff.

State government assistance

In addition to free assays and determinations of rocks and minerals carried out for prospectors by the Mines Departments of the States and Territories, technical officers of these departments provide advice to the mining and allied industries where required, carry out field examinations of mining prospects, advise on exploration and development, select sites for water supply, and generally give a free technical service to the mining industry.

New South Wales

The Department of Minerals and Energy is a New South Wales Government Department created on 19 October 1988 by the amalgamation of the former Departments of Mineral Resources and Energy. It continues the activities of its predecessors, operating within a new and dynamic organisational structure. The mission established for the department is 'to promote the responsible development, management and utilisation of the mineral and energy resources of New South Wales'. The Department derives its authority and responsibilities from the Acts of Parliament it administers, including the Mining Act, the Coal Mining Act, the Energy Administration Act, the Gas Act, the Electricity Act, the Pipelines Act, and the Petroleum Act. It seeks to encourage and advance the exploration for and assessment of the State's mineral and energy resources and to promote the safe, responsible, effective and efficient provision and use of energy, and production of minerals.

A wide range of services, information and advice is provided on many subjects including geological and geophysical investigations, scientific and chemical research, geological and metallogenic mapping, prospecting, mining legislation and administrative procedures. Additional capabilities are provided by the Mineral Resources Development Laboratory located at Lidcombe, the Mining Museum, one of the State's foremost specialist museums, and the Londonderry Bore Core Library, all of which are administered by the Department.

The Department is engaged in the continuous assessment of the State's mineral and energy resources; its coal resource assessment program, in particular, has identified many significant coal deposits.

Victoria

The Department of Industry, Technology and Resources advises on, monitors, coordinates and implements minerals and energy policy. The Department conducts geological, hydrocarbon and mineral surveys, produces geological maps, and issues scientific and technical reports thereon. Drilling operations are carried out and the results are used in sedimentary basin studies to evaluate petroleum, mineral and ground water potential of the State. The Department's administration of legislation covering petroleum, pipeline, mining and extractive industry activity ensures that Victoria's natural resources (both onshore and offshore) are regulated and controlled. Technical assistance and advice are available to anyone wishing to undertake exploration or prospecting. Information is also available on mining law and mineral statistics.

The Minerals Group of the Department is developing an integrated Geological, Exploration and Development Information System (GEDIS). Its first stage will, in 1989-90, produce a titles and tenement mapping and administrative system, together with geological, bore data and geophysical indexes.

Queensland

The purpose of the Department of Mines is to ensure that Queensland's mineral and energy resources are assessed, developed and utilised to the maximum extent practicable consistent with sound economic, safety and environmental management.

The Department encourages and assists the search for and development of the State's mineral resources, working through a system of permits, leases and licences issued under Acts of Parliament. The Department staff contains qualified experienced professionals including mining engineers, geologists, geophysicists, technical experts in the mechanical and electrical fields, surveyors, cartographers, draftsmen, ecologists, fuel technologists, economists and administrators.

Detailed information of assistance to mineral searchers is collated from in-house geological and geophysical studies and continuous scientific appraisal of results achieved and reported by commercial exploration groups. Over the years this information effort has been underpinned by Departmental drilling for stratigraphic information, resources assessment and applied research.

The Department of Mines carries out continuous inspection on mine safety and provides an expert technical advisory service to the mining industry. Other activities include research on mine safety and health and the administration of safety regulations on gas installations and explosives.

At a time of intense competition among suppliers of resources, the Department of Mines intends to maintain its pre-eminent position as a reliable, efficient and progressive body. To this end it has, in the last two years, undergone major organisational reviews designed to improve the management structure and the program management systems.

The Department currently delivers its services from eight Programs which report to a directorate comprising the Director-General and two Assistant Directors-General. In addition to the comprehensive skills and expertise available within the program management framework, the Department also draws on the skills of specialist advisers.

The Department continues to strengthen existing links with overseas governments, corporations and individual entrepreneurs at the same time as it works to encourage the establishment of new opportunities in mineral and energy resource development. It offers a rapid response to development and investment inquiries, both from within Australia and abroad.

To realise its purpose, the Department is structured along program lines to achieve the following major goals:

Corporate Services

To meet the needs of the Department for administrative support services by providing resource management systems and advice, organisation improvement initiatives and executive support.

Information Services

To satisfy the information needs of industry, government and the community, and to foster awareness and appreciation of the mining industry's significant contribution to the economic well-being of Queenslanders by providing accurate and timely information services and products.

Titles and Tenures Services

To enhance the administration and registration of exploration and mining tenures consistent with the needs of the mining industry, government and the community by providing cartographic, surveying and administration services.

Mineral Resources Development

To facilitate exploration, development and utilisation of Queensland's mineral resources in an environmentally responsible manner, to interpret trade and economic trends and to ensure that industry investment benefits the community by management of exploration and mining tenures, provision of mineral resource information, management of the State's royalty system, and through prompting the perception of mining as a compatible land use in accordance with government policy and sound economic and environmental management, and land use planning.

Safety and Technology

To promote safety, health, technology and environmental management at mines, petroleum and gas operations and installations, and to promote the safe storage, handling and transport of flammable gases and explosives by providing informed advisory and inspection services supported by the community and by a practical legislative framework.

Geological Survey

To provide the geoscientific framework for mineral and energy exploration and the development of the State by expanding knowledge of the geology and energy resources, and the occurrence of geological hazards.

Energy Resources Development and Utilisation

To promote and facilitate exploration, development and efficient utilisation of energy resources in Queensland by managing exploration and mining tenures, identifying opportunities, determining policies and promoting energy-related research and development for the benefit of industry, community and government.

Safety in Mines Testing and Research Station

To improve safety and health in hazardous industries and enhance the development and application of new technologies, while maximising revenue through fee for service and externally funded grants by providing commercial research, testing, calibration, laboratory services and information management expertise and facilities, and by marketing a range of specialised services to meet client needs.

South Australia

The principal functions of the Department of Mines and Energy are to:

- administer mining legislation, including the granting of mineral leases and collection of royalties and fees;
- provide advice to Government and private industry on the exploration, development and processing of the State's mineral, energy and underground water resources;
- ensure that these resources are assessed and developed in accordance with Government policy;
- encourage exploration for mineral and energy resources by private enterprise;
- provide advice to the Government on energy development, utilisation and conservation, including alternative energy sources;
- provide research and specialist services in the geosciences;
- store geoscientific data on South Australia and make it available to the mining and energy industries, other Government Departments and the community;
- ensure that industries which are engaged in resource development adopt effective safety precautions within their operations and that the Government's environmental protection policies are adopted.

The Department has responsibility, through the Minister for Mines and Energy, for administration of legislation relating to Roxby Downs ore deposits, Cooper Basin oil and gas fields and the Stony Point Liquids Project.

Western Australia

The Western Australian Department of Mines carries out the registration of mining tenement titles, the survey of tenements and the subsequent collection of mining royalties. Through its Geological Survey Division, the Mines Department carries out geological investigations and surveys throughout the State. The results of this work are made available in both map and report format. The Chemistry Centre (WA), a division of the Mines Department provides analytical and research services to government, industry and the public. In addition the Department administers legislation relating to the use and transport of explosives and dangerous goods and the safety of workers in the mining and petroleum industries.

Tasmania

The Department of Mines assists industry in maintaining and increasing the value to the State of its mineral and petroleum resources. Companies are required to extract resources in the most complete manner and to minimise environmental impact. The Department is the State's centre for earth sciences and mineral resources. Mineral resource maps, geological maps, mineral exploration data bases and geophysical information are available.

The following services are provided:

- geological and mining engineering advice;
- engineering geology and ground water services;

- chemical and metallurgical laboratories;
- drill and plant hire;
- ore dressing research into metallurgical recoveries;
- selection and design of treatment plants;
- financial assistance is extended to approved mining lessees.

Northern Territory

The Department of Mines and Energy encourages and assists the development of an efficient mining and processing industry throughout the Northern Territory. Through five divisions the Department administers relevant legislation and provides a wide range of services.

Mines Division acts as a single point of contact for all mineral mining related matters in the Northern Territory. In this context it is also responsible for controlling and ensuring the efficient, orderly and safe exploration for, and recovery and utilisation of mineral resources in the Northern Territory. The Division formulates and implements policy and legislation designed to investigate the feasibility of mining and development proposals, provides technical advice to prospecting and mining operations, and strives for compatibility between mining and alternate land uses. It also administers all mining titles and is responsible for the collection of mineral royalties.

The Geological Survey Division provides the essential scientific basis for the overall operations of the Department of Mines and Energy. The Division studies the regional geology and geophysics of the Northern Territory and publishes reports of this work for use by industry, other government departments and the public.

Energy Division is responsible for the development and implementation of energy policies, research into alternative sources of energy, planning of energy supply and consumption in the Northern Territory and for safety and environmental supervision of petroleum exploration. This includes promotion of the exploration for and development of indigenous energy resources, research into diversification of the Northern Territory's energy base, energy conservation and security.

The Alligator Rivers Region Unit is responsible for the oversight and coordination of all stages of uranium mining, milling and rehabilitation processes in the Alligator Rivers Region. The unit is the focal point for the industry and the public for matters concerning uranium mines in the Northern Territory.

The Administration Division ensures effective administration of the Department's functions and responsibilities and provides a range of common services to operational divisions.

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. 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 129 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 \$27 million are being handled by AMIRA.

International Relations

Because Australia is a large supplier of certain minerals to the rest of the world, and because the welfare of the domestic industry depends to a large extent on the maintenance of a high level of exports, international relations are of considerable importance to the industry, and 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 International Tin Research Institute (ITRI) becoming a subsidiary of the ATPC in 1988. Since 1987, the ATPC has been operating a program of production restraint which, with the cooperation of non-members Brazil and China, is aimed at reducing the 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 1960. 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, and a further meeting is to occur in late 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, Suriname 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.

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.

Statistics are also available for *enterprises engaged in the mining industry*. The latest statistics for mining are in respect of 1984-85 and were published in the *Annual Economic Censuses and Surveys: Enterprise Statistics Australia, 1984-85, Final* (8103.0). A description of the statistics and broad summary tables, in respect of the 1983-84 and 1984-85 censuses and survey are given in Chapter 18.

The following table shows key items of data for establishments in Australia for 1987-88 based on the 1983 edition of the *Australian Standard Industrial Classification* (ASIC).

Mineral Production

This section contains details of the output (quantity and value) of selected minerals produced and the metallic content of ores, concentrates, etc.

The statistics shown have been derived from data collected in the annual mining census and in returns to the various State Mines Departments, supplemented in some cases by information made available by the Department of Primary Industries and Energy and from other sources.

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.

Quantity of minerals produced

The following tables show particulars of the quantities of selected minerals produced and contents of selected metallic minerals produced during 1987-88 and earlier years. Further data are available relative to all minerals in the annual publication *Mineral Production, Australia* (8405.0).

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS, BY INDUSTRY CLASS, 1987-88

ASIC code	at Description	Establish-ments end of 30 June	Employment at salaries June(a)	Wages and (b)	Turnover		Stocks		selected Closing	Total purchases transfers in and Value expenses		less added	Fixed capital expenditure disposals
					\$m	\$m	Opening	\$m		\$m	\$m		
	Metallic minerals—	No.	No.	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m	\$m
	Ferrous metal ores—												
1111	Iron ores	15	} 7,316	283	2,164	122	129	1,023	1,148	123			
1112	Iron ore pelletising	2											
	Non-ferrous metal ores—												
1121	Bauxite	9	2,040	67	601	27	56	112	518	15			
1122	Copper ores	6	3,030	107	541	69	58	195	334	145			
1123	Gold ores	195	8,175	245	2,524	203	360	1,120	1,561	865			
1124	Mineral sands	17	1,941	52	456	70	86	148	325	35			
1125	Nickel ores	3	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.			
1126	Silver-lead-zinc ores	13	5,237	206	963	114	101	438	512	118			
1127	Tin ores	10	468	18	69	15	8	36	26	4			
1128	Uranium ores	2	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.			
1129	Non-ferrous metal ores n.e.c.	9	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.			
11	Total metallic minerals	281	31,486	1,096	8,080	904	1,082	3,244	5,015	1,342			
	Coal, oil and gas—												
1201	Black coal	103	28,387	1,241	6,498	898	617	2,839	3,378	607			
1202	Brown coal	6	2,715	88	386	8	10	60	328	—			
1300	Oil and gas	37	4,943	218	4,273	226	227	371	3,902	1,684			
12-13	Total coal, oil and gas	146	36,045	1,547	11,157	1,133	855	3,270	7,608	2,291			
	Construction materials—												
1401	Sand and gravel	352	2,061	49	355	17	18	153	203	23			
1404	Construction materials n.e.c.	431	3,849	99	684	64	64	319	365	41			
14	Total construction materials	783	5,910	148	1,039	81	82	472	568	64			
	Other non-metallic minerals—												
1501	Limestone	56	729	17	94	6	7	43	52	5			
1502	Clays	91	469	10	41	7	10	25	19	17			
1504	Salt	14	589	20	117	21	24	37	83	11			
1505	Non-metallic minerals n.e.c.	104	1,525	46	384	93	104	135	260	37			
15	Total other non-metallic minerals	265	3,312	93	636	128	146	240	414	69			
	Total mining (excl. services to mining)	1,475	76,753	2,883	20,912	2,246	2,165	7,226	13,606	3,766			

(a) includes working proprietors. (b) Excludes amount drawn by working proprietors.

QUANTITY OF SELECTED MINERALS PRODUCED

<i>Mineral</i>		1985-86	1986-87	1987-88
METALLIC MINERALS				
Bauxite	'000 tonnes	31,864	33,168	35,142
Copper concentrate	"	n.p.	878	n.p.
Copper ore	tonnes	19,739	22,028	23,748
Gold bullion(a)	kg	81,008	112,393	167,486
Iron ore	'000 tonnes	n.p.	(b)96,364	(b)102,202
Lead concentrate	"	n.p.	n.p.	n.p.
Lead-copper concentrate	tonnes	38,209	28,774	32,763
Lead-zinc concentrate	"	55,534	124,094	178,694
Manganese ore—				
Metallurgical grade	'000 tonnes	1,152	864	1,060
Mineral sands—				
Ilmenite concentrate(c)	"	1,272	1,400	1,569
Rutile concentrate	"	n.p.	247	236
Zircon concentrate	"	476	432	469
Nickel concentrate	"	455	406	389
Tantalite-columbite concentrate	tonnes	n.p.	n.p.	n.p.
Tin concentrate	"	n.p.	n.p.	13,667
Tungsten concentrates—				
Scheelite concentrate	"	2,029	1,757	2,001
Wolfram concentrate	"	1,194	232	1
Uranium concentrate (U ₃ O ₈)	"	4,450	4,505	4,193
Zinc concentrate	'000 tonnes	n.p.	n.p.	n.p.
COAL				
Coal (other than lignite)—				
Saleable coal(d)				
Semi-anthracite	'000 tonnes	358	394	284
Bituminous	"	120,398	134,233	122,490
Sub-bituminous	"	13,599	14,096	13,654
Washery rejects(d)	"	29,314	33,717	31,333
Lignite—				
For briquettes	"	2,157	2,087	1,956
Other	"	33,312	39,712	41,525
Briquettes	"	851	828	807
OIL AND GAS				
Crude oil (stabilised)	megalitres	31,669	30,205	31,297
Natural gas	gigalitres	14,274	14,488	14,751
Ethane	"	196	161	189
CONSTRUCTION MATERIALS				
Sand	'000 tonnes	28,019	29,953	29,465
Gravel	"	18,677	14,952	14,895
Crushed and broken stone	"	70,061	66,772	65,944
Other (decomposed rock, dimension stone, etc.)	"	33,595	30,009	29,382
OTHER NON-METALLIC MINERALS				
Clays	'000 tonnes	7,911	8,884	n.p.
Limestone (including shell and coral)	"	n.p.	12,338	n.p.
Salt	"	5,735	n.p.	n.p.
Silica	"	n.p.	2,209	2,596

(a) Includes alluvial gold. (b) Tasmanian production is in the form of pellets. (c) Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. (d) Raw coal is saleable coal plus washery rejects.

CONTENTS OF SELECTED METALLIC MINERALS PRODUCED—*continued*

<i>Contents of metallic minerals produced</i>		1985-86	1986-87	1987-88
Antimony	tonnes	1,262	1,202	1,159
Cadmium	"	2,167	n.p.	n.p.
Cobalt	"	2,918	3,046	2,504
Copper	"	241,706	246,085	n.p.
Gold	kg	64,780	n.p.	n.p.
Iron(a)	'000 tonnes	n.p.	61,456	65,080
Lead	tonnes	n.p.	n.p.	n.p.
Manganese	"	n.p.	n.p.	n.p.
Monazite	"	15,538	10,474	10,393
Nickel	"	80,528	74,509	72,231
Palladium	kg	421	490	454
Platinum	"	94	105	82
Silver	"	1,074,227	1,036,905	1,135,073
Sulphur	tonnes	449,706	517,250	531,965
Tantalite-columbite (Ta ₂ O ₅ + Nb ₂ O ₅)	kg	n.p.	n.p.	n.p.
Tin	tonnes	7,391	n.p.	n.p.
Titanium dioxide (TiO ₂)	"	1,023,561	954,371	1,457,723
Tungstic oxide (W ₂ O ₃)	mtu (b)	232,253	143,996	149,172
Yttrium oxide (Y ₂ O ₃)	kg	n.p.	n.p.	n.p.
Zinc	tonnes	722,599	n.p.	n.p.
Zirconium dioxide (ZrO ₂)	"	331,678	302,789	327,511

(a) Excludes iron content of iron oxide not intended for metal extraction. Includes iron contained in iron concentrate. (b) Metric ton unit (mtu) equals 10 kilograms.

Value of minerals produced

The following table shows the value of principal minerals produced during 1987-88 and earlier years. Further data are available in the annual publication *Mineral Production, Australia* (8405.0).

VALUE OF SELECTED MINERALS PRODUCED
(\$'000)

<i>Mineral</i>	1985-86	1986-87	1987-88
METALLIC MINERALS			
Bauxite	n.p.	n.p.	n.p.
Copper concentrate	341,334	n.p.	n.p.
Copper ore	1,130	1,170	n.p.
Gold bullion(a)	944,139	(b)1,752,158	(b)2,585,011
Iron ore	n.p.	1,884,198	(b)1,687,541
Lead concentrate	n.p.	n.p.	n.p.
Lead-copper concentrate	n.p.	42,333	n.p.
Lead-zinc concentrate	7,786	27,261	n.p.
Manganese ore—			
Metallurgical grade	n.p.	n.p.	n.p.
Mineral sands—			
Ilmenite concentrate(c)	57,003	88,664	152,246
Rutile concentrate	n.p.	n.p.	133,011
Zircon concentrate	62,441	80,353	n.p.
Nickel concentrate	n.p.	n.p.	n.p.
Tantalite-columbite concentrate	n.p.	n.p.	n.p.
Tin concentrate	89,857	n.p.	n.p.
Tungsten concentrates—			
Scheelite concentrate	n.p.	8,415	n.p.
Wolfram concentrate	6,310	872	4
Uranium concentrate	n.p.	n.p.	n.p.
Zinc concentrate	269,048	n.p.	n.p.

VALUE OF SELECTED MINERALS PRODUCED—continued
(*\$'000*)

Mineral	1985-86	1986-87	1987-88
COAL			
Coal (other than lignite)—			
Saleable coal—			
Semi-anthracite	10,904	12,730	8,187
Bituminous	4,770,138	5,093,916	(b)4,118,386
Sub-bituminous	398,289	n.p.	395,156
Lignite—			
For briquettes
Other	233,912	268,314	301,527
Briquettes	15,714	25,019	18,717
OIL AND GAS			
Oil and Gas	n.p.	3,702,445	4,138,725
CONSTRUCTION MATERIALS			
Sand	161,075	162,127	n.p.
Gravel	109,515	103,126	n.p.
Crushed and broken stone	536,271	493,687	n.p.
Other (Decomposed rock, dimension stone, etc.)	114,191	111,838	n.p.
OTHER NON-METALLIC MINERALS			
Clays	46,257	(d)53,156	(d)56,451
Gems—			
Diamond	147,568	284,095	248,203
Opal	49,950	67,425	106,077
Sapphire	12,066	16,457	22,841
Limestone (incl. shell and coral)	n.p.	72,075	n.p.
Salt	99,194	n.p.	n.p.
Silica	n.p.	24,815	n.p.

(a) Includes alluvial gold. (b) Excludes Tasmanian production. (c) Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. (d) Excludes Northern Territory.

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	51.1
Victoria	11.1	15.2	12.3	15.5	33.9	21.4
Queensland	80.7	79.5	88.6	120.6	159.3	133.4
South Australia	54.4	57.6	48.9	11.0	18.9	16.5
Western Australia	184.7	189.8	205.2	323.3	466.3	392.0
Tasmania	18.0	17.8	10.6	10.9	10.4	15.1
Northern Territory	24.2	28.0	24.6	27.9	48.9	66.9
Australia	428.7	437.3	422.0	556.8	799.2	696.5

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	234.5
Offshore	540.6	373.6	398.0	134.1	223.2	407.0
Total	823.7	793.2	765.7	305.2	495.1	641.5

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

**PRODUCTION (a) OF PRINCIPAL MANUFACTURED PRODUCTS
OF MINERAL ORIGIN—continued**

Commodity		1986-87	1987-88	1988-89
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.

Considerable quantities of metallic ores, concentrates, slags, and residues are exported from Australia for refining overseas. The following table shows selected items exported during 1987 and their principal metallic content as estimated by assay.

**PRINCIPAL METALLIC CONTENTS OF SELECTED ORES AND CONCENTRATES ETC.
EXPORTED FROM AUSTRALIA, 1987**

Ores and concentrates etc.	<i>Metallic contents—estimated from assay</i>							
	<i>Copper</i>	<i>Lead</i>	<i>Zinc</i>	<i>Tin</i>	<i>Iron</i>	<i>Tungstic oxides</i>	<i>Gold</i>	<i>Silver</i>
	tonnes	tonnes	tonnes	tonnes	'000 tonnes	tonnes	kg	kg
Copper concentrate	55,817	809	1,201	238	—	—	3,939	32,643
Blister copper	—	—	—	—	—	—	—	—
Copper (a)	1,395	1,110	—	18	—	—	457	12,870
Gold concentrate	3,720	—	—	—	—	—	1,287	639
Lead concentrate	1,621	64,003	6,684	—	—	—	893	197,693
Lead bullion	—	191,234	—	—	—	—	67	501,223
Lead slags and residues	133	826	—	16	—	—	38	2,357
Zinc concentrate	289	13,607	426,508	—	—	—	100	102,221
Zinc slags and residues	—	—	4,506	—	—	—	—	—
Tin concentrate	—	—	—	6,835	—	—	—	—
Tin slags and residues	—	—	—	—	—	—	—	—
Iron ore—								
Pellets	—	—	—	—	1,211	—	—	—
Fines	—	—	—	—	34,895	—	—	—
Lump	—	—	—	—	24,057	—	—	—
Scheelite concentrate	—	—	—	—	—	1,399	—	—
Wolfram concentrate	—	—	—	—	—	2	—	—
Total metallic content	62,975	271,589	438,899	7,107	60,163	1,401	6,781	849,646

(a) Includes copper matte, copper slags and residues and copper-lead dross and speiss.

REVIEW OF RECENT DEVELOPMENTS IN THE AUSTRALIAN MINERAL INDUSTRY

(Source: Australian Bureau of Agricultural and Resource Economics)

Major recent developments in the Australian mineral 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 (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 6 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 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 liquified 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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