15

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 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, tin, 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 and the Australian Mineral Industry Quarterly and Annual Reviews.

Administration

All mineral rights in Australia are vested in the Crown except those on land which was granted before the Crown began to reserve mineral rights. In practice, these private mineral rights are not important. In the States, these rights are held by the State governments. On 1 July 1980, executive authority with respect to mining and minerals except in relation

to certain prescribed substances within the meaning of the Atomic Energy Act (principally uranium) was transferred from the Commonwealth Government to the Northern Territory Government. Private mineral rights in the Australian Capital Territory are vested in the Commonwealth Government. The Commonwealth Government is able also 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 Consultative 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.

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)

	1981–82	*1982–83*	*1983–84*	*1984–85*	*1985–86*	*1986–87*
New South Wales*(a)*	88,186	105,403	111,100	109,558	119,315	136,295
Victoria*(b)(c)*	108,782	124,861	180,585	206,086	213,292	157,991
Queensland*(a)*	81,450	89,793	107,673	142,640	196,413	176,751
South Australia	8,811	9,321	14,172	27,739	58,352	33,592
Western Australia	81,330	102,454	*(d)*168,477	131,640	162,208	154,056
Tasmania	2,209	2,082	2,137	1,043	1,507	1,641
Northern Territory	3,020	2,934	3,963	5,483	8,079	7,186
Commonwealth Government*(c)*	56,580	83,609	103,535	114,330	187,091	119,806
Total	**430,368**	**520,457**	**691,642**	**738,519**	**946,257**	**787,318**

(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 1988

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, drilling and well-head plant; plant for the liquefaction of natural gas; 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 and plant necessary for those operations; access roads; certain treatment plant; 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 may be allowed in lieu of spreading the cost over the life of the oil field or mine. 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 role of BMR is to:

- develop an integrated, comprehensive, scientific understanding of the geology of the Australian continent, the Australian offshore area and the Australian Antarctic Territory, as a basis for minerals exploration; this to be done where appropriate in cooperation with State Geological Surveys and other relevant organisations and having regard to priorities for the search for minerals approved by the Minister for Primary Industries and Energy;
- be the primary national source of geoscience data and to publish and provide information;
- undertake mineral resource assessments in accordance with programs and priorities approved by the Minister for Primary Industries and Energy with the advice of the BMR.

At 31 August 1987, BMR had a full-time staff of approximately 565 people, including 245 research and other scientists, (geologists, geophysicists, chemists, engineers, and mineral economists etc.), 215 technical and cartographic and around 105 clerical and other support staff.

BMR's research program is carried out by four Divisions—Geophysics, Continental Geology, Marine Geosciences and Petroleum Geology, and Petrology and Geochemistry. Mineral and petroleum resource assessments are undertaken by the Resource Assessment Division which includes Mineral Commodities Branch, a Petroleum Branch, a Mineral Projects and Evaluation Branch, and a Geoscience Computing and Database Branch. Other branches are Planning and Programs, and Special Projects and Geoscience Services.

BMR maintains laboratories in Canberra engaged on geochemical, geochronological, organic geochemistry, and petroleum technological studies, and basic research into the design and testing of geophysical equipment. It also maintains geophysical observatories at Kowen Forest (Australian Capital Territory), Mundaring (Western Australia), Mawson (Antarctica), and Macquarie Island. The geophysical observatories are engaged in geomagnetic, ionospheric, and seismology research.

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 primary objective of the Department of Mineral Resources is to promote the responsible development of mineral resources in New South Wales. The Department administers the various Acts (Coal, Petroleum and Mining) and grants titles to encourage and facilitate the exploration for, prospecting and development of, the State's mineral resources. The Department's staff is deployed in many diverse areas of activity to encourage and assist mining and resource development projects by the mining industry.

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 Department's Mineral Resources Development Laboratory located at Lidcombe particularly in the fields of mineral product utilisation, environmental management and geochemical analysis. The Geological and Mining Museum, one of the State's foremost specialist museums, is maintained by the Department, as is

the reference library of geology, mining and allied topics situated at the Department's head office and Bore Core Library situated at Londonderry, near Penrith.

The Department is engaged in the continuous assessment of the State's mineral resources; its coal exploration and assessment programme 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, ground water 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 the petroleum, mineral and ground water potential of the State. A comprehensive library is maintained, while a core library retains cores and cuttings from government and private drilling operations. The administration of petroleum, pipeline, mining and extractive industry legislation ensures that mineral, stone and petroleum exploration and production (both onshore and offshore), mining and quarrying are regulated and controlled. Technical assistance and advice are available for mineral, stone, ground water and petroleum exploration and prospecting. Five stamp batteries located throughout the State provide an ore-crushing service to enable test crushing to be made at nominal cost. Information is available on mining law and mineral statistics. Assays of ores and analytical services are also available from the State Chemical Laboratory for a fee.

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 with which to do business. To this end, it has, in the last two years, undergone a major organisational review and the consequences of that review are now becoming evident.

Perhaps the most important of these is the re-arrangement of the management structure, with the introduction of program management systems and an emphasis on facilitation of mineral and energy resources exploration and development.

Broadly, the Department is now structured around a number of clearly defined programs which report to the Department's directorate comprising a Director-General and two Assistant Directors-General. In addition to the comprehensive skills and expertise of the program management systems, 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 enhance the delivery of services to Departmental clients by providing human resource management systems and advice, organisational improvement initiatives and executive support.

Geological Survey—Regional Investigations
To provide the geoscientific framework for mineral and energy exploration and the development of the State generally by expanding knowledge of the geology and the factors controlling the distribution of mineral and energy resources.

Geological Survey—Services
To furnish specialised geoscientific information, by provision of a geoscientific consultancy service and drilling, core storage and field services to the mining and energy industries and Departmental and other Government clients.

Information Services
To help satisfy the mineral, energy, resources, social and environmental information needs of industry, Government, media, the educational community and the broader public by providing accurate and timely information services and products from a range of data and human skills available to the Department of Mines.

Titles and Tenures Services
To facilitate and regulate the development of the State's mineral and energy resources consistent with the needs of the mining industry, Government Departments and the community by:

- administering and registering exploration and mining tenures;
- determining the availability of land to such tenures, or for setting apart pursuant to the various mining statutes; and
- supervising, administering and promoting fossicking activities.

Resource Economics
To assist Government decision making about resource development and management and to collect an adequate and equitable financial return to the community by providing economic and commercial policy advice and information and by management of the State's royalty system.

Mineral Resources Development
To facilitate the assessment, development and utilisation of Queensland's mineral resources for the benefit of the community in accordance with Government policy and sound economic and environmental management.

Energy Resources Development and Utilisation
To facilitate exploration, development and efficient utilisation of energy resources in Queensland by identifying opportunities, determining policies, promoting energy-related research, development and demonstration and by providing technology transfer for the benefit of industry, community and Government in Queensland.

Mining Safety and Technology
To promote improvement in safety, health, technology and environmental management at mines, petroleum operations and installations by providing informed advisory and monitoring services supported by the community and by a practical legislative framework.

Dangerous Goods
To contribute to the optimum safety of personnel and the protection of the environment at installations and in the practices and procedures used with dangerous goods by providing expert advisory, coordination and inspection services together with a practical legislative framework to suppliers and users.

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.

Bureau of Mineral Resources, Geology and Geophysics—BMR

BMR is one of the largest geoscience research organisations in Australia. Its role is to develop an integrated scientific understanding of the geology of the Australian continent, its Territories and offshore areas, as a basis for mineral exploration and resource assessment.

BMR carries out programs in:

- Fossil fuels and minerals research: with components covering Controls on Fossil Fuels Occurrence; Onshore Sedimentary Basins; Offshore Sedimentary Basins; Overseas Basins; Mineral Deposits and Provinces; Regolith, Related Resources and Remote Sensing; Regional Structure and Tectonics; and Geophysical Mapping (Continental and Offshore).
- Ground water research and assessment: comprising a component on Basin Hydrogeology.
- National geophysical observatories and Antarctic surveys: involving components on Earthquake and Volcanic Hazards; Monitoring of Nuclear Explosions; Geomagnetism; Antarctic Onshore Surveys; and Antarctic Offshore Basins.
- Petroleum and minerals resource assessment: covering components on Petroleum Resource Assessment and Availability; and Mineral Resource Assessment and Availability.
- National geoscience databases: including components on Databases Coordination, Research and Operations; and Geoscience Maps, Cartography and Image Processing.
- BMR management and information: with components on Geoscience Management, Coordination and Public Relations; Publications; Geoscience Library and Museum; Resources Management and Services; and International Agreements and Project Coordination.

Commonwealth Scientific and Industrial Research Organization—CSIRO

Minerals research by the Commonwealth Scientific and Industrial Research Organization (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 more than 150 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 $20 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 commitments are discussed below.

International Tin Agreement

The present International Tin Agreement is the sixth in a series of agreements, the first of which commenced on 1 July 1956. For details of earlier agreements *see Year Books* No. 57, pages 911–12; No. 61, page 942 and No. 66, page 376.

The Sixth International Tin Agreement is administered by the International Tin Council which has the following members: Producers—Australia, Indonesia, Malaysia, Nigeria, Thailand, Zaire; Consumers—Belgium, Luxembourg, Canada, Denmark, Finland, France, Germany (Federal Republic of), Greece, India, Ireland (Republic of), Italy, Japan, Netherlands, Norway, Sweden, Switzerland and the United Kingdom.

Prior to the expiry date of the present (Sixth) Agreement on 30 June 1987, member countries agreed to extend the Agreement for two years from 1 July 1987 to 30 June 1989. During this period of extension, the economic provisions of the Agreement will remain suspended following the cessation of buffer stock operations by the International Tin Council on 24 October 1985.

Association of Tin Producing Countries—ATPC

The ATPC came into force 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, Zaire. The main objective of the ATPC is to encourage greater consumption of tin through research, development and promotion. Since 1987, the ATPC has been operating a program of production restraint in an attempt to reduce the overhang of stocks on the world market.

International Lead and Zinc Study Group

With the cessation of stockpile buying of lead and zinc by the United States Government in 1958, world producers were faced with the prospect of a serious imbalance between world supply and demand for these metals. To meet this problem, a series of meetings was held, culminating in the formation of the International Lead and Zinc Study Group in January 1960. The following countries are currently members of the Study Group: Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Czecholslovakia, Denmark, Finland, France, Germany (Federal Republic of), Hungary, India, Iran, Italy, Japan, Korea (Republic of), Morocco, Netherlands, Norway, Peru, Poland, South Africa, Spain, Sweden, Tunisia, Union of Soviet Socialist Republics, United Kingdom, United States of America and Yugoslavia.

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 providing continuous information on the supply and demand situation and its probable development.

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. Membership currently accounts for about 45 per cent of world iron ore exports. The Agreement establishing the

Association provides for a Conference of Ministers once every two years and a Board, comprising representatives of each member country, which meets twice a year. The Association's Secretariat publishes a statistical bulletin twice a year.

Following the receipt of notices of intention to withdraw from the Association by Sweden, Peru and Sierra Leone, member countries are considering options for the future role and activities of the Association and its statistical activities.

Inter-governmental Council of Copper Exporting Countries—CIPEC

CIPEC was established in 1967 by the Governments of Chile, Peru, Zaire and Zambia as an inter-governmental consultative organisation for copper exporting countries.

Indonesia, Yugoslavia and Papua New Guinea are Associate Members of CIPEC. Australia was also an Associate Member but withdrew from the Council as of 31 December 1987.

The key objectives of CIPEC are to coordinate measures to achieve continuous growth in real earnings from copper exports and to harmonise the decisions and policies of members relating to copper production and marketing.

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.

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). Enterprise statistics for mining are now produced annually and should be available within two years of the end of the financial year to which they relate. 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 1986–87 based on the 1983 edition of the *Australian Standard Industrial Classification* (ASIC).

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS BY INDUSTRY CLASS, 1986–87

Industry		*Establishments at 30 June*	*Average employment over whole year(a)*	*Wages and salaries*	*Turnover*	*Stocks*		*Total purchases transfers in and selected expenses*	*Value added*
ASIC code	*Description*			*(b)*		*Opening*	*Closing*		
		No.	No.	$m	$m	$m	$m	$m	$m
	Metallic minerals—								
	Ferrous metal ores—								
1111	Iron ores	16							
1112	Iron ore pelletising	2	8,032	276	2,237	115	171	1,117	1,176
	Non-ferrous metal ores—								
1121	Bauxite	8	2,124	64	514	31	28	97	414
1122	Copper ores	4	2,447	85	396	54	66	134	274
1123	Gold ores	177	6,098	196	1,693	106	182	649	1,120
1124	Mineral sands	16	1,747	44	333	42	67	138	220
1125	Nickel ores	5	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1126	Silver–lead–zinc ores	14	5,395	185	760	129	121	349	403
1127	Tin ores	15	723	20	75	19	19	40	36
1128	Uranium ores	2	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1129	Non-ferrous metal ores n.e.c.	9	736	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
11	*Total metallic minerals*	*268*	*29,472*	*974*	*6,699*	*729*	*941*	*2,743*	*4,168*
	Coal, oil and gas—								
1201	Black coal	114	32,459	1,315	6,971	763	898	2,997	4,110
1202	Brown coal	6	2,669	79	321	11	8	54	264
1300	Oil and gas	31	4,792	187	4,015	184	234	352	3,713
12,13	*Total coal, oil and gas*	*151*	*39,920*	*1,582*	*11,308*	*958*	*1,140*	*3,403*	*8,087*
	Construction materials—								
1401	Sand and gravel	349	2,056	44	319	15	18	145	177
1404	Construction materials n.e.c.	426	3,828	92	612	55	62	297	322
14	*Total construction materials*	*775*	*5,884*	*136*	*930*	*70*	*80*	*441*	*499*
	Other non-metallic minerals—								
1501	Limestone	56	652	14	83	6	7	42	42
1502	Clays	88	232	5	35	6	7	19	17
1504	Salt	13	578	18	117	22	21	34	82
1505	Non-metallic minerals n.e.c.	100	1,329	38	322	38	89	116	257
15	*Total other non-metallic minerals*	*257*	*2,791*	*75*	*557*	*72*	*124*	*211*	*398*
	Total mining (excl. services to mining)	**1,451**	**78,067**	**2,767**	**19,494**	**1,829**	**2,284**	**6,798**	**13,152**

(a) Includes working proprietors. *(b)* Excludes amount drawn by working proprietors.

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 1986–87 and earlier years. Further data are available relative to all minerals in the annual publication *Mineral Production, Australia* (8405.0).

QUANTITY OF SELECTED MINERALS PRODUCED

Mineral		*1984–85*	*1985–86*	*1986–87*
METALLIC MINERALS				
Bauxite	'000 tonnes	n.p.	31,864	33,168
Copper concentrate	"	n.p.	n.p.	878
Copper ore	"	28,737	19,739	22,028
Gold bullion*(a)*	kg	n.p.	81,008	n.p.
Iron ore	'000 tonnes	n.p.	n.p.	*(b)*96,364
Lead concentrate	"	764	n.p.	n.p.
Lead-copper concentrate	tonnes	28,200	38,209	28,774
Lead-zinc concentrate	"	46,276	55,534	124,094
Manganese ore—				
Metallurgical grade	'000 tonnes	n.p.	1,152	864
Mineral sands—				
Ilmenite concentrate*(c)*	"	1,264	1,272	1,400
Rutile concentrate	"	191	n.p.	247
Zircon concentrate	"	452	476	432
Nickel concentrate	"	486	455	406
Tantalite-columbite concentrate	tonnes	185	n.p.	n.p.
Tin concentrate	"	13,321	n.p.	n.p.
Tungsten concentrates—				
Scheelite concentrate	"	2,045	2,029	1,757
Wolfram concentrate	"	1,427	1,194	232
Uranium concentrate	"	n.p.	n.p.	n.p.
Zinc concentrate	'000 tonnes	1,311	n.p.	n.p.
COAL				
Coal (other than lignite)—				
Saleable coal*(d)*				
Semi-anthracite	'000 tonnes	231	358	394
Bituminous	"	105,859	120,398	134,233
Sub-bituminous	"	12,177	13,599	14,096
Washery rejects*(d)*	"	26,906	29,314	33,717
Lignite—				
For briquettes	"	2,131	2,157	2,087
Other	"	36,369	33,312	39,712
Briquettes	"	802	851	828
OIL AND GAS				
Crude oil (stabilised)	megalitres	30,919	31,669	30,205
Natural gas	gigalitres	12,958	14,274	14,488
Ethane	"	200	196	161
CONSTRUCTION MATERIALS				
Sand	'000 tonnes	27,017	28,019	29,888
Gravel	"	16,951	18,677	14,952
Crushed and broken stone	"	65,573	70,061	66,772
Other (decomposed rock, dimension stone, etc.)	"	32,298	33,595	30,009
OTHER NON-METALLIC MINERALS				
Clays	'000 tonnes	8,620	7,911	8,882
Limestone (including shell and coral)	"	11,811	n.p.	12,338
Salt	"	n.p.	5,735	n.p.
Silica	"	n.p.	n.p.	2,209

(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

Contents of metallic minerals produced		*1984–85*	*1985–86*	*1986–87*
Antimony	tonnes	1,409	1,262	1,202
Cadmium	"	2,670	2,167	n.p.
Cobalt	"	2,602	2,918	3,046
Copper	"	251,782	241,706	246,085
Gold	kg	48,853	64,780	n.p.
Iron*(a)*	'000 tonnes	n.p.	n.p.	61,456
Lead	tonnes	n.p.	n.p.	n.p.
Manganese	"	n.p.	n.p.	n.p.
Monazite	"	14,001	15,538	10,474
Nickel	"	82,267	80,528	74,509
Palladium	kg	461	421	490
Platinum	"	81	94	105
Silver	"	1,044,105	1,074,227	1,036,905
Sulphur	tonnes	429,710	449,706	517,250
Tantalite–columbite (Ta_2O_5 + Nb_2O_5)	kg	87,648	n.p.	n.p.
Tin	tonnes	n.p.	7,391	n.p.
Titanium dioxide (TiO_2)	"	858,586	1,023,561	954,371
Tungstic oxide (WO_3)	mtu *(b)*	239,883	232,253	143,996
Yttrium oxide (Y_2O_3)	kg	12,600	n.p.	n.p.
Zinc	tonnes	744,401	722,599	n.p.
Zirconium dioxide (ZrO_2)	"	314,544	331,678	302,789

(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 1986–87 and earlier years. Further data are available in the annual publication *Mineral Production, Australia* (8405.0).

VALUE OF SELECTED MINERALS PRODUCED
($'000)

Mineral	*1984–85*	*1985–86*	*1986–87*
METALLIC MINERALS			
Bauxite	n.p.	n.p.	n.p.
Copper concentrate	305,939	341,334	n.p.
Copper ore	1,411	1,130	1,170
Gold bullion*(a)*	n.p.	n.p.	944,139
Iron ore	n.p.	n.p.	*(b)*1,884,198
Lead concentrate	n.p.	n.p.	n.p.
Lead-copper concentrate	n.p.	n.p.	42,333
Lead-zinc concentrate	8,038	7,786	27,261
Manganese ore—			
Metallurgical grade	n.p.	n.p.	n.p.
Mineral sands—			
Ilmenite concentrate*(c)*	45,858	57,003	88,664
Rutile concentrate	67,092	n.p.	n.p.
Zircon concentrate	49,659	62,441	80,353
Nickel concentrate	n.p.	n.p.	197,919
Tantalite-columbite concentrate	4,827	n.p.	n.p.
Tin concentrate	n.p.	89,857	n.p.
Tungsten concentrates—			
Scheelite concentrate	n.p.	n.p.	8,415
Wolfram concentrate	7,435	6,310	872
Uranium concentrate	n.p.	n.p.	n.p.
Zinc concentrate	341,303	269,048	n.p.

For footnotes *see* end of table.

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

Mineral	*1984–85*	*1985–86*	*1986–87*
COAL			
Coal (other than lignite)—			
Saleable coal—			
Semi-anthracite	5,733	10,904	12,730
Bituminous	3,988,421	4,770,138	5,093,916
Sub-bituminous	330,781	398,289	n.p.
Lignite—			
For briquettes	..	..	..
Other	204,758	233,912	268,314
Briquettes	23,851	15,714	25,019
OIL AND GAS			
Oil and Gas	4,034,400	n.p.	3,702,445
CONSTRUCTION MATERIALS			
Sand	141,297	161,075	162,127
Gravel	110,347	109,515	103,126
Crushed and broken stone	462,087	536,271	493,687
Other (Decomposed rock, dimension stone, etc.)	90,027	114,191	111,838
OTHER NON-METALLIC MINERALS			
Clays	n.p.	46,257	55,503
Gems—			
Diamond	n.a.	147,568	284,095
Opal*(d)*	45,079	49,950	67,425
Sapphire	13,627	12,066	16,457
Limestone (incl. shell and coral)	64,167	n.p.	72,075
Salt	n.p.	99,194	n.p.
Silica	18,269	n.p.	24,815

(a) Includes alluvial gold. *(b)* Value for Tasmanian production is for pellets. *(c)* Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. *(d)* Partly estimated.

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 exploration for minerals *other than petroleum* are derived from the annual mineral exploration census conducted by the Australian Bureau of Statistics (ABS) in each State and the Northern Territory (in New South Wales the census is conducted jointly with the State Department of Mineral Resources).

Petroleum exploration statistics are obtained from the quarterly census conducted by the ABS.

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)
($'000)

	1981–82	*1982–83*	*1983–84*	*1984–85*	*1985–86*	*1986–87*
Expenditure—						
New South Wales	89,751	65,713	55,563	49,464	51,793	47,587
Victoria	25,140	18,532	11,120	15,179	12,318	15,491
Queensland	124,976	88,428	80,749	79,512	88,559	120,649
South Australia	64,772	50,590	54,380	57,554	48,863	10,961
Western Australia	216,072	170,380	184,699	189,817	205,245	323,279
Tasmania	22,841	18,631	18,042	17,798	10,619	10,917
Northern Territory	32,021	25,637	24,150	28,005	24,636	27,894
Australia	**575,572**	**437,911**	**428,702**	**437,328**	**442,033**	**556,778**

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

PRIVATE PETROLEUM EXPLORATION

	1981–82	*1982–83*	*1983–84*	*1984–85*	*1985–86*	*1986–87*
Expenditure ($ million)—						
Onshore	378.6	345.1	283.1	419.6	367.8	171.0
Offshore	425.4	582.3	540.6	373.6	398.0	134.1
Total	**804.0**	**927.4**	**823.7**	**793.2**	**765.7**	**305.2**

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		*1985–86*	*1986–87*	*1987–88*
	METALS (*b*)			
Non-ferrous—				
Alumina	'000 tonnes	9,080	9,839	10,330
Refined aluminum	"	870	921	1,074
Blister copper*(c)*	"	162	174	180
Refined copper	"	163	171	186
Lead bullion (for export)*(c)*	"	188	183	201
Refined lead	"	206	142	182
Refined zinc	"	297	300	306
Refined tin	tonnes	2,208	784	501
Ferrous—				
Pig iron	'000 tonnes	5,925	5,783	5,455
Raw steel	"	6,826	6,387	6,093
Precious—				
Refined gold *(d)*	kg	56,928	81,856	111,934
Refined silver	"	315,337	270,608	304,426
	FUELS			
Coal products—				
Metallurgical coke	'000 tonnes	3,534	3,253	3,727
Brown coal briquettes	"	852	811	809
Petroleum products *(e)*—				
Diesel-automotive oil	megalitres	8,139	8,198	9,399
Industrial fuel and marine fuel	"	329	240	229
Fuel oil for burning	"	2,264	2,274	2,078
Automotive petrol	"	15,652	15,296	15,995
	BUILDING MATERIALS			
Clay bricks	millions	1,980	1,847	1,870
Portland cement	'000 tonnes	6,106	5,920	6,150
	CHEMICALS			
Sulphuric acid	'000 tonnes	1,788	1,678	1,816
Superphosphate *(f)*	"	2,610	2,769	3,194

(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*: Bureau of Mineral Resources, Geology and Geophysics (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 P_2O_5 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.	*Metallic contents—estimated from assay*							
	Copper	*Lead*	*Zinc*	*Tin*	*Iron*	*Tungstic oxides*	*Gold*	*Silver*
	tonnes	tonnes	tonnes	tonnes	'000 tonnes	tonnes	kg	kg
Copper concentrate	38,028	1,724	2,434	—	—	—	104	5,512
Blister copper	3,491	—	—	—	—	—	—	403
Copper matte, slags, etc. *(a)*	1,247	394	80	10	—	—	75	6,925
Gold concentrate	—	—	—	—	—	—	2	—
Lead concentrate	2,550	56,657	2,941	—	—	—	999	155,623
Lead bullion	—	178,300	—	—	—	—	63	436,396
Lead slags and residues	11	6,701	3	8	—	—	120	16,643
Zinc concentrate	266	11,027	410,733	—	—	—	40	111,901
Zinc slags and residues	—	—	5,795	—	—	—	—	—
Tin concentrate	—	—	—	7,005	—	—	—	—
Tin slags and residues	—	13	—	5	—	—	—	—
Iron ore—								
Pellets	—	—	—	—	1,358	—	—	—
Fines	—	—	—	—	25,010	—	—	—
Lump	—	—	—	—	22,900	—	—	—
Scheelite concentrate	—	—	—	—	—	1,340	—	—
Wolfram concentrate	—	—	—	—	—	86	—	—
Total metallic content	45,593	254,816	421,986	7,028	49,268	1,426	1,403	733,403

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

REVIEW OF RECENT DEVELOPMENTS IN THE AUSTRALIAN MINERAL INDUSTRY

(*Source*: **Bureau of Mineral Resources, Geology and Geophysics**)

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 *Australian Mineral Industry Annual Review 1987* published by the Bureau of Mineral Resources, Geology and Geophysics. That publication contains comprehensive reviews of mineral commodities of importance to the Australian economy, as well as a general review of the industry's performance during the year. The *Australian Mineral Industry Quarterly*, Volume 40, Number 4, details Australia's identified mineral resources, 1987

General review of 1987

The Gross Domestic Product (GDP) of Australia in 1986–87 was $260,379 million, of which an estimated $13,376 million was generated by the mining industry, excluding smelting and refining. If smelting and refining were included, an estimated $3,230 million could be added to this figure, thus making the mineral industry the largest primary sector contributor to the GDP.

The ex-mine value of mine production in Australia in 1987 was $21,207 million. This was $1,488 million, or 8 per cent more than the 1986 value of $19,720 million. However the 1987 value was $901 million below the record level of $22,108 million established in 1985, mainly because crude oil prices were still well below 1985 levels. With a few notable exceptions, most major mineral commodities improved on their 1986 performance. There were substantial increases in the ex-mine values of gold, crude oil, lead, natural gas, mineral sands, brown coal and copper. Major commodities to suffer significant falls were black coal, iron ore, LPG, construction materials and uranium.

Exports—1987

The value of mineral exports rose substantially (10 per cent) to $16,308 million, a new record. Major minerals to show gains on their 1986 levels included alumina, aluminium metal, copper, crude oil, gold, lead, mineral sands (ilmenite, rutile and zircon), silver and zinc. Decreases were recorded for black coal, iron ore, LPG, nickel and uranium.

Black coal, at $5,045 million, remained Australia's largest single export earner, and accounted for about 31 per cent of the value of mineral exports. Gold, which increased by 74 per cent to $1,694 million in 1987, was the second largest (ranked fifth in 1986), followed by iron ore $1,686 million (down 13 per cent compared with 1986), alumina $1,539 million (up 8 per cent), aluminium metal $1,420 million (up 46 per cent) and crude oil $994 million (up 49 per cent). These six minerals together accounted for over three-quarters of mineral exports and almost one-third of the total value of all merchandise exports.

Imports—1987

The value of mineral imports has traditionally been dominated by crude oil although over recent years that domination has weakened. In 1987 imports of crude oil rose by 29 per cent to $1,251 million following a partial recovery in prices in the wake of the collapse of world prices in late 1985. Crude oil imports represented 65 per cent of the total mineral import bill of $1,910 million which was up 24 per cent on the 1986 level. Other significant mineral imports included diamonds, gold bullion, iron and steel, phosphate rock and sulphur. Australia's mineral balance of trade (value of mineral exports minus value of mineral imports) was a record $14,398 million in 1987. ($13,276 million in 1986.)

Pattern of mineral trade—1987

During 1987, Australia exported minerals to more than 100 countries. Japan accounted for 37 per cent of these exports by value, down from 41 per cent in 1986 and its lowest share since 1965 (33 per cent). Principal mineral products exported to Japan included alumina, aluminium, black coal, copper, gold, iron ore, lead, mineral sands, nickel and zinc.

The EEC accounted for 17 per cent (including 6 per cent to the United Kingdom) of Australia's mineral exports by value. Major items included black coal, copper, gold, iron ore, lead, mineral sands, zinc and uranium. The United States accounted for a further 10 per cent comprised mainly of alumina, bauxite, crude oil, mineral sands, nickel, uranium and zinc.

The share of mineral exports going to Asian countries other than Japan has increased in recent years, and in 1987 accounted for 24 per cent of the total (21 per cent in 1986). The main country destinations, and commodities exported, were: Korea (aluminium, black coal and iron ore); Hong Kong (black coal and gold); and China, Taiwan Province (aluminium and black coal).

The Middle East supplied 38 per cent of Australia's mineral imports by value, and Indonesia a further 20 per cent; virtually all of the imports from these sources were crude oil.

Bauxite, alumina and aluminium

In 1987, production of bauxite increased by 7 per cent to 34.2 million tonnes, alumina production increased by about 7 per cent, to 10.1 million tonnes, compared with 1985, while aluminium production increased by 14 per cent to 1,003,947 tonnes. Australia was again the world's largest producer of bauxite and alumina.

In Western Australia all bauxite production is refined at either Alcoa's refineries at Kwinana, Pinjarra and Wagerup, or at Worsley refinery. In the Northern Territory bauxite not exported is refined at Nabalco's refinery at Gove, Northern Territory. In Queensland

about 70 per cent of Weipa bauxite is refined at Gladstone (Queensland) and the balance exported.

Gladstone supplies alumina to Comalco's Boyne Island smelter, Queensland (207,000 tonnes per year capacity), to Alcan's Kurri Kurri smelter, New South Wales (capacity 150,000 tonnes per year), to the Bell Bay, Tasmania smelter (117,000 tonnes per year capacity) and to the Tomago, New South Wales (230,000 tonnes per year capacity). Tomago also receives alumina from Gove. Australia's remaining smelters, Point Henry (capacity 165,000 tonnes per year) and the newly opened Portland smelter (capacity 300,000 tonnes per year) are both in Victoria and receive alumina from Western Australia.

Copper

Australia ranks as the seventh largest mine producer of copper but accounts for only 3 per cent of mine production in the Western world. Nevertheless, copper is an important export earning mineral for Australia, the world's ninth largest exporter. In 1987 mine production of copper decreased by 6 per cent to 232,322 tonnes because of lower output from both Mount Isa and Mount Lyell. Production also fell at Woodlawn as the result of the change to an underground operation. There was no production from Mount Gunson which closed in mid 1988 and only small output from Warrego where copper production ceased in February 1987. Production of primary blister copper increased to 177,081 tonnes and production of primary refined copper increased to 182,446 tonnes. Construction began on the Olympic Dam Project in South Australia in March 1986 and production from the first phase of the project is planned to begin around mid 1988. Annual production of about 40,000 tonnes of refined copper, 2,000 tonnes of U_3O_8 and about 2,800 kilograms of gold is planned.

Gold

In 1987, Australia's gold production increased for the seventh successive year, reaching 109,887 kilograms, the highest since 1905. During the year, 29 new gold mines were commissioned and plans were made to bring at least 16 prospects to production in the future. Australia was the fourth ranking gold producer in the Western world in 1987.

Iron

A summary of growth of the Australian iron ore industry 1965 to 1975 was published in the *Australian Mineral Industry Quarterly*, Vol. 29, No. 1. Production of iron ore in 1987 increased by 8 per cent to 101.7 million tonnes. Major increases in output at Pannawonica, Newman and Paraburdoo were only slightly offset by decreases in production at other centres. Despite a recovery in export demand from mid year, exports fell by 2 per cent to 78.3 million tonnes. Shipments of iron ore and pellets for consumption in domestic ironmaking and steelmaking was 7.4 million tonnes in 1987. Australia was the world's fourth largest producer, and continued to be the second largest exporter, after Brazil.

Robe River Iron Associates purchased the Broken Hill Proprietary Co. Ltd (BHP) 50 per cent interest in the Robe River project railway and Cape Lambert port facilities as well as BHP's remaining Deepdale limonite resources, estimated to exceed 2,000 million tonnes. An agreement between Mount Newman Mining Co. and Hancock Mining Ltd announced in 1987 provides for limited mining of scree iron ore deposits to begin at McCamey's Monster, 35km south-east of Newman, at a rate of 750,000 tonnes per year. The agreement also provides for Mount Newman to service Hancock Mining's Romanian contracts from 1988 and for further study into the feasibility of establishing a more permanent 5 million tonnes per year mine at McCamey's.

Hamersley Iron reached agreement with China Metallurgical Import and Export Corporation for joint development of an iron ore mine at Channar, 20km east of Paraburdoo. Production, which is to be blended with output from Hamersley's other mines, is to begin in 1990 at a rate of 3 million tonnes per year and will be progressively increased to 10 million tonnes per year as required.

Mount Newman announced that it would expand the production capacity of its Orebody 29 mine from 1.5–2 million tonnes to 5 million tonnes per year at a cost of $42.9 million.

CRA Ltd purchased CSR Ltd's remaining 50 per cent interest in deposits of pisolitic limonite resources at Yandicoogina, 100 kilometres north-west of Newman.

Goldsworthy Mining Ltd completed design work and began construction, worth $87 million, of its Extension Project which is expected to be operational in 1989. The project will extend operations for twenty years at a production rate of 5 million tonnes per year.

Silver, lead and zinc

Mine production of lead (486,186 tonnes), zinc (753,757 tonnes) and silver (1,103 tonnes) increased in 1987, with the return to a full year's production at Broken Hill and the bringing on-stream of the new Hellyer mine in Tasmania in mid year. Cadjebut, Western Australia, also came on-stream during the year although production was stockpiled in readiness for the commissioning of a new mill in February 1988.

Production of primary refined zinc increased in 1987, as did the production of primary refined lead (an increase of 29 per cent to 201,317 tonnes) with the return to a full year's production at Australia's only primary refining facility at Port Pirie, South Australia.

Detailed exploration and development of a number of deposits continued in 1987. These included Hilton, Lady Loretta, Thalanga, Liontown and Conjuboy, all in Queensland; Scuddles, Blendevale, and Twelve Mile (Lennard Shelf) in Western Australia and Benambra, Victoria.

Black coal

Raw black coal production in 1987 was a record 178.6 million tonnes, 5 per cent higher than in 1986. The output of saleable coal rose by 4 per cent to the record level 144.9 million tonnes. Domestic consumption rose to the record level of 44.7 million tonnes in 1987, mainly due to the growth in use by the electricity and iron and steel industries. Exports rose by 5 per cent to 102.0 million tonnes in 1987 and the value of exports fell to $5,045 million. Of total exports 47.1 million tonnes were shipped to Japan. Australia was the world's leading coal exporter in 1987.

Demand for steaming coal on the international market has remained high. As a result Australian exports of steaming coal rose to 47.1 million tonnes in 1987. Coking coal exports rose by more than 12 per cent in 1987 compared with 1986, to 54.9 million tonnes. This was despite difficulties faced by world steel producers and the consequent over-supply of coking coal on the world market.

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.

Petroleum

At the end of 1987 there were 106 fields producing stabilised crude oil, which is 5 per cent more than in 1986 (101 fields). In 1987 production of crude oil increased by 6.3 per cent to 29.5 million cubic metres compared to 1986. The 1987 production was only 6.8 per cent below the record production level of 31.6 million cubic metres in 1985. The production of natural gas and condensate rose by 2.1 per cent and 18.1 per cent respectively.

Total refinery input increased by 4.8 per cent and the proportion of total input from indigenous sources remained at 77 per cent as in 1986. Consumption of automotive gasoline (motor spirit) increased by 1.3 per cent. Consumption of all other major petroleum products except fuel oil, lighting and power kerosene, heating oil and bitumen also increased. The quantity of imported crude oil, enriched crude oil, other refinery feedstock and products increased by 0.2 per cent in 1987 compared to 1986, and its value increased

by 14.7 per cent from $1,533 million to $1,758 million. Total exports of petroleum products rose in value in 1987 by 19.5 per cent to $2,155 million, compared to $1,804 million in 1986.

The number of exploration wells drilled increased from 139 in 1986 to 226 (211 onshore, 15 offshore) in 1987, and total metres drilled for exploration increased from 266,200 metres in 1986 to 442,944 metres in 1987, an increase of 66.4 per cent. Geophysical exploration continued to decrease during 1987. Offshore exploration resulted in the discovery of one oil, one gas and one oil-gas-condensate fields. Onshore exploration resulted in 21 oil, 19 gas, 7 oil and gas, 7 gas-condensate and 4 oil-gas-condensate discoveries. Development drilling in 1987 was above the level achieved in the 1986. The total of 56 development wells drilled was 51 per cent more than in 1986 (37 wells), and offshore drilling (20 wells) was the same as in 1986. Development wells were drilled offshore in the Gippsland Basin (Flounder and Snapper fields) at Jabiru in the Timor Sea, and at South Pepper, North Herald and North Rankin fields in the Carnarvon Basin of Western Australia.

In 1987 major development projects which were already under construction continued. These included the second phase of the North West Shelf gas project to supply liquefied natural gas to Japan by October 1989, and the establishment of facilities for the enhanced oil recovery project in the Tirrawarra and Moorari fields in the Cooper Basin in South Australia. Plans were announced to develop the Saladin oilfield in the Carnarvon Basin and the Challis oilfield in the Timor Sea. Development drilling was underway at North Herald and South Pepper oilfields south of Barrow Island. These small fields commenced production at a rate of about 1,300 cubic metres per day in early 1988. Other proposals include the construction of a gas separation plant at Darwin for the production of LNG and helium and the duplication of sections of the Roma–Brisbane pipeline. In Bass Strait a 32 kilometre pipeline linking the Bream platform to the West Kingfish platform has been completed and the first oil was produced in mid 1988. Other fields in the area are currently being evaluated for development, and at the end of 1987, plans were announced for the development of the small Whiting, Tarwhine, and Seahorse oilfields.

Economic and sub-economic demonstrated resources of crude oil at 31 December 1987 were 272 gigalitres, an increase from the previous figure of 262 gigalitres at the end of 1986. Economic and sub-economic demonstrated resources of gas increased to 2,240,000 million cubic metres. Expenditure on petroleum exploration decreased 21.8 per cent from $498.1 million in 1986 to $389.4 million in 1987.

Nickel

Mine production of nickel in ore and concentrates was an estimated 73,800 tonnes in 1987. Australia was the third largest world producer after Canada and the USSR. Concentrates produced in Western Australia are smelted at the Kalgoorlie nickel smelter. Some of the matte produced is railed to the Kwinana nickel refinery to be refined to nickel metal and the remainder is exported. Lateritic nickel ore mined at Greenvale, Queensland, is treated at the Yabulu nickel refinery, to produce nickel oxide sinter for export.

Mineral sands

The history of the mineral sands industry is presented in the *Australian Mineral Industry Quarterly*, Vol. 25, No. 1, and updated in the *Proceedings of the Australasian Institute of Mining & Metallurgy*, Symposia Series, No, 46.

Australia is still the world's largest producer and exporter of natural rutile, ilmenite, zircon and monazite. Output of concentrates in 1987 were: rutile production 249,207 tonnes, ilmenite 1,349,500 tonnes, zircon 465,875 tonnes and monazite 12,127 tonnes.

Diamonds

Argyle Diamond Mines Pty Ltd produced 30,332,677 carats of diamonds, retaining its position as the world's leading diamond producer. Argyle's annual production exceeded that of any country in the world, accounting for about 36 per cent of the world's output of natural diamonds. Diamonds from the AK–1 pipe at Argyle comprise about 6 per cent gem, 39 per cent cheap gem, and about 55 per cent industrial grades.

The Bow River Joint Venture completed construction of an alluvial treatment plant about 18km east of Argyle. The new diamond operation commenced production in February 1988 with 625,000 carats per annum.

Uranium

During 1987, uranium was produced from the Ranger and Nabarlek operations in the Northern Territory. Total production for the year was 4,457 tonnes U_3O_8. Uranium exports for 1987 were 3,812 tonnes U_3O_8 at an average f.o.b. unit value of $40.71 per pound U_3O_8. The construction phase of the Olympic Dam copper–uranium–gold project continued through 1987 and 1988 culminating in the commencement of production of uranium oxide concentrates in August 1988. The project has an annual capacity of 1,900 tonnes U_3O_8, however, initial production will be at a rate of 1,550 tonnes U_3O_8 per annum.

BIBLIOGRAPHY

ABS Publications

Monthly Summary of Statistics (1304.0)
Digest of Current Economic Statistics, Australia (1305.0)
Census of Mining Establishments: Summary of Operations (Preliminary) by Industry Class, Australia (8401.0)
Census of Mining Establishments: Details of Operations by Industry Class, Australia (8402.0)
Australian Mineral Industry Quarterly (8403.0)
Mineral Production, Australia (8405.0)
Mineral Exploration, Australia (8407.0)

Other Publications

AUSTRALIAN ATOMIC ENERGY COMMISSION. Annual Report
BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS. *Australian Mineral Industry Annual Review*