CHAPTER FIFTEEN

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 the Chapter. 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 and the Australian Atomic

Energy Commission 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, 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. The Commonwealth is also taking steps to proclaim as much of its Act as is necessary for exploration to proceed, under the planned joint arrangements. 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 of 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)

	1980–81	1981–82	1982–83	1983–84	1984–85	1985–86
New South Wales (a)	116,682	88,186	105,403	111,100	109,558	119,315
Victoria (b) (c)	118,611	108,782	124,861	180,585	206,086	213,292
Queensland (a)	73,274	81,421	89,766	107,645	142,614	196,413
South Australia	7,312	8,811	9,321	14,172	27,739	58,352
Western Australia	78,341	81,330	102,454	168,477	131,640	162,208
Tasmania	3,557	2,209	2,082	2,137	1,043	1,507
Northern Territory (d)	5,666	3,020	2,934	3,963	5,483	8,079
Commonwealth Government (c)	57,319	56,580	73,333	89,853	101,129	173,258
Total	**460,762**	**430,339**	**510,154**	**677,932**	**725,292**	**932,424**

(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) Excludes the mining royalties paid into Aboriginal Benefits trust fund prior to 1978–79.

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 administrative 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 Organisation (CSIRO) as well as through the National Energy Research, Development and Demonstration Program.

Income taxation concessions as at 30 June 1987

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.

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.

Payments to producers of phosphate fertilizers.

The *Phosphate Fertilizers Subsidy Act 1986* provides for a subsidy to be paid on phosphatic substances produced in Australia and sold in Australia for use as a fertilizer. The subsidy varies according to the percentage of available phosphorous content of the fertilizer. When this is below 10 per cent, the subsidy is $153 for each tonne of available phosphorous content. When the percentage available is 10 per cent or more but less than 15 percent, the subsidy is $163 for each tonne of available phosphorous content of the fertilizer. In any other case the subsidy is $188 for each tonne of available phosphorous.

Payments to producers of nitrogenous fertilizers

The *Nitrogenous Fertilizers Subsidy Act 1986* provides for a subsidy to be paid on inorganic nitrogenous substances produced in Australia and sold for use in Australia as a fertilizer. Subsidy is payable at the rate of $20 per tonne of the nitrogen content of which the substance consists.

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 co-operation 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 Product 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. 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, co-ordinates and implements minerals and energy policy. The Department conducts geological, groundwater 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 groundwater 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, groundwater 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 Queensland Department of Mines encourages, assists and regulates the search for and development of mineral and energy resources, working through a system of permits, leases and licences issued under Acts of Parliament. Advice on these and associated matters is provided through the Honourable the Minister for Mines and Energy to the government. The Department also provides services and advice to government on a variety of geological, economic and safety matters.

Staff includes qualified and experienced professionals including mining and petroleum engineers, geologists, geophysicists, technical experts in the mechanical and electrical fields, surveyors, ecologists, cartographers, fuel technologists, economists, computer scientists, journalists 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 private sector exploration groups. The information effort is underpinned by a program of geological mapping and by Departmental drilling for stratigraphic information, resource assessment and research purposes; a core library provides a storage and retrieval system for cores, cuttings, and geological data.

The Department carries out regular inspections to ensure mine safety and provides an expert technical advisory service to mining organisations. It also undertakes research on mine safety and health. Other responsibilities include the administration of legislation on the safe utilisation and handling of various gases and legislation providing comprehensive controls over explosives and other hazardous substances.

Thus the Department carries the responsibility for State government supervision to ensure that natural resources are assessed, developed and put to work safely and effectively.

South Australia

The role of the Department of Mines and Energy is to:

- provide an information service and advice to the government, government agencies, private industry and general public on exploration, development and processing of the State's mineral, energy and underground water resources;
- ensure that the State's mineral, energy and underground water resources are assessed and developed in accordance with government policy;
- encourage private sector exploration for mineral and energy resources in the State;
- provide advice to government on overall energy development, utilisation and conservation, including alternative energy sources;
- ensure that industries engaged in exploring, extracting and processing mineral and energy resources adopt effective safety precautions within their operations;
- ensure that the government's policies on environmental protection measures are adopted by organisations engaged in exploration and development of the State's mineral, energy and underground water resources;
- provide geoscientific research and specialist services as part of an ongoing process of acquiring and updating geological and geophysical data throughout the State for the benefit of the mining industry, other government departments and the community.

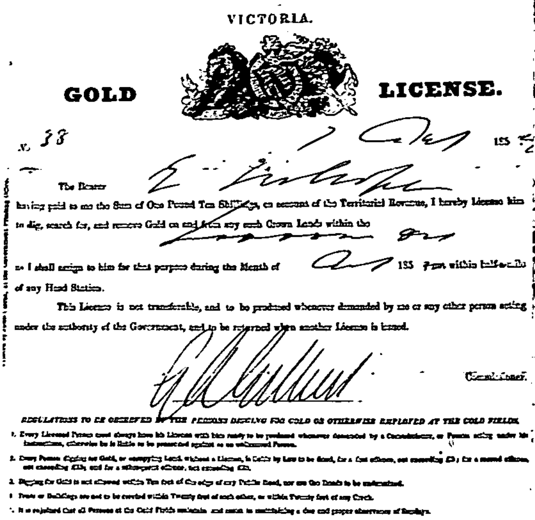
Western Australia

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 Government Chemical Laboratories 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.

MINERAL INDUSTRY



VICTORIA.

GOLD LICENSE.

No. 38 ... 185

The Bearer

having paid to me the Sum of One Pound Ten Shillings, on account of the Territorial Revenue, I hereby License him to dig, search for, and remove Gold on and from any such Crown Lands within the

as I shall assign to him for that purpose during the Month of ... 185 not within half-a-mile of any Head Station.

This License is not transferable, and to be produced whenever demanded by me or any other person acting under the authority of the Government, and to be returned when another License is issued.

Commissioner.

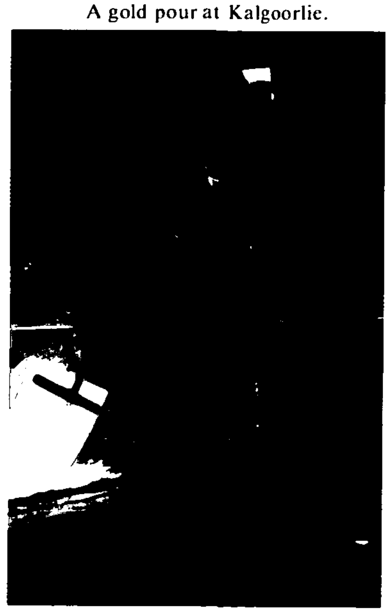
REGULATIONS TO BE OBSERVED BY THE PERSONS DIGGING FOR GOLD OR OTHERWISE EMPLOYED AT THE GOLD FIELDS.

1. Every Licensed Person must always have his License with him ready to be produced whenever demanded by a Commissioner, or Person acting under his instructions, otherwise he is liable to be proceeded against as an unlicensed Person.
2. Every Person digging for Gold, or occupying Land, without a License, is liable by Law to be fined, for a first offence, not exceeding [illegible]; for a second offence, not exceeding [illegible], and for a subsequent offence, not exceeding [illegible].
3. Digging for Gold is not allowed within Ten feet of the edge of any Public Road, nor are the Roads to be undermined.
4. Tents or Buildings are not to be erected within Twenty feet of each other, or within Twenty feet of any Creek.
5. It is enjoined that all Persons at the Gold Fields maintain and assist in maintaining a due and proper observance of Sundays.

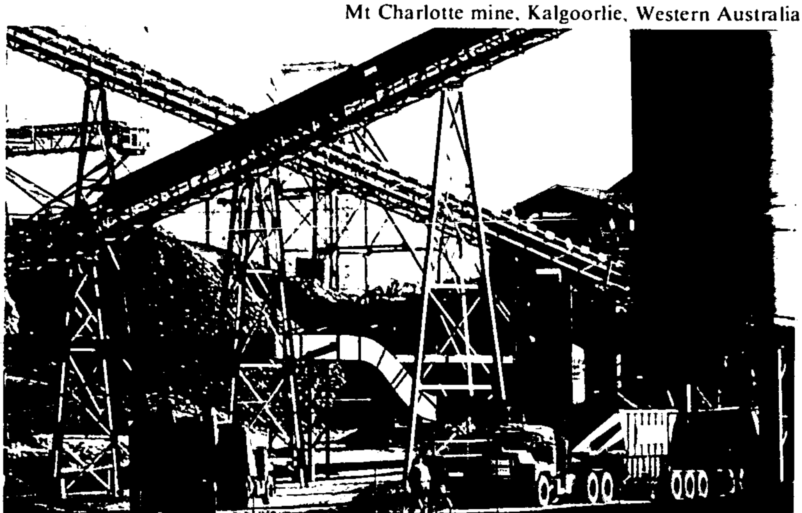
Gold diggers licence, Victoria, 1853.

Nineteenth century gold prospectors.

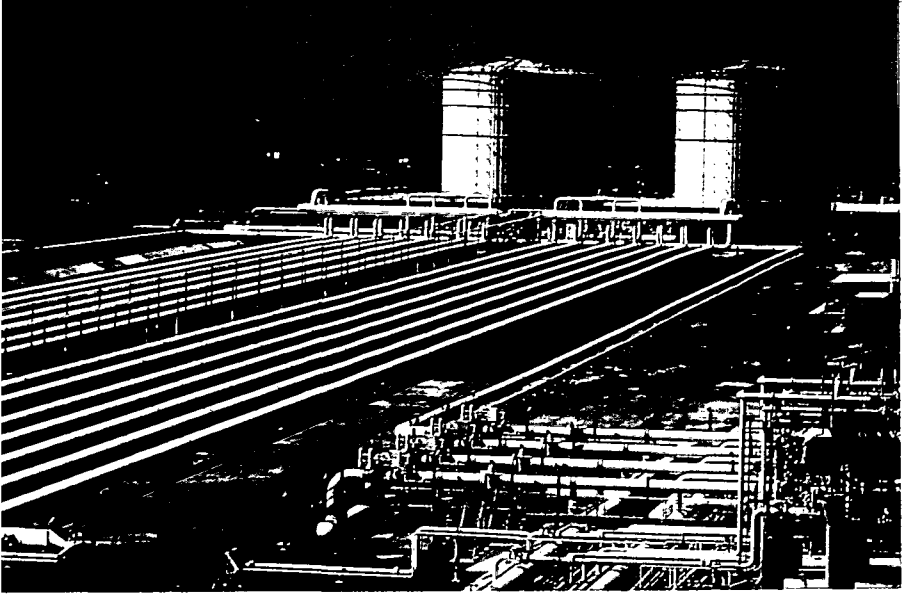
A gold pour at Kalgoorlie.



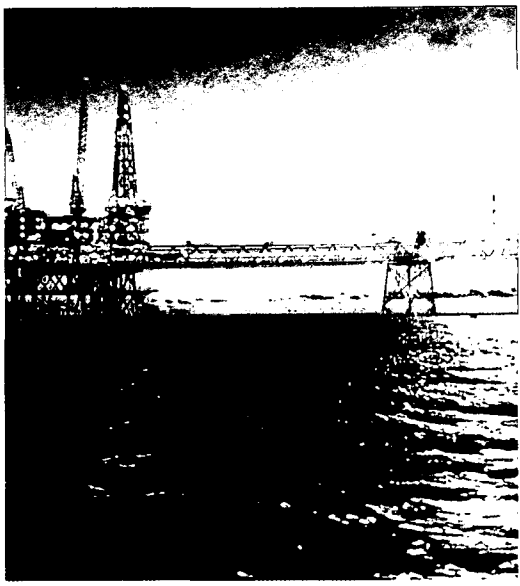
Mt Charlotte mine, Kalgoorlie, Western Australia.



Photographs—Promotion Australia.

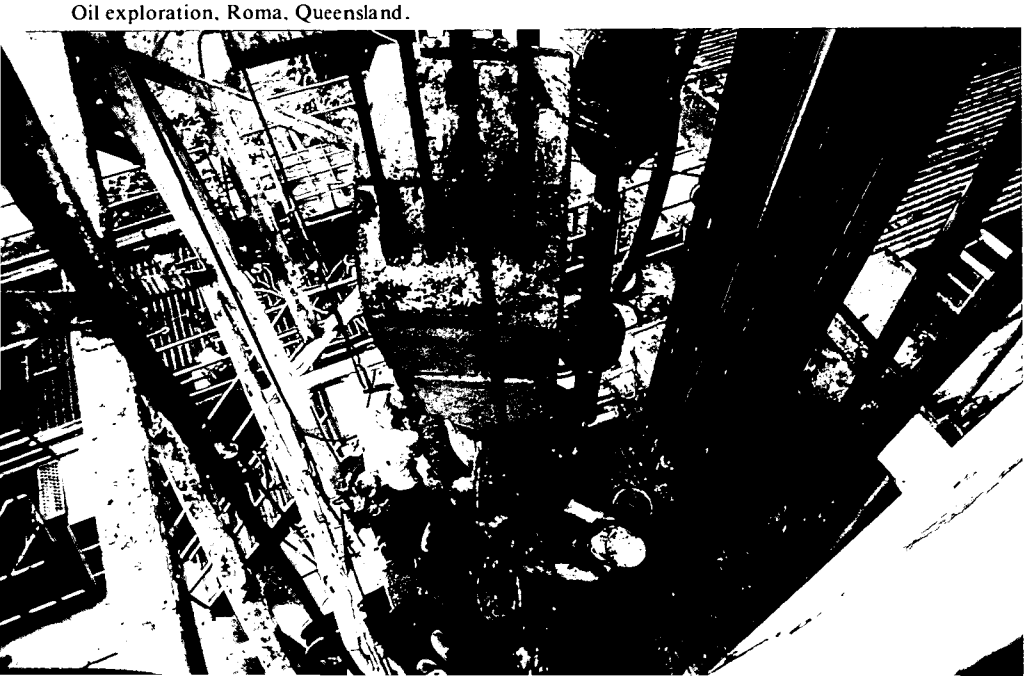


Separation plant near Dampier, Western Australia where light crude oil is separated from natural gas.



North Rankin natural gas field on the North West Shelf, 130 km off the NW coast of Australia.

Oil exploration, Roma, Queensland.

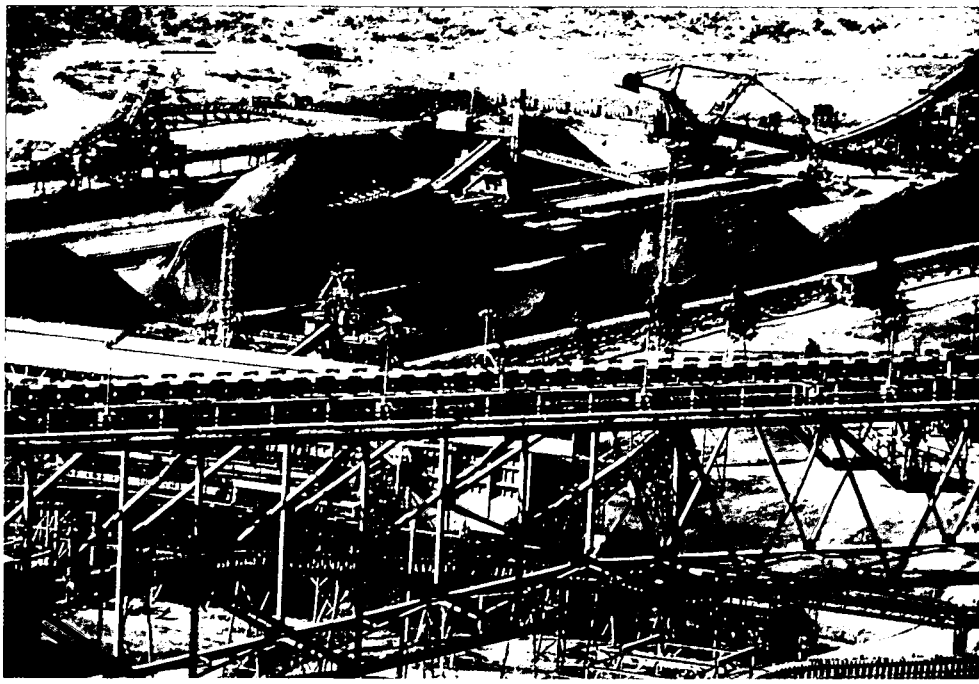


Mount Tom Price is one of several large, high-grade deposits of haematite in the Hammersley Range area in the north-west of Western Australia, about 595 kilometres by road north of Perth. Iron ore from the huge open-cut mine is conveyed by rail 293 kilometres to the deepsea port at Dampier.

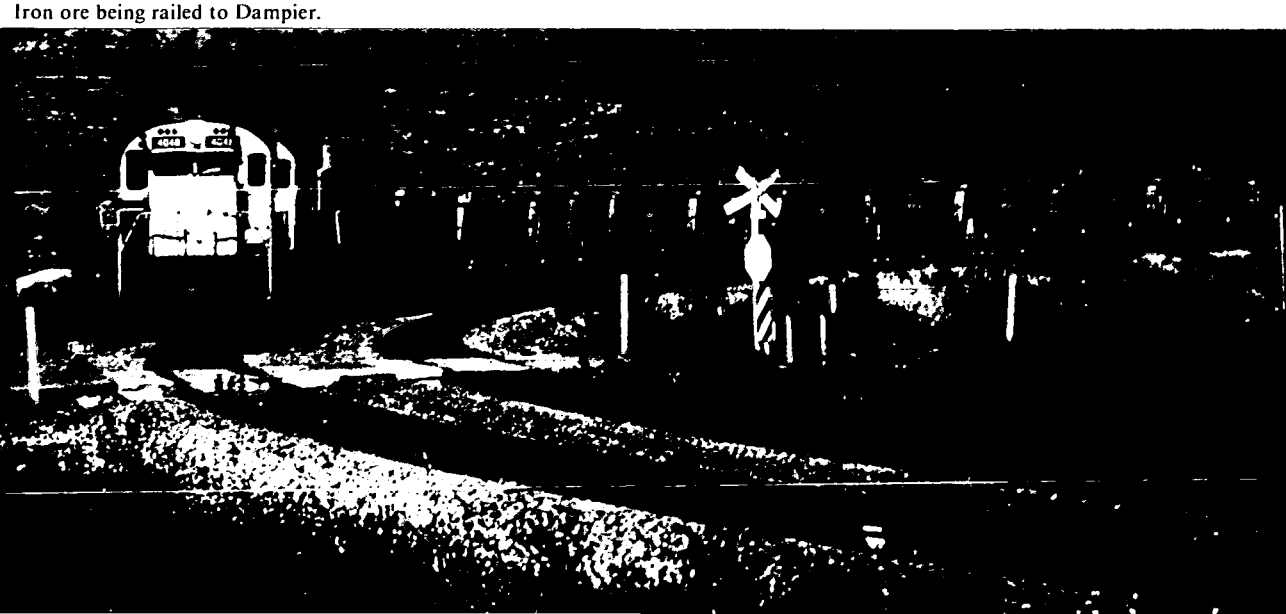
Photographs—Promotion Australia

Blasting at Mount Tom Price.

Stockpiles of iron ore.

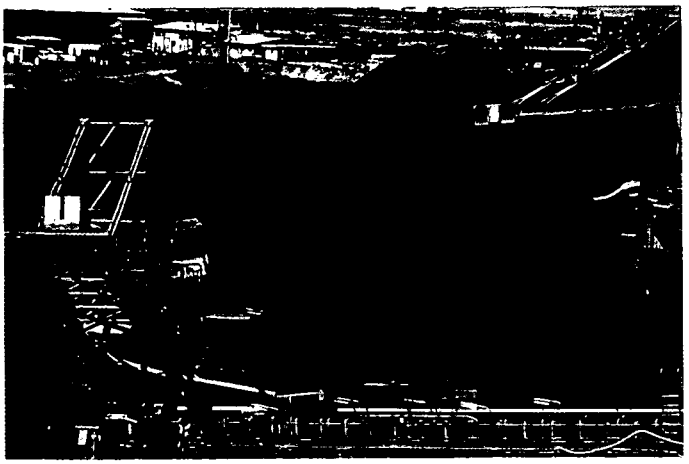


Iron ore being railed to Dampier.



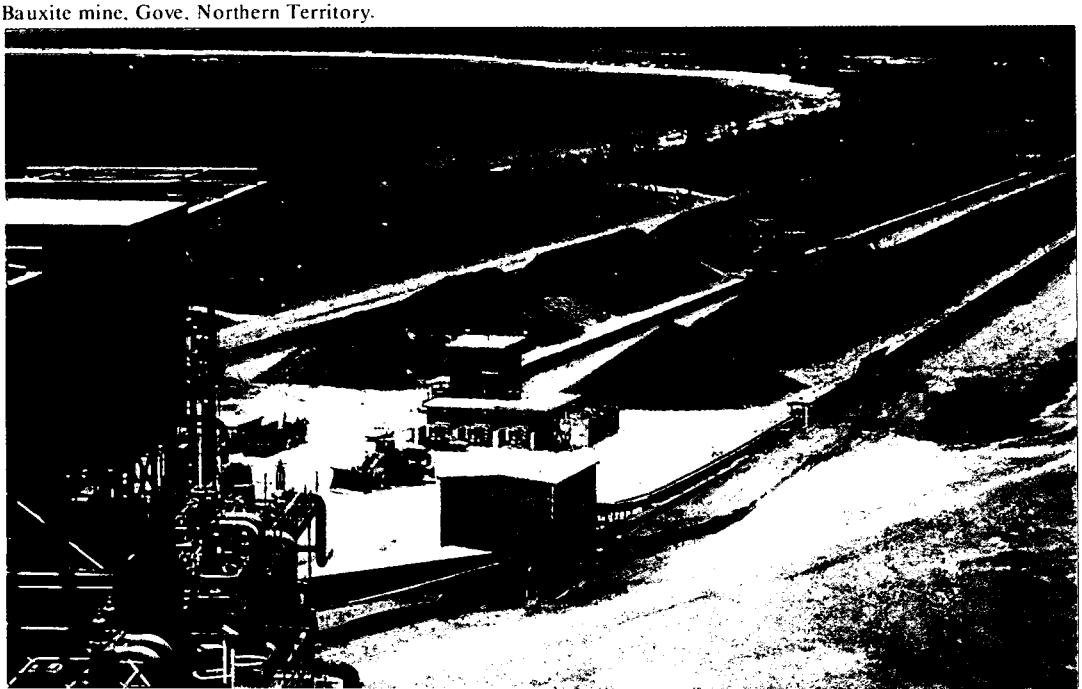
Working the coal face, Newlands, Queensland.

Stock piles of coal at Hay Point, Queensland.



Photographs—Promotion Australia.

Bauxite mine, Gove, Northern Territory.



The following services are provided:
- geological and mining engineering advice;
- engineering geology and groundwater 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 mineral 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.

Alligator Rivers Region 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.

Administration 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.

The Australian Mineral Development Laboratories

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, Canberra, Darwin and Townsville. Extensive laboratory facilities are available in the fields of analytical chemistry, mineralogy, materials science and petroleum. Mineral processing testing is carried out at bench and laboratory 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).
- Groundwater 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; Geomagnestism; 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 Co-ordination, Research and Operations; and Geoscience Maps, Cartography and Image Processing.
- BMR management and information: with components on Geoscience Management, Co-ordination and Public Relations; Publications; Geoscience Library and Museum; Resources Management and Services; and International Agreements and Project Co-ordination.

Commonwealth Scientific and Industrial Research Organisation

Minerals research by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) is undertaken within the Institute of Energy and Earth Resources. The research has the objectives of improving methods of locating, evaluating, defining and characterising Australia's mineral resources and of planning their recovery, development and effective use consistent with the minimisation of environmental stresses. Divisions of the Institute engaged in minerals research are the Division of Geomechanics at Syndal (Vic.); the Division of Fossil Fuels at North Ryde (N.S.W.); the Division of Mineral Chemistry at Port Melbourne (Vic.); the Division of Mineral Engineering at Clayton (Vic.); the Division of Minerals and Geochemistry at Perth (W.A.), the Division of Mineral Physics and Mineralogy at North Ryde (N.S.W.), and the Division of Energy Chemistry at Lucas Heights (N.S.W.). The Institute Headquarters is located in Canberra (A.C.T.).

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 100 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 $13 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 First International Tin Agreement (of the post-war period) was in operation for five years from 1 July 1956 to 30 June 1961. It was followed by the Second, Third, Fourth, Fifth and Sixth International Tin Agreements, which came into force on 21 February 1962, 21 March 1967, 1 July 1971, 1976 and 1982 respectively. Australia joined the Fourth, Fifth and Sixth Agreements as a 'producing' (i.e. exporting) member, whereas in the first three agreements Australia's status had been that of a 'consuming' (i.e. importing) member. Details of the Second and Third Agreements are given in *Year Book* No. 57, pages 911–12. Details of the Fourth Agreement are given in *Year Book* No. 61, page 942, and those of the Fifth in *Year Book* No. 66, page 376.

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.

The Sixth International Tin Agreement is administered by the International Tin Council, which is made up of the following governments: *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, Poland, Sweden, Switzerland, and the United Kingdom. The producing countries hold a total of 1,000 votes, distributed so that each country receives five initial votes and an additional number corresponding to its percentage as laid down by the Agreement. The consuming countries hold a total of 1,000 votes also distributed so that each country receives five initial votes and an additional number proportionate to quantities consumed. The allocation of votes in each category is periodically reviewed.

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.

International Lead-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 of interested governments were held at which Australia was represented. These meetings culminated in the formation of the International Lead-Zinc Study Group which was established in January 1960. The Study Group comprises the following governments: Algeria, Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Czechoslovakia, Denmark, Finland, France, Germany (Federal Republic of), Hungary, India, Iran, Ireland (Republic of), Italy, Japan, Mexico, Morocco, Netherlands, Norway, Peru, Poland, South Africa (Republic of), Spain, Sweden, Tunisia, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America, Yugoslavia and Zambia. The Group provides opportunities for inter-governmental consultations on international trade in lead and zinc and for studies of the world situation in lead and zinc.

Association of Iron Ore Exporting Countries—APEF

Australia is a founder member of the APEF whose members account for about 44 per cent of world iron ore exports. Other members are Algeria, India, Liberia, Mauritania, Peru, Sierra Leone, Sweden and Venezuela.

The Association was formed in 1975 with a Secretariat located in Geneva, Switzerland. The Agreement establishing the Association provides for a Conference of Ministers, which meets once every two years. A Board, comprising representatives of each member country meets twice a year.

The objectives of the Association are to promote close co-operation among member countries with a view to safeguarding their interests in relation to the iron ore export industry.

The Association provides a forum for consultations and exchange of information on problems relating to the iron ore export industry.

The Association's Secretariat publishes a statistical bulletin twice a year as well as occasional papers on the iron ore industries of major producing countries.

Inter-governmental Council of Copper Exporting Countries—CIPEC

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

Australia and Papua New Guinea were admitted as Associate Members and Indonesia as a Full Member in 1975, the latter changing to Associate Membership from 1 January 1986. Yugoslavia was admitted as an Associate Member in 1977. Associate Members may participate in meetings but have no voting rights and are not bound by CIPEC's decisions.

The key objectives of CIPEC are to co-ordinate 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 co-operative 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. In November 1986 the Council adopted recommendations on minimum CIF prices for bauxite and alumina sold by member countries in 1987. Australia was not included in the majority that voted for the recommendations and is not bound by them. 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 annual mining census is conducted throughout Australia on an integrated basis with other economic censuses, e.g. the annual census of manufacturing establishments, electricity and gas establishments and the periodic censuses of 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 *Enterprise Statistics: Details by Industry Sub-division, Australia* (8107.0). 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 surveys are given in Chapter 18.

The following table shows key items of data for establishments in Australia for 1985–86 based on the 1978 edition of the *Australian Standard Industrial Classification* (ASIC).

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS BY INDUSTRY CLASS, 1985–86

Industry ASIC code	Description	Establishments at 30 June	Average employment over whole year(a)	Wages and salaries (b)	Turnover	Stocks Opening	Stocks Closing	Total purchases transfers in and selected expenses	Value added
		no.	no.	$m	$m	$m	$m	$m	$m
	Metallic minerals—								
	Ferrous metal ores—								
1111	Iron ores	18	8,167	260.4	2,423.8	125.4	117.2	1,028.8	1,386.8
1112	Iron ore pelletising	2							
	Non-ferrous metal ores—								
1121	Bauxite	8	2,092	66.1	515.3	27.2	31.2	112.6	406.7
1122	Copper ores	7	2,755	88.5	334.6	60.1	54.8	128.9	200.4
1123	Gold ores	137	4,999	145.0	942.3	85.7	104.8	373.7	587.7
1124	Mineral sands	15	1,529	37.9	259.1	35.6	40.8	117.7	146.7
1125	Nickel ores	5	2,411	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1126	Silver-lead-zinc ores	14	6,455	200.9	719.9	139.5	127.3	346.4	361.3
1127	Tin ores	58	1,098	23.3	96.2	38.3	36.6	48.7	45.8
1128	Uranium ores	2	512	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1129	Non-ferrous metal ores n.e.c.	7	814	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
11	*Total metallic minerals*	*273*	*30,832*	*937.6*	*6,002.2*	*696.3*	*728.4*	*2,402.3*	*3,632.0*
	Coal, oil and gas—								
1201	Black coal	127	32,111	1,180.4	7,071.8	660.3	752.7	3,241.1	3,923.1
1202	Brown coal	6	2,446	70.5	262.7	14.3	12.8	52.6	208.6
1300	Oil and gas	31	4,698	188.4	4,961.1	163.9	178.9	501.9	4,474.2
12,13	*Total coal, oil and gas*	*164*	*39,255*	*1,439.3*	*12,295.7*	*838.5*	*944.4*	*3,795.7*	*8,605.9*
	Construction materials—								
1401	Sand and gravel	360	1,940	40.7	313.3	15.3	15.5	148.0	165.5
1404	Construction materials n.e.c.	465	4,148	96.0	640.0	47.8	56.6	307.5	341.4
14	*Total construction materials*	*825*	*6,088*	*136.7*	*953.3*	*63.1*	*72.2*	*455.5*	*506.8*
	Other non-metallic minerals—								
1501	Limestone	54	725	15.5	74.0	7.4	5.8	38.9	33.5
1502	Clays	92	229	4.5	34.6	3.9	4.0	20.6	14.1
1504	Salt	15	586	18.1	105.8	20.2	22.0	35.3	72.3
1505	Non-metallic minerals n.e.c.	105	1,254	21.0	152.4	26.9	41.5	75.9	91.2
15	*Total other non-metallic minerals*	*266*	*2,794*	*59.0*	*366.9*	*58.4*	*73.3*	*170.7*	*211.1*
	Total mining (excl. services to mining)	**1,528**	**78,969**	**2,572.6**	**19,618.1**	**1,656.3**	**1,818.2**	**6,824.2**	**12,955.8**

(a) Includes working proprietors (b) Excludes amounts 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 1985–86 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		*1983–84*	*1984–85*	*1985–86*
METALLIC MINERALS				
Bauxite	'000 tonnes	n.p.	n.p.	31,864
Copper concentrate	"	n.p.	n.p.	n.p.
Copper ore	"	40,371	28,737	19,739
Gold bullion (*a*)	kg	n.p.	n.p.	81,008
Iron ore	'000 tonnes	76,478	n.p.	n.p.
Lead concentrate	"	n.p.	764	n.p.
Lead-copper concentrate	tonnes	20,835	28,200	38,209
Lead-zinc concentrate	"	37,932	46,276	55,534
Manganese ore—				
Metallurgical grade	'000 tonnes	n.p.	n.p.	1,152
Mineral sands—				
Ilmenite concentrate (*b*)	"	1,017	1,264	1,272
Rutile concentrate	"	163	191	n.p.
Zircon concentrate	"	412	452	476
Nickel concentrate	"	506	486	455
Tantalite-columbite concentrate	tonnes	92	185	n.p.
Tin concentrate	"	16,448	13,321	n.p.
Tungsten concentrates—				
Scheelite concentrate	"	1,801	2,045	2,029
Wolfram concentrate	"	1,499	1,427	1,194
Uranium concentrate	"	n.p.	n.p.	n.p.
Zinc concentrate	'000 tonnes	1,147	1,311	n.p.
COAL				
Coal (other than lignite)—				
Saleable coal(*c*)				
Semi-anthracite	'000 tonnes	n.a.	231	358
Bituminous	"		105,859	120,398
Sub-bituminous	"		12,177	13,599
Washery rejects(*c*)	"		26,906	29,314
Lignite—				
For briquettes	"	1,900	2,131	2,157
Other	"	31,345	36,369	33,312
Briquettes	"	760	802	851
OIL AND GAS				
Crude oil (stabilised)	megalitres	26,826	30,919	26,826
Natural gas	gigalitres	12,098	12,958	14,274
Ethane	"	175	200	196
CONSTRUCTION MATERIALS				
Sand	'000 tonnes	24,760	27,017	28,019
Gravel	"	14,612	16,951	18,677
Crushed and broken stone	"	55,407	65,573	70,061
Other (decomposed rock, dimension stone, etc.)	"	29,239	32,298	33,595
OTHER NON-METALLIC MINERALS				
Brick clay and shale	'000 tonnes	6,476	7,668	6,925
Limestone (including shell and coral)	"	10,333	11,811	n.p.
Salt	"	n.p.	n.p.	5,735
Silica	"	2,060	n.p.	n.p.

(*a*) Includes alluvial gold. (*b*) Includes ilmentite from which titanium dioxide is not commercially extractable and beneficiated ilmentite. (*c*) Raw coal is saleable coal plus washery rejects.

CONTENTS OF SELECTED METALLIC MINERALS PRODUCED

Contents of metallic minerals produced		*1983–84*	*1984–85*	*1985–86*
Antimony	tonnes	719	1,409	1,262
Cadmium	"	2,214	2,670	2,167
Cobalt	"	1,952	2,602	2,918
Copper	"	249,282	251,782	241,706
Gold	kg	33,881	48,853	64,780
Iron(*a*)	'000 tonnes	n.p.	n.p.	n.p.
Lead	tonnes	n.p.	n.p.	n.p.
Manganese	"	n.p.	n.p.	n.p.
Monazite	"	15,207	14,001	15,538
Nickel	"	75,770	82,267	80,528
Palladium	kg	506	461	421
Platinum	"	71	81	94
Silver	"	n.p.	1,044,105	1,074,227
Sulphur	tonnes	345,094	429,710	449,706
Tantalite-columbite ($Ta_2O_5+Nb_2O_5$)	kg	50,013	87,648	n.p.
Tin	tonnes	8,688	n.p.	7,391
Titanium dioxide (TiO_2)	"	758,233	858,586	1,023,561
Tungstic oxide (WO_3)	mtu(*b*)	239,236	239,883	232,253
Yttrium oxide (Y_2O_3)	kg	15,060	12,600	n.p.
Zinc	tonnes	n.p.	744,401	722,599
Zirconium dioxide (ZrO_2)	"	275,153	314,544	331,678

(*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 1985–86 and earlier years. Further data are available in the annual publication *Mineral Production, Australia* (8405.0).

VALUE OF SELECTED MINERALS PRODUCED
($'000)

Mineral	*1983–84*	*1984–85*	*1985–86*
METALLIC MINERALS			
Bauxite	n.p.	n.p.	n.p.
Copper concentrate	275,385	305,939	341,334
Copper ore	2,242	1,411	1,130
Gold bullion(*a*)	n.p.	n.p.	944,139
Iron ore	n.p.	n.p.	n.p.
Lead concentrate	n.p.	n.p.	n.p.
Lead-copper concentrate	n.p.	n.p.	n.p.
Lead-zinc concentrate	9,786	8,038	7,786
Manganese ore—			
Metallurgical grade	n.p.	n.p.	n.p.
Mineral sands—			
Ilmenite concentrate(*b*)	32,191	45,858	57,003
Rutile concentrate	42,879	67,092	n.p.
Zircon concentrate	43,431	49,659	62,441
Nickel concentrate	n.p.	n.p.	n.p.
Tantalite-columbite concentrate	2,411	4,827	n.p.
Tin concentrate	n.p.	n.p.	89,857
Tungsten concentrates—			
Scheelite concentrate	n.p.	n.p.	n.p.
Wolfram concentrate	8,891	7,435	6,310
Uranium concentrate	n.p.	n.p.	n.p.
Zinc concentrate	278,040	341,303	269,048
COAL			
Coal (other than lignite)—			
Saleable coal—			
Semi-anthracite	6,443	5,733	10,904
Bituminous	3,320,769	3,988,421	4,770,138
Sub-bituminous	234,686	330,781	398,289
Lignite—			
For briquettes	..	..	..
Other	135,736	204,758	233,912
Briquettes	18,136	23,851	15,714

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

Mineral	*1983–84*	*1984–85*	*1985–86*
OIL AND GAS			
Oil and Gas	3,024,008	4,034,400	n.p.
CONSTRUCTION MATERIALS			
Sand	123,520	141,297	161,075
Gravel	98,606	110,347	109,515
Crushed and broken stone	374,348	462,087	536,271
Other (Decomposed rock, dimension stone, etc.)	91,996	90,027	114,191
OTHER NON-METALLIC MINERALS			
Brick clay and shale	21,007	27,041	27,201
Gems			
Opal(*c*)	45,987	45,079	49,950
Sapphire	9,905	13,627	12,066
Limestone (incl. shell and coral)	54,767	64,167	n.p.
Salt	n.p.	n.p.	99,194
Silica	23,466	18,269	n.p.

(*a*) Includes alluvial gold. (*b*) Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. (*c*) 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 and oil shale)

Definition

Exploration consists of the search for and/or appraisal of new ore occurrences and known deposits of minerals (including extensions to deposits being worked) by geological, geophysical, geochemical and other methods (including drilling). Exploration for water is excluded. The construction of shafts and adits is included if primarily for exploration purposes. Excluded are mine development activities carried out primarily for the purpose of commencing or extending mining or quarrying operations (including the construction of drives, shafts, winzes, etc. in underground mines, and the preparation of quarrying sites, including overburden removal, for open-cut extraction).

Sources of statistics

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

Classification

The data obtained in the mineral exploration census are divided into the following categories:

(*a*) *Private exploration on production leases*—relates to exploration carried out on the production lease by privately-operated mines currently producing or under development for the production of minerals.

(*b*) *Other private exploration*—relates to exploration carried out by private enterprises on areas covered by exploration licences, authorities to enter, authorities to prospect and similar licences and authorities issued by State governments for exploration of minerals. Also included is exploration by private enterprises which is not directly connected with areas under lease, licence, etc.

(*c*) *Exploration by government*—relates to exploration of minerals carried out by Federal and State government departments, local government authorities and business undertakings operated by those departments or authorities.

Expenditure, metres drilled

The following table shows expenditure and metres drilled on private mineral exploration other than for petroleum and oil shale in Australia during the last six years.

PRIVATE MINERAL EXPLORATION (OTHER THAN FOR PETROLEUM AND OIL SHALE)

	1980–81	*1981–82*	*1982–83*	*1983–84*	*1984–85*	*1985–86*
Expenditure ($'000)—						
On drilling	126,088	141,872	89,723	93,503	96,728	101,777
Other	344,401	433,700	348,188	335,199	340,600	340,256
Australia	**470,489**	**575,572**	**437,911**	**428,702**	**437,328**	**442,033**
Metres drilled ('000)—						
Drilled-core	1,156	1,201	871	1,089	975	1,033
Drilled-non-core	2,808	2,824	1,882	2,110	2,416	2,503
Australia	**3,965**	**4,025**	**2,752**	**3,198**	**3,391**	**3,537**

Oil shale exploration

Statistics of exploration for oil shale are derived from an annual exploration census conducted by the Australian Bureau of Statistics.

In 1985–86 expenditure in Australia on private exploration for oil shale amounted to $1,780,000 with 3,000 metres being drilled.

Petroleum exploration

Source of statistics

These statistics of expenditure on petroleum exploration have been obtained by the addition of values collected in a quarterly census conducted by the Australian Bureau of Statistics. Other data shown were collected by the Bureau of Mineral Resources, Geology and Geophysics. Further information relating to petroleum exploration is published by the Australian Bureau of Statistics in its annual publication *Mineral Exploration, Australia* (8407.0) and by the Bureau of Mineral Resources, Geology and Geophysics in *The Petroleum Newsletter* (issued quarterly) and *The Australian Mineral Industry Annual Review.*

Scope

Petroleum exploration consists of the search for and/or appraisal of deposits of crude oil and/or natural gas and natural gas liquids by geological, geophysical, geochemical, and other exploration methods, including drilling. Included in the expenditure are the costs of drilling exploratory oil and/or gas wells and the testing of such wells. Also included are the costs of access roads, site construction, permits, licences and similar fees, relevant office buildings and furniture, transportation equipment, storage facilities, plant and equipment, and review work where these are undertaken primarily for purposes of exploration for deposits of petroleum. Details of developmental oil and/or gas wells are excluded.

PETROLEUM EXPLORATION

		1983–84	*1984–85*	*1985–86*
Expenditure—				
Private	$'000	823,692	803,204	765,727
Government	$'000	n.p.	n.p.	n.p.
Total	**$'000**	**n.p.**	**n.p.**	**n.p.**
Wells (*a*)—				
Drilled (i.e. those which reached final depth)—				
As oil producers	No.	43	65	24
As gas producers	No.	27	37	20
Plugged and abandoned	No.	141	168	95
Total	**No.**	**211**	**270**	**139**
Average final depth of wells drilled	m	1,976	1,904	1,964
Drilling still in progress at 31 December (uncompleted holes)	No.	14	11	6
Wells drilled or drilling over 3,000 metres	No.	39	25	17
Metres drilled (*a*)—				
Completed wells	m	390,050	493,920	267,818
Uncompleted holes	m	20,993	18,192	7,438
Total	**m**	**411,043**	**512,112**	**275,256**

(*a*) *Source*: Bureau of Mineral Resources, Geology and Geophysics. Data relates to year ended 31 December.

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		*1982–83*	*1983–84*	*1984–85*
METALS(*b*)				
Non-ferrous—				
Alumina	'000 tonnes	6,701	8,030	8,120
Refined aluminium	tonnes	403,917	617,921	822,315
Blister copper(*c*)	"	172,163	182,090	176,594
Refined copper	"	172,456	166,429	165,491
Lead bullion (for export)(*c*)	"	179,462	186,561	181,182
Refined lead	"	212,176	190,121	189,100
Refined zinc	"	288,250	299,738	299,386
Refined tin	"	2,898	2,937	2,824
Ferrous—				
Pig iron	'000 tonnes	4,990	5,258	5,341
Steel ingots	"	5,392	6,093	6,301
Precious—				
Refined gold(*d*)	kg	25,784	30,661	40,501
Refined silver	"	303,889	273,788	284,963
FUELS				
Coal products—				
Metallurgical coke	'000 tonnes	3,338	3,181	3,266
Brown coal briquettes	"	760	760	802
Petroleum products—				
Diesel-automotive oil	'000 tonnes	6,540	6,405	6,807
Industrial fuel and marine fuel	"	721	649	n.p.
Fuel oil for burning	"	2,810	3,136	2,588
Automotive petrol	mil. litres	14,845	14,427	14,965
BUILDING MATERIALS				
Clay bricks	millions	1,694	1,771	1,982
Portland cement	'000 tonnes	5,350	5,072	5,680
Plaster of paris	"	n.p.	n.p.	n.p.
Plaster sheets	'000 sq m	51,229	60,313	69,207
CHEMICALS				
Sulphuric acid	'000 tonnes	1,734	1,706	1,783
Caustic soda	tonnes	n.p.	n.p.	n.p.
Superphosphate(*e*)	'000 tonnes	2,877	2,668	2,647

(*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*) Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22% 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 1986 and their principal metallic content as estimated by assay.

PRINCIPAL METALLIC CONTENTS OF SELECTED ORES AND CONCENTRATES ETC. EXPORTED FROM AUSTRALIA, 1986

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	65,746	1,437	2,110	—	—	—	—	6,105
Blister copper	—	—	—	—	—	—	—	—
Copper matte, slags, etc.(*a*)	1,354	1,678	15	—	—	—	102	9,157
Lead concentrate	5,144	92,284	1,804	—	—	—	1,735	226,126
Lead bullion	—	184,920	—	—	—	—	63	435,312
Lead slags and residues	59	9,903	12	20	—	—	209	23,983
Zinc concentrate	553	11,119	432,638	—	—	—	686	65,209
Zinc slags and residues	—	—	7,412	—	—	—	—	—
Tin concentrate	—	—	—	7,202	—	—	—	—
Tin slags and residues	—	40	—	150	—	—	—	—
Iron ore—								
Pellets	—	—	—	—	1,125	—	—	—
Fines	—	—	—	—	27,419	—	—	—
Lump	—	—	—	—	21,482	—	—	—
Scheelite concentrate	—	—	—	—	—	n.a.	—	—
Wolfram concentrate	—	—	—	—	—	578	—	—
Total metallic content	**72,856**	**301,381**	**443,991**	**7,372**	**50,026**	**n.a.**	**2,796**	**765,892**

(*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* 1985 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 39, Number 4, details Australia's identified mineral resources, 1986.

General review of 1986

The Gross Domestic Product (GDP) of Australia in 1985–86 was $238,939 million, of which an estimated $15,275 million was generated by the mining industry, excluding smelting and refining. If smelting and refining were included, an estimated $3,200 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 1986 was $19,720 million. This was $2,387 million, or 11 per cent, less than the record ex-mine value of $22,107 million established in 1985, and was the first fall for 25 years. The decrease in 1986 was mainly attributable to a fall in the value of petroleum products, from $10,098 million to $6,420 million, caused principally by the collapse of world crude oil prices. Despite the overall decrease, there were substantial increases in the ex-mine values of gold, black coal, diamonds and uranium. Apart from petroleum, the only major commodities to suffer significant falls were nickel, lead and manganese.

Imports—1986

The value of mineral imports has traditionally been dominated by crude oil although over the last two years that domination has weakened. In 1986, imports of crude oil fell by 36 per cent to $966 million; however this still represented 63 per cent of the total mineral import bill of $1,535 million which was down 24 per cent compared to 1985. Other significant mineral imports included phosphate rock, gold bullion, elemental sulphur and diamonds. Imports of mineral primary products in 1986 accounted for 4.3 per cent of the total value of merchandise imports compared with 5.9 per cent in 1985. Australia's mineral balance of trade (value of mineral exports minus value of mineral imports) was a record $13,276 million in 1986, marginally ahead of the 1985 balance of $13,238 million.

Exports—1986

The value of mineral exports fell slightly (3 per cent) to $14,811 million in 1986 compared to $15,262 million in 1985. Major minerals to show gains on their 1985 levels included aluminium, black coal, diamonds, gold, lead, mineral sands and uranium. Decreases were recorded for copper, crude oil, iron ore, LPG, nickel, tin and zinc among the major minerals.

Black coal remains the largest single export earner, accounting for $5,364 million or about 36 per cent of the total value of mineral primary products exported. Iron ore was the second largest with a value of $1,938 million (a decrease of 3 per cent compared to 1985) followed by alumina which was virtually steady at $1,427 million, and aluminium metal, $975 million (an increase of 13 per cent over the 1985 value). These four minerals together account for about two-thirds of the total value of mineral primary products exported. A significant contribution was also made by copper, crude oil, gold, lead, LPG, mineral sands, nickel, uranium and zinc.

Pattern of mineral trade—1986

During 1986, Australia exported minerals to more than 100 countries. Japan accounted for 41 per cent of these exports by value, about the same as in 1985. Principal mineral products exported to Japan included alumina, aluminium metal, black coal, copper, gold, lead, mineral sands, nickel and zinc.

The E.E.C. accounted for 17.7 per cent (including 4.6 per cent to the U.K.) of Australia's mineral exports. Major items comprised black coal, copper, iron ore, lead, mineral sands, uranium and zinc. U.S.A. accounted for a further 9.9 per cent consisting mainly of alumina, bauxite and nickel.

Bauxite, alumina and aluminium

In 1986, production of bauxite increased by 2 per cent to 32.4 million tonnes, alumina production increased by about 7 per cent compared with 1985, while aluminium production increased by 4 per cent to 881,910 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 150,000 tonnes per year) are both in Victoria and receive alumina from Western Australia.

Copper

A summary of the copper mining industry in Australia 1953 to 1975 and the sufficiency of present ore reserves was published in the *Australian Mineral Industry Quarterly*, Vol. 30, No. 1.

In 1986 mine production of copper decreased by 4 per cent to 248,496 tonnes because of lower output from Warrego in the Northern Territory, the Mount Gunson mine in South Australia which ceased operations around mid-year and Teutonic Bore in Western Australia where milling operations ceased in the first half of the year. Production of primary blister copper increased slightly to 168,855 tonnes although production of primary refined copper declined slightly to 162,604 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 30,000 tonnes of refined copper, 2,000 tonnes of U_3O_8 and about 2,800 kilograms of gold is planned.

Gold

In 1986, Australia's gold production increased for the sixth successive year, reaching 73,817 kilograms, the highest since 1913. During the year, 29 new gold mines were commissioned and plans were made to bring another 41 prospects to production in the future. Australia was the fourth ranking gold producer in the Western world in 1986.

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 1986 decreased by 4 per cent to 94.0 million tonnes. Substantial decreases in output at Pannawonica, Paraburdoo, Tom Price and Yampi Sound, were partially offset by increased production at Shay Gap, Middleback Range and Newman. Exports of iron ore and iron ore pellets also fell by 8 per cent to 79.7 million tonnes. Shipments of iron ore and pellets for consumption in domestic ironmaking and steelmaking increased to 9.3 million tonnes in 1986. Australia was the world's fourth largest producer, and continued to be the second largest exporter, after Brazil.

The Broken Hill Proprietary Co. Ltd (BHP) announced in 1986 that it planned to develop its limonite resources at Yandicoogina, 100 kilometres north-west of Newman. Resources which are close to the Newman-Port Hedland rail link are estimated at about 1,800 million tonnes. In 1986, CRA Ltd acquired a 50 per cent share in CSR Ltd's Yandicoogina deposits and the agreement provided access to Hamersley Iron's existing iron ore infrastructure. This lease, which is adjacent to BHP's holdings, is estimated to contain 3,000 million tonnes of limonite.

Goldsworthy Mining Ltd announced details of plans to invest $87 million, to enable an extension of its mining activities in the Shay Gap area for a further twenty years.

Silver, lead and zinc

Mine production of lead (449,427 tonnes) and zinc (694,472 tonnes) declined in 1986, largely because of the closure of the major Broken Hill mines in mid-year because of industrial disputes.

Production of primary refined zinc increased slightly in 1986, but the production of primary refined lead fell sharply because fewer concentrates were available as a result of the Broken Hill industrial dispute. Lead metal production including secondary was 171,039 tonnes and zinc metal production including secondary was 307,615 tonnes.

Detailed exploration of a number of deposits continued in 1986. These included Hilton, Lady Loretta, Thalanga, Liontown and Conjuboy, all in Queensland; Scuddles, Blendevale, Cadjebut and Twelve Mile (Lennard Shelf) in Western Australia; Benambra, Victoria and Hellyer in Tasmania.

Black coal

Raw black coal production in 1986 was a record 169.9 million tonnes, 7 per cent higher than in 1985. The output of saleable coal rose by 7 per cent to the record level 139.1 million tonnes. Domestic consumption rose to the record level of 43.4 million tonnes in 1986, mainly due to the growth in use by the electricity industry. Exports rose by 5 per cent to 92.0 million tonnes in 1986 and the value of exports rose to $5,327 million. Of total exports 41.9 million tonnes were shipped to Japan. Australia was the world's leading coal exporter in 1986.

Demand for steaming coal on the international market has remained high. As a result Australian exports of steaming coal rose to 43.3 million tonnes in 1986. Downturn in the world's steel industry in 1985 and 1986 caused Australian exports of coking coal to fall by 2 per cent in 1986 to 48.7 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.

Petroleum

At the end of 1986 there were 101 fields producing stabilised crude oil, which is 25 per cent more than in 1985 (81 fields). In 1986 production of crude oil fell by 12.3 per cent to 27.7 million cubic metres compared to the 1985 record level of 31.6 million cubic metres. The production of natural gas and condensate rose by 9.2 per cent and 10.7 per cent respectively.

Total refinery input declined by 2.6 per cent and the proportion of total input from indigenous sources decreased from 80 per cent in 1985 to 77 per cent in 1986. Consumption of automotive gasoline (motor spirit) decreased by 3.2 per cent. Consumption of all other major petroleum products except automotive diesel oil and aviation turbine fuel also decreased. The quantity of imported crude oil, enriched crude oil and other refinery feedstock increased by 18.4 per cent in 1986 compared with that in 1985, however its value decreased by 28.3 per cent from $2,133 million to $1,531 million. Total exports of petroleum products fell in value in 1986 by 45.5 per cent to $1,797 million, compared to $3,300 million in 1985.

The number of exploration wells drilled decreased from 270 in 1985 to 139 (111 onshore, 28 offshore) in 1986, and total metres drilled for exploration decreased from 512,112 m in 1985 to 275,256 m in 1986, a decrease of 46.3 per cent. Geophysical exploration also decreased during 1986. Offshore exploration resulted in one oil, two gas and two oil and gas discoveries, and two gas/condensate discoveries. Onshore exploration produced fifteen oil, ten gas, five oil and gas discoveries, and seven gas/condensate discoveries. Development drilling in 1986 was below the level achieved in the last 5 years. The total of 37 development wells drilled was 61 per cent less than in 1985 (94 wells). Onshore drilling (17 wells) was down 78 per cent compared with 1985 (76 wells), and offshore drilling (20 wells) was marginally more than for 1985 (18 wells). Development wells were drilled offshore at Flounder (7), Snapper (5), Fortescue (3), and at North Rankin (5) platforms.

In 1986 there was a rapid decline in world oil prices followed by a slow recovery to about three quarters of the early 1985 value. In spite of this, several new developments proceeded during 1985 and 1986, the largest being the start of construction of the Liquefied Natural Gas (LNG) export phase of the North West Shelf gas project, designed to supply LNG to Japan commencing in 1989. The construction of a 1,500 kilometre gas line linking the Palm Valley and Mereenie fields to supply gas to the Channel Island power station in Darwin was another major development. In the Bass Strait Flounder, Snapper, Cobia and Fortescue development drilling proceeded, and the Bream platform was installed. Development drilling of the field from this platform commenced in 1987. Other significant developments in 1985 and 1986 were the installation of facilities, development drilling and initiation of production at the Jabiru and Harriet oil fields, and the development drilling of Palm Valley and Mereenie fields.

In Queensland, plants to extract liquids from gas were built at Kincora and Wallumbilla in the Surat Basin, and a small refinery was built at Eromanga to supply products locally, using oil from nearby fields as feedstock. The township of Warrnambool in Victoria was connected to the North Paaratte gas field, and an oil pipeline was constructed to connect Alice Springs to the Mereenie oil and gas field.

Plans are being formulated for the development of the Challis, Saladin, and North Herald/South Pepper offshore fields in Western Australia.

The Centre for Petroleum Engineering Studies was established at the University of New South Wales. This is the first Australian institution which will provide graduates in Petroleum Engineering to the industry.

Economic and sub-economic demonstrated resources of crude oil at 31 December 1986 were 262 gigalitres, a decrease from the previous figure of 289 gigalitres at the end of 1984. Economic and sub-economic demonstrated resources of gas increased to 2,089,000 million cubic metres. Expenditure on petroleum exploration decreased 22 per cent from $750.0 million in 1985 to $586.8 million in 1986.

Nickel

Mine production of nickel in ore and concentrates was an estimated 78,000 tonnes in 1986. Australia was the third largest world producer after Canada and U.S.S.R. 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. Nickel-laterite ore mined at Greenvale, Queensland, is treated at the Yabulu nickel treatment plant 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 1986 were: rutile production 220,046 tonnes, ilmenite 1,291,349 tonnes, zircon 419,290 tonnes and monazite 10,583 tonnes.

Diamonds

Commercial production of diamonds from the alluvial deposits in the Upper Smoke Creek and Limestone Creek alluvials and from the scree deposits overlying the AK-1 Kimberlite pipe at Argyle commenced in January 1983; the alluvial and scree deposits were mined out in 1985. In its first year of full scale mining of the AK-1 pipe, Argyle Diamond Mines Pty Ltd produced 29,210,764 carats of diamonds in 1986, easily exceeding production from any other mine in the world, or for that matter, the annual production from any country. Diamonds from the AK-1 pipe comprise about 6 per cent gem, 39 per cent cheap gem and about 55 per cent industrial grades.

Uranium

Preliminary estimates of production of uranium in Australia in 1986 amounted to 4,899 tonnes of U_3O_8 (4,154 tonnes contained U) 30.0 per cent greater than in 1985. Exports for 1986 were 4,166 tonnes of U_3O_8 (preliminary estimates only).

HISTORICAL DEVELOPMENT OF THE AUSTRALIAN MINERAL INDUSTRY

(This special article has been contributed by the Bureau of Mineral Resources—written by I. R. McLeod)

The history of the Australian mineral industry began with the first European settlement when settlers quarried stone and dug clay for bricks for their buildings. The industry since then has had its booms and depressions, but from the discovery of gold at least, it has been an important contributor to the Australian economy. It provides the nation's basic industrial requirements—construction materials, fuel, and industrial raw materials; it has facilitated decentralisation of both population and industry, as towns, railways and ports were established to serve the mines and smelters; it has encouraged technological advancement, both in its own and other, unrelated, fields; and it has been a major earner of export income.

The industry has created wealth for the nation and its people through the discovery and mining of mineral deposits and processing the ore. It now produces some 65 different mineral commodities with an annual value of mine production ranging up to more than $5,000 million in the case of coal. Australia is one of the world's leading miners of bauxite (the ore of aluminium), diamonds, gold, iron ore, lead, manganese ore, nickel, titanium (rutile and ilmenite), tungsten, zinc and zircon. It mines, or has unworked deposits of, almost all mineral commodities—of the major mineral raw materials it now lacks only sulfur. Some commodities, such as petroleum and aluminium, have had a relatively short production history in Australia; others, such as the base metals, iron ore, and, especially, coal, go back to the early days of the industry.

AUSTRALIAN ECONOMIC DEMONSTRATED RESOURCES, MAJOR MINERAL COMMODITIES

(Mt unless otherwise indicated)

Commodity	*Pre 1965(a)*	*1975*	*1985*
Bauxite	21(1954)	3,000	2,889
Black coal (recoverable)	(*b*)4,276(1962)	19,500	34,000
Brown coal (recoverable)	17,000(1960)	12,600	41,900
Copper (kt)	1,300(1960)	5,900	16,100
Diamond (10^6 carat)			
gem	—	—	187
industrial	—	—	229
Gold (t)	250(1960)	156	959
Iron ore	374(1959)	17,800	16,220
Lead (kt)	4,300(1960)	13,900	14,500
Manganese ore	<2(1962)	490	326
Nickel (kt)	—	1,900	1,700
Petroleum ($10^6 m^3$)			
crude oil	—	243	231
natural gas	—	326,100	691,000
Silver (kt)	7(1960)	24	31
Tin (kt)	(*c*)28(1960)	(*c*)332	262
Titanium (concentrate)			
ilmenite (kt)	(*d*)3,500(1955)	58,400	41,400
rutile (kt)	2,500(1955)	9,200	8,000
Uranium (recoverable) (kt)	n.a.	300	470
Zinc (kt)	4,000(1960)	19,300	21,200
Zircon (kt) (concentrate)	2,900(1955)	15,700	11,500

(*a*) Only partly on same basis as later years. (*b*) Excludes Victoria, where reserves were small. Not specified whether in situ or recoverable. (*c*) Recoverable; in situ resources estimated to be about 20 per cent higher. (*d*) Not suitable for pigment production.
Source: Bureau of Mineral Resources.

Coal

It is not surprising that coal was the first mineral, other than those used for construction, to be found, because seams crop out along the coast to the north and south of Sydney. Coal was first discovered in the Newcastle area by escaped convicts in 1791. Mining began near Newcastle in 1799, and in 1800 coal became the first mineral exported from Australia.

Production increased steadily from the 1830s onwards, and in the mid-1920s Australian production was almost 14 Mt, but the depression of the 1930s saw it fall by over a third of this amount. Renewed growth faltered in the late 1940s. Exports, which normally exceeded 1 Mt/year until the mid-1920s, had fallen to about 50,000 t by the late 1940s because of increasing competition. At that time also, petroleum products began to replace coal in industry and railways, and these trends were exacerbated by prolonged industrial unrest.

It was widely agreed then that coal would be of diminishing importance as a major mineral commodity. However, measures taken to improve the efficiency of mining, realisation of the economic importance of near-surface seams in the Bowen Basin in Queensland, and the emergence of large markets for coking coal in Japan particularly, brought about a resurgence in the industry. Exports began to increase rapidly in the mid-1950s, and, with impetus added by the oil shocks of the 1970s, Australia became the world's largest coal exporter, with exports reaching 88 Mt in 1985.

The pattern of production changed also. In 1950, New South Wales provided 75% of the total production and Queensland, 14%. In 1985, the two States provided 47% and 49% respectively, and exports from the two were about equal, 68% of the total Australian production being exported. Despite its changing fortunes, the coal industry has been a major sector of the mineral industry for 150 years. The rapid increase in exports in the 1960s consolidated its pre-eminence; in 1985 coal contributed 24% of the total value of ex-mine production in Australia, represented about a third of the industry's total assets, and provided 16% of total Australian merchandise exports.

Minerals

In the circumstances at the time, the early settlers were little interested in minerals. Traces of gold were reported from 1823 onwards, and occurrences of other metals were reported from time to time. The first metalliferous mining was of silver-lead, at Glen Osmond near Adelaide, in 1841. Copper mining began at Kapunda, in the same general area, in 1842, and at Burra, to the north, in 1844. At the end of the same decade, the first pig iron was produced from a small deposit of iron ore near Mittagong, New South Wales.

It was the discovery of payable alluvial gold in 1851 near Bathurst in New South Wales and, soon after, the rich Victorian fields, that gave impetus to the metalliferous sector of the mineral industry. As search and discovery quickly spread to other parts of eastern Australia, the migrants which the gold attracted, the infrastructure which resulted, and realisation of the mineral potential of the young country, all profoundly influenced the development of Australia from the 1850s onwards.

The wealth created by the newly-mined gold and the influx of migrants began the transition away from an agricultural and pastoral economy. As industries were established to supply the machinery and transport facilities needed by the mines, service industries expanded to cater for increasing population and growing commercial activities.

Gold was the prospectors' prime target for many years after 1851, and the Victorian discoveries were followed by many others around the continent, though few were so rich. Many of the new gold-fields were abandoned as the shallow surface alluvials were exhausted, but on some, especially in Victoria, mining progressed to the deep leads—alluvial deposits covered by tens of metres of later sediments or by lava flows.

Prospecting on some fields discovered primary gold lodes rich enough to be worked. But working such lodes necessitated deep shafts and machinery and treatment plants, and these required capital. The individual miner or syndicate was replaced by companies, employing dozens or even hundreds of men. Towns were established and, as confidence in the long life of the mines increased, tents and shanties gave way to more permanent private and commercial buildings. When, decades later, the mines did start to peter out, many such towns survived because they had become centres for the surrounding agricultural and pastoral industries, or were at convenient points on well established transport routes.

The interest and expertise in prospecting aroused by gold soon led to discoveries of other metals. Tin mining began almost simultaneously in 1872 at Inverell, New South Wales, Mount Bischoff, Tasmania, and Stanthorpe, Queensland. With the discovery soon after of

other fields, especially Herberton in North Queensland, Australia became the major world source of tin in the late 1870s and early 1880s. Base metals were discovered at many places, including Moonta-Wallaroo, South Australia, Zeehan-Dundas and Mount Lyell, Tasmania and Cobar, New South Wales, and Mount Morgan, Queensland. The fabulous Broken Hill lode, whose profits spawned a variety of industries, including steel at Newcastle in 1915, was discovered in 1883.

By the beginning of the twentieth century, the metalliferous mining industry, with associated smelters and refineries, was well established. Gold was still pre-eminent, accounting for three quarters of the total value of metalliferous mine production, with copper, lead and silver accounting for most of the remaining quarter.

Like the goldfields, each mine needed a town for its workers, engineering and machinery suppliers and transport facilities—including ports to ship its products to other parts of the world. Many towns in existence today owe their foundation to a mineral deposit found in the last four decades of the nineteenth century.

The industry continued to prosper in the early years of the twentieth century. However, it was severely affected by the collapse of metal prices after the ending of World War I. Many mines closed, and the value of mineral exports fell from $15.3 million in 1919–20 to $7.6 million in 1921–22.

In the late 1930s the mineral industry, although well established, played a minor role in the Australian economy. The need for new ore reserves of many minerals was the major concern of the industry in the late 1930s and early 1940s. Indeed, the forty-year drought of new discoveries, after the flood of the previous century, led some to the belief that there were few new resources to be found, and that the industry would gradually run down. An embargo was placed on the export of iron ore in 1938 by the Commonwealth Government, when reserves of high-grade ore were believed to be no more than 260 Mt. Few new mineral deposits were found from the beginning of the century until after World War II.

In the late 1940s there began a series of discoveries that was to completely change the structure of the industry and elevate Australia to a major mineral exporting country. In the 1950s the mainstays of the industry were lead, zinc, copper, gold, and coal, and only the first four were exported in any quantity. By the late 1960s Australia was a world force in aluminium, coal, iron ore, nickel, manganese, titanium, uranium and zirconium as well as the traditional lead and zinc.

The reason for the surge of discoveries is manifold. Some of the 'new' deposits had been known previously, but were not economically workable. The economics of working such deposits changed remarkably because of technological advances which lowered the cost of mining and transporting huge quantities of material, but these advances would not have been decisive without the emergence of Japan as a major buyer of coal, iron ore and bauxite.

The discovery of new ore bodies close to former mines and the striking of the many new deposits was aided by the development of geochemical and geophysical exploration methods suited to Australian conditions. Many techniques developed in the northern hemisphere were not successful in the arid, deeply weathered terrain characteristic of most of Australia. However, these techniques were modified and new ones developed, and Australia is now a world leader in expertise for mineral exploration in arid regions.

Apart from Japan's economic growth, the expansion of the world economy in the 1950s and 1960s meant an ever increasing demand for minerals. Australia, with its well established industry, had the experience needed to find and develop the new deposits needed to meet this demand.

The greatly increased knowledge of the geology of Australia resulting from systematic geological and geophysical studies led to a better understanding of the geological evolution of the continent. Mineral explorers were able to search more efficiently by using geological theories on the origin of mineral deposits to target specific areas for concentrated exploration. The better understanding showed also that Australia had a high potential for the discovery of mineral deposits. This realisation, together with Australia's political stability, led to an influx in the early 1960s of major overseas mining companies who, in addition to increasing exploration expenditure, brought in new expertise and ideas.

The search for a variety of minerals in diverse geological conditions has developed a highly experienced mineral exploration industry which has begun exporting its skills to other parts of the world.

Petroleum

The 1960s saw also the discovery of economic accumulations of what had been Australia's most serious mineral deficiency—petroleum.

Although it had been sought for many years, petroleum (which includes crude oil and natural gas) was a latecomer to the mineral production scene in Australia. However, it has made up for lost time and has become one of Australia's major mineral products in terms of value of production; and in 1985, following a change in government policy on petroleum exports, it was Australia's second most valuable mineral export.

Hydrocarbons, in the form of crude bitumen, were first recorded in 1839, at the mouth of the Victoria River, near the Western Australia–Northern Territory border. The first well drilled specifically for petroleum was put down in 1882 at Alfred Flat, in the Coorong area of South Australia. However this well, and several others in the same general area, did not encounter any oil.

In 1900, at Roma in Queensland, natural gas was encountered in an artesian water bore which was being deepened. Gas continued to flow freely from the well and in 1906 it was reticulated for town lighting; however, the flow failed after 10 days. This discovery marks the real beginning of petroleum exploration in Australia. Many wells were drilled subsequently in the Roma region; some encountered small quantities of oil or gas.

The first substantial flow of oil was in 1953 from the Rough Range No. 1 well in the north-west of Western Australia. However, a commercial field did not eventuate, and the interest in petroleum exploration aroused by the discovery began to wane. Because of the economic and strategic advantages of an indigenous supply of petroleum, the Commonwealth Government had encouraged the search for it since soon after World War I. With the increasing importance of petroleum and petroleum products to the Australian economy, the Government in 1957 adopted several measures, including a subsidy for specific approved operations, to encourage petroleum exploration. These measures did much to re-encourage exploration.

Australia's first commercial oil field was discovered at Moonie, 200 km south-east of Roma, in 1961. A pipeline was built to Brisbane, and commercial production began in 1964. 1964 marked several other important events: the discovery of oil and gas at Barrow Island, Western Australia; of gas in what has become a cluster of oil and gas fields in north-west South Australia and the adjoining part of Queensland; and the most important of all, the discovery of gas some 25 km off the Gippsland coast in Australia's first offshore well. The Gippsland shelf fields now supply three quarters of the crude oil and nearly half of the natural gas produced in Australia.

The Gippsland Shelf discovery, as well as becoming Australia's main source of oil and gas, also turned attention to Australia's extensive continental shelf, and 1971 saw the discovery of the huge gas fields of the North West Shelf which, in addition to supplying Western Australia, will begin to feed one of the world's few liquefied natural gas export projects at the end of the 1980s.

In the early 1970s, petroleum exploration again began to languish—indications from exploration were that onshore oilfields probably would be small and hence unlikely to be economic. However, the oil shocks of 1973 and 1979, when oil prices increased several-fold, completely changed the economics of the industry. Expenditure on exploration increased rapidly, from $49 million in 1976 to $948 million in 1982. Some known fields, such as Palm Valley and some Bass Strait fields, were developed, and many new fields were discovered, especially in south-west Queensland and the adjoining part of South Australia.

While exploration has been primarily for oil, it has discovered large resources of natural gas. Indeed, indications are that geological conditions in Australia in the past have favoured the formation of gas rather than oil. Natural gas contributed 19 per cent of total Australian energy consumption in 1985.

Most Australian crude oils are 'light', and oil still has to be imported to supply heavy fractions needed for lubricating oils, bitumen, etc. In 1985, 96 per cent of Australia's crude oil requirement was met by domestic production. However, unless major new discoveries are made, Australia's crude oil self sufficiency will begin to decrease as production from some existing fields declines. Natural gas supplies, however, are adequate for many years, although resources are unevenly distributed around the continent.

Twenty years of growth

In the mid-1960s, the Australian mineral industry began to expand with growth in both production and exports and the relative importance of the various commodities changed. The relative importance of gold and the base metals declined, while coal, iron ore and 'other minerals' increased in relative importance.

In 1965, industry spent $22 million on mineral exploration, and $48 million on petroleum exploration. These amounts had increased to peaks of $576 million in 1981–82 on mineral exploration, and $948 million in 1982 on petroleum exploration. Allowing for inflation these peaks represent a multiplication of exploration effort of seven times for minerals and five times for petroleum.

The Australian manufacturing industry, despite its growth, absorbed only a small part of the greatly increased mineral production, and the proportion of production exported (in either raw or processed form) increased greatly in the late 1960s and early 1970s. The index of mineral output at constant prices for 1985 was almost 6 times that for 1965, while the 1985 index of exports of metals and minerals at constant prices was over 11 times the 1965 figure. These exports relieved the pressure on the Australian balance of payments but also made the industry dependent on the health of the world economy.

The destination of exports changed between 1965 and 1985. In 1965, 41% of Australia's mineral exports went to Europe (and 24% of total exports were to the United Kingdom); 41% went to Asia (32% of the total going to Japan); and 16% went to America. In 1985, the corresponding figures were 14% (4%); 63% (41%); and 12%. In 1985 mining, smelting and petroleum production contributed 8% of the Australian GNP, was responsible for 16% of private fixed capital expenditure, and employed 132,000 persons.

In the early 1980s, lower mineral prices resulting from decreased world demand for minerals caused a drastic decline in the Australian industry's profitability; which was only 2.2 per cent of shareholders funds in 1981–82. Measures to increase efficiency, including mining higher grade ores, work-force reductions and changed work practices, and, in a number of cases, mine closures, had their effect, and by 1985–86 the return on shareholders funds had increased to 4.9 per cent.

Australia is now the world's first, second or third largest exporter of about 10 mineral commodities (including alumina, coal, iron ore, lead, nickel, mineral sands—rutile, ilmenite and zircon—and zinc) and a major exporter of many others.

The Australian mineral industry is almost all owned and operated by the private sector. For much of the industry's history the relationship between it and government generally had been simple: State governments granted mining leases, ensured that the mining laws were observed, and collected royalties; the Commonwealth Government collected those taxes to which it was entitled.

Many of the new mines were planned as large scale operations from the very beginning. They needed a large workforce—which had to be housed and provided with community services—and transport facilities to handle millions of tonnes of product each year. Rather than provide these facilities themselves, governments made it a condition of many new mining leases that the companies provided, or made a major financial contribution to, the infrastructure for the mining operation—not only the railways and ports, but the social infrastructure such as streets, houses, schools, hospitals and recreation facilities.

This requirement arose partly because governments had difficulty finding the funds required because of competing demands in a time of rapid economic expansion; but another argument was that, because the mineral deposits belonged to the State, the benefits of their exploitation should go to the public generally as well as the companies concerned. Some governments took this argument further, and made the industry a source of revenue additional to the relatively small amount of royalty payments by imposing charges for services (e.g. rail freights) considerably higher than the cost of providing the service.

Environmental issues

In the 1950s the industry began to be affected by increasing public concern for the quality of the environment. With the rising awareness that preservation of natural features such as scenery and plant and animal habitats had a value to society, governments increased the controls on discharge of potentially polluting emissions such as water containing sediments or chemicals, and noxious gases. Whereas the industry once, by and large, had priority in land use, it now had to justify its activities in competition with other potential uses of the land. Governments also took account of the likely effect of a proposed mining or treatment process on the surroundings before deciding whether it should go ahead, and required that, where

feasible, mined-out areas be rehabilitated by reshaping and revegetating the surface so that the site could be used for other purposes.

The mineral industry's former priority for land use was eroded further in the 1970s when title to extensive tracts of land in the Northern Territory and some States was granted to the land's traditional Aboriginal owners. One result of this was that companies had to obtain the consent of the Aboriginal owners before they could explore or mine on such land. Because of the significance of land to Aboriginal society, and because of the owners' wish to minimise the effect of a different culture on their traditional way of life, this requirement commonly required prolonged negotiations and this in turn added to the costs and uncertainty of the mineral exploration process.

The industry today

In the late 1970s, the rate of growth of the mineral industry in Australia, which had been maintained for more than 15 years, began to slow. New mines had been developed around the world to meet a forecast demand for minerals which turned out to be overly optimistic. The Australian industry's costs had increased but, in general, mineral prices had not. The industry was largely dependent on exports and had to compete for sales with mines in other countries; some of these mines were less affected by cost increases, or were assisted in various ways by their governments.

Many new coal mines were established in Australia after the second oil shock in 1979, but world demand stagnated, leaving the industry in Australia (and the world) with substantial surplus capacity. Metal prices failed to increase in line with the world economic upturn in the early 1980s, and few new metal mines were opened—Australian production increased largely because of capacity increases at existing mines to achieve economies of scale. Statistics show mine production and exports increased year after year, but the return on funds employed generally was low and a number of mines closed because they had become uneconomic. Petroleum exploration expenditure had increased rapidly after the second oil shock in 1979; several new commercial fields were discovered, especially in south-west Queensland, and, because of the greatly increased price of crude oil, decisions were made to develop some previously uneconomic fields. However, the collapse of world crude oil prices in the first quarter of 1986 completely changed the fortunes of the petroleum industry. Production fell (mainly because of virtual cessation of exports), exploration was reduced sharply, and development of a number of fields was deferred.

At the exploration stage, the industry has to meet new challenges. Not surprisingly, the mineral deposits found in the first century of mineral search were those well exposed at the surface; and the first petroleum accumulations found tended to be the larger, better delineated, ones. Consequently, finding further economic ore bodies and petroleum accumulations has become progressively more difficult, requiring the use of increased skills in applying suitable methods and interpreting the results.

By the mid-1980s, one of the few bright spots in the Australian mineral industry was gold. Because its price was fixed, gold was largely ignored in the expansion of the industry after World War II. Interest revived to some extent when the price was freed in 1968 and strengthened with increasing confidence that the price increases of the late 1970s were likely to be sustained.

Two other factors heightened the interest. One was the development of an efficient method of recovering very fine grained gold; the other was the realisation that modern methods allowed the economic mining by open cut and treatment of an entire zone of gold bearing veins (both the veins and the intervening barren rock) whereas in the past only the veins themselves would have been mined.

So another gold mining boom emerged in the early 1980s. Australian gold production multiplied from 18 t in 1981 to 57 t in 1985. In 1984 and 1985 alone, 24 new gold mines were opened, and retreatment of old tailings began at several centres. Notably, almost all the deposits opened up were close to, or at, old mines—very few were completely new discoveries.

History probably will show that the 1980s was another period of change for the mining industry: a period of consolidation rather than expansion, especially in the structure of the industry, even though the volume of production continued to increase; a period of increasing diversity of export markets, with reduced dependence on a few major customers; a period of strenuous efforts to improve the efficiency of operations; and a period in which the Australian industry, despite far-reaching changes in world mineral production and consumption patterns, was able to retain its role as a major supplier to international markets, and a major source of income for the Australian economy.

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