

# CHAPTER 16

## MINERAL INDUSTRY

### GENERAL

#### 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 miles 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 widely throughout the Precambrian and Palaeozoic rocks of the continent. Palaeozoic mineralisation is perhaps more varied, but the Palaeozoic deposits now being worked are in general smaller than those found in Precambrian rocks. Most of Australia's metallic mineral deposits occur within two broad regions: one of Precambrian rocks in the west and central areas of the continent; and one of younger Palaeozoic rocks in the east.

##### Mineral resources

Australia is self-sufficient in most minerals of economic importance (and much more than self-sufficient in some). Known adequate reserves of minerals with production sufficient for domestic demand and exports include aluminium (bauxite), black coal, copper, gold, iron ore, lead, natural gas, nickel, salt, silver, tin, tungsten and zinc. Adequate reserves sufficient for domestic demand include clays (except light grade china clay), brown coal, dolomite and feldspar.

For further details of principal Australian mineral deposits, and notes on principal mineral resources, see Year Book No. 61, pages 925-932.

#### 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 important only in the New South Wales coalfields. In the States, these rights are held by the State Governments and in the Territories of the Commonwealth they are vested in the Commonwealth Government. The Commonwealth Government is able also to influence over-all 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.

##### Control of mining

Each State or Territory has its own mining Acts or Ordinances and regulations governing the prospecting for and working of mineral deposits. These Acts, etc., are similar in principle but different in detail. They all made provision for a miner's rights 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.

#### **Control of mineral exploration**

This section refers in general to the exploration for all types of mineral deposits in Australia. Additional information relating to the search for petroleum is set out in the following section.

As a result of the introduction of large scale modern prospecting methods (particularly airborne prospecting), the small prospecting areas referred to in the previous section 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 only) 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.

#### **Control of petroleum exploration**

*On-shore.* In Australia, all petroleum is the property of the Crown. Consequently, 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:

- (a) the permit, covering initial geological, geophysical and exploration drilling;
- (b) the licence (in Victoria only), which covers detailed surveys and drilling; and
- (c) the lease, which covers development operations and production.

Further details of the petroleum legislation are given in Year Book No. 55, pages 996-7.

*Off-shore.* The *Sea and Submerged Lands Act 1973* asserted Commonwealth sovereignty over the territorial sea and continental shelf. However, for the purpose of administering petroleum exploration in off-shore areas, complementary legislation was passed by the Commonwealth Government and each State Government in 1967 and the arrangements under this legislation are still applied. Thus the *Petroleum (Submerged Lands) Act 1967* is the instrument whereby the control and safeguarding of the exploration and exploitation of petroleum resources on the territorial sea-bed and on the continental shelf are assured. Each State Government administers the Act in relation to its adjacent off-shore area, but refers certain matters to the Commonwealth Government. The Commonwealth Government has the administrative responsibility for the area adjacent to the Northern Territory. However, after 1 October 1978, certain administrative changes may be necessary in respect to the Designated Authority, but these changes will not affect the general administration of the Act.

The legislation provides for a two-stage system of titles: the exploration permit, which covers all forms of exploration including drilling; and the production licence, which covers development and exploration. Royalty is generally shared between State and Commonwealth Governments on a 60 : 40 basis; however, overriding royalty is payable to the State under certain conditions.

#### **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)

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
New South Wales(a)	10,237	9,592	13,496	37,864	32,660	46,354
Victoria(b)	16,875	18,025	23,922	26,657	29,893	32,696
Queensland(a)	3,805	3,525	4,319	34,867	36,753	50,842
South Australia	1,821	1,807	1,944	2,500	2,788	3,346
Western Australia	25,247	27,666	33,615	39,385	43,111	51,638
Tasmania(c)	489	498	506	342	576	1,496
Northern Territory(d)	634	910	242	99	545	362
Commonwealth Government(e)	7,567	7,896	10,786	12,155	13,440	13,805
<b>Total</b>	<b>66,676</b>	<b>69,921</b>	<b>88,831</b>	<b>153,869</b>	<b>159,766</b>	<b>200,539</b>

(a) Includes royalty on sand and gravel from Crown lands. (b) Includes royalty on brown coal paid by State Electricity Commission and royalties received under the *Petroleum (Submerged Lands) (Royalty) Act 1967*. (c) Includes rent and fees from mineral lands and royalties on iron ore. (d) Excludes Aboriginal Benefits Trust Fund royalties from mining operations for which details are not available. (e) Includes royalties received under the *Petroleum (Submerged Lands) (Royalty) Act 1967*.

**Control of Exports**

The Commonwealth Government maintains export controls over certain metals, petroleum and petroleum products, and all raw and semi-processed minerals. Export control policy is currently under review.

**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:

- (i) 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;
- (ii) to ensure that the coal resources of the State are conserved, developed, worked and used to the best advantage in the public interest;
- (iii) to 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; and
- (iv) to promote the welfare of workers engaged in the coal industry in the State.

**Queensland Coal Board**

The Queensland Coal Board has functions similar to those of the Joint Coal Board. It also carries out research and sampling tests of Queensland coals. It makes funds available to colliery proprietors for equipment and makes grants and/or loans for the provision of amenities for employees and for communities in coal mining districts. The price fixing of coal sold within Queensland is another important function.

**Australian Atomic Energy Commission**

During 1953, legislation was enacted to set up an Atomic Energy Commission to be responsible, in an overall sense, for the production and utilisation of uranium in Australia. This Act, the *Atomic Energy Act 1953*, superseded the *Atomic Energy (Control of Materials) Act 1946*, but retained a provision of that Act which provided for the control of substances which could be used for production or use of atomic energy.

The functions of the Commission fall under two main headings: firstly, it is responsible for undertaking and encouraging the search for and mining of uranium and is empowered to co-operate with the appropriate authorities of the States in connection with these and related matters; secondly, it is authorised to develop the practical uses of atomic energy by constructing and operating plant for this purpose, carrying out research and generally fostering the advancement of atomic energy technology. The Commission operates under the direction of the Minister for National Development.

**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 page.

### 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 and the Commonwealth Scientific and Industrial Research Organisation.

*Income taxation concessions.* 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.

Special deductions for capital expenditure incurred in the discovery and mining of 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 costs of exploratory surveys, drilling and well-head plant; plant for the liquefaction of natural gas; and of access roads and expenditure on housing and welfare. The enterprise is entitled to these special deductions against income from any source. While the special deductions for exploration expenditure are deductible immediately against the net income of the enterprise, the deductions for capital expenditure on development are allowable over the life of the oil or gas field or over five years, whichever is less on a reducing balance 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 five years, whichever is the less. Expenditure incurred by a mining enterprise in exploring for general minerals is allowable as an immediate deduction against net income derived from mining operations. 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 40 per cent of the cost of certain new plant in its initial phase, or at 20 per cent in its second phase.

Special deductions are allowable for capital expenditure incurred on certain transport facilities used primarily and principally in relation to minerals mined in Australia for the transport of raw minerals 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 deduction applies 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.

An income tax rebate of 30 cents for each dollar of share capital subscribed after 24 August 1977 is available to shareholders of petroleum mining companies exploring or mining for petroleum in off-shore areas of Australia where those companies lodge appropriate declarations with the Commissioner of Taxation in respect of the moneys subscribed. By lodging those declarations, certifying that the capital subscriptions have been, or will be, spent on eligible outgoings within a specified period, the petroleum mining companies forgo deductions to which they might otherwise be entitled for capital expenditure incurred in off-shore operations after 24 August 1977.

*Petroleum search subsidy.* The petroleum search subsidy scheme, introduced in 1957, was terminated on 30 June 1974. For details see Year Book No. 61, pages 936-7.

*Pricing of Australian crude oil.* In August 1977, the Commonwealth Government announced new arrangements in the pricing, allocating, and levying arrangements of crude oil. These will take the price of indigenous crude oil from presently known fields in the direction of import parity. This will be achieved through a uniform method of price determination. The new scheme, which took effect from 17 August 1977, applies to each known field in Australia.

Producers receive the import parity price for a specified part of their production. Import parity is received for either the first 6 million barrels of oil produced from each field per annum, or for a proportion of production per annum which will be increased over time according to a specified schedule, whichever is the greater in any particular case. The schedule is 10 per cent from 17 August 1977 until the end of the 1977-78 financial year, rising to 20 per cent for the financial year 1978-79, 35 per cent for 1979-80 and 50 per cent for 1980-81. For all additional production from each field or new development, the producers receive the price which was current up to the time of the introduction of the

new arrangements, i.e. \$2.33 per barrel in the case of the Bass Strait fields, and \$2.88 per barrel in the case of the Barrow Island field. All production from the Moonie and Alton fields and other small fields will, in practice, receive import parity prices, as the output from those fields is well below 6 million barrels per annum.

The Government will review the position before June 1981 to decide the rate at which the further progression to full import parity should take place for presently known fields. Oil from fields discovered after 14 September 1975 will continue to receive full import parity.

The import parity price will be set every six months by the Commonwealth Government and will be calculated on the basis of the price of Arabian light oil at the nearest refinery port, adjusted to allow for an appropriate quality differential. This differential will take account of the suitability of indigenous crude oil for the local market. For the period until 31 December 1978, the import parity price is set at \$12.59 per barrel for Bass Strait crude oil, \$12.64 for Barrow Island crude, and \$13.52 for Moonie crude delivered to Westernport, Kwinana, and Brisbane/Roma respectively.

*Payments to producers of phosphate fertilisers.* The *Phosphate Fertilisers Bounty Act 1963* provides for a bounty to be paid on phosphatic substances produced and sold in Australia as a fertiliser. Phosphatic substances used as a supplement to stock food are also regarded as being used as a fertiliser. Bounty is payable at the rate of \$12 per tonne in respect of superphosphate where the available phosphorus content is not less than 8.5 per cent or more than 8.9 per cent by weight. Outside this range, bounty is payable at \$138 per tonne of the available phosphorus content of the substance. The intention of the Act is to assist consumers of phosphate fertilisers (primary producers). The Act expires on 30 June 1982.

*Bureau of Mineral Resources, Geology and Geophysics.* The functions of BMR are as follows:

- (i) as a primary function, to obtain, study, publish and provide basic geological and geophysical information necessary for the exploration and development of the nation's mineral resources (this is to be done, where appropriate, in co-operation with State and Territorial authorities);
- (ii) to undertake experimental studies and research into geology and geophysics in order to support the function of obtaining basic information;
- (iii) to make basic investigations of the earth's magnetic and gravitational fields and in seismology and vulcanology;
- (iv) to complement the work of the State and Territorial authorities by undertaking geological and geophysical investigations into the occurrence and distribution of underground water;
- (v) to undertake geological and geophysical investigations on behalf of other Commonwealth Government Departments and authorities including the provision of resident staff by arrangement with the Territories;
- (vi) to obtain basic information on, and review the mineral resources of Australia and its Territories; to study the various sectors of the mineral industry both in the national and international spheres; and to publish and provide information about the mineral industry;
- (vii) to undertake such investigations in mining engineering and petroleum technology as are relevant to (i) and (vi) above;
- (viii) to prepare advice for Government on the mineral industry, including the exploration and development of mineral resources in the national interest;
- (ix) when directed by Government, to administer schemes for the assistance of sectors of the mineral industry and to undertake special mineral projects.

BMR comprises five branches under the Director: Operations, Mineral Resources, Geological, Geophysical, and Petroleum Exploration. The Operations Branch consists of five sections: Planning and Co-ordination, Publications and Information, Automatic Data Processing Applications, Cartography and Administrative. It carries out central office functions, including planning and control of program, assessment of results, co-ordination of activities, liaison, distribution of information and provision of ADP and cartographic services. The Mineral Resources Branch comprises the sections Mineral Economics and Mining Engineering and is concerned largely with those aspects of BMR's work which involve studies of the mineral industry as a whole, including the assessment of Australia's mineral resources and the preparation of advice and reviews for the Government, industry and the public. The Geological and Geophysical Branches are responsible for the principal field activities of BMR and the operation of observatories. The Petroleum Exploration Branch is concerned with the technical administration of the *Petroleum (Submerged Lands) Act 1967*, the assessment of sedimentary basins in Australia and its Territories, and monitors the level of petroleum exploration, development, and production activity and associated economic factors. At 30 June 1978, 529 officers were employed at BMR, this included 242 professional officers (geologists, geophysicists, chemists, engineers and mineral economists).

BMR maintains laboratories in Canberra engaged on geochemical, geochronological 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 State Mines Department renders scientific, technical and financial assistance to the mining industry. Grants are made to cover up to half the cost of prospecting and drilling operations. These grants are repayable if sufficient pay minerals are discovered or if certain other conditions are met. A quantity of equipment is also available for hire in several localities. The Department has itself undertaken a program of contract drilling to investigate the existence of mineral deposits in the State (including the testing and proving of coal resources). Expenditure on financial assistance in 1976-77 amounted to \$394,543, including \$216,444 on the Department's own drilling program.

*Victoria.* The Department of Minerals and Energy conducts geological and mineral surveys and produces geological maps, and issues scientific and technical reports thereon. Extensive rotary, percussion and auger drilling operations are carried out and, in conjunction with these, sedimentary basin studies are made to evaluate petroleum, mineral and ground water potential. A comprehensive library and a geological museum are maintained, and a core library retains cores and cuttings from drilling operations. The administration of petroleum, pipeline, mining and extractive industry legislation ensures that petroleum exploration and production (both on-shore and off-shore), mining and quarrying are carried on in a safe and effective manner. Technical and drilling assistance and loans or grants are available for mineral exploration and prospecting and for approved development operations. Six stamp batteries provide an ore crushing service to enable test crushings to be made at nominal cost. Information is available on mining law and mineral statistics. Assays of ores, analytical services, advice on metallurgical treatments, industrial pollution and chemical problems are available, together with information on the manufacture, handling and use of explosives and inflammable liquids. Financial assistance is available to municipalities to reclaim mine-damaged land in areas where a reclamation committee recommends such action.

*Queensland.* The Department of Mines provides assistance to mining by way of geological services, grants for construction and maintenance of roads in mining areas, repayable advances or subsidies for mine development, hiring and equipment, and assistance to prospectors. The Department maintains a concentration plant for tin ores at Irvinebank, an assay office at Cloncurry and diamond drilling plants in various parts of the State. The Queensland Coal Board carries out research and sampling tests of Queensland coals. It also makes funds available to colliery proprietors for equipment and makes grants and/or loans for the provision of amenities for employees and for communities in coal mining districts.

*South Australia.* The Department of Mines provides the following services and facilities to the mineral industry: drilling and testing of mineral deposits; geophysical investigation; well logging; development of sub-surface water supplies for farming, pastoral, irrigation, and mining purposes; geological examination of mineral deposits, ground water supplies, dam foundation and drainage problems; and publication and issue of geological bulletins and maps. It also provides, through the Australian Mineral Development Laboratories, facilities for chemical, metallurgical, analytical and assay investigations, testing and treatment of ores and minerals, and petrographic, mineragraphic and radiometric determinations. Pilot scale metallurgical and chemical treatment plants are maintained and operated for the development of mineral extraction processes.

*Western Australia.* Prospectors receive assistance of either \$15 or \$17.50 a week according to the prospecting locality. North of the 26th parallel and within a defined area south of this lying largely outside the agricultural areas, assistance is given to the extent of \$17.50 a week. In the remainder of the State prospectors receive \$15 a week. Provision is also made for the supply of some tools required for prospecting. There are fifteen State batteries operating intermittently throughout the goldfields for the treatment of ore from prospectors and small mine owners at a nominal charge. A cartage subsidy is also granted to such operators sending gold and lead ores to State batteries for treatment. Provision is made for loans to mine-owners who require assistance to develop mines.

**Tasmania.** The Department of Mines provides financial assistance to mining lessees for the purchase of plant and machinery; for sinking, repairing or de-watering of shafts; for construction of dams and water races; for testing and proving a deposit of any mining product; for developmental work; and for diamond and other types of drilling. The Department has available for hire percussion and diamond drills for exploration, as well as a complete plant for small shaft sinking and tunnelling. Other assistance is rendered to the industry through geological and engineering advice, ore-dressing research into metallurgical recoveries, and the selection and design of treatment plant.

**Northern Territory.** To encourage the development of the mining industry the Department of Mines and Energy operates two batteries for the treatment of ores for miners. The Tennant Creek Battery is treating parcels of gold ore, while the Mount Wells Battery is crushing parcels of gold, tin, lead, copper and wolfram ore, and carrying out experimental work on more complex ores. The crushing charges are subsidised by the Government. Mining plant such as drills, compressors, pumps, and small hoists are available for hire to prospectors. Financial assistance is available to prospectors for mine development such as shaft sinking, driving, rising or winzing, and for cartage subsidies. Roads and water supply services are provided and maintained for mines under active development throughout the Northern Territory.

The Northern Territory Geological Survey undertakes geological and geophysical investigations including some engineering geology projects, and is also available to assist with the evaluation of individual mineral occurrences for prospectors and exploration companies. Technical libraries and collections of drill cores and cuttings are maintained in Darwin, Alice Springs and Tennant Creek.

## Research

Research investigations into problems of exploration, mining, ore-dressing and metallurgy are conducted by Government bodies, by universities, by private enterprise, and by combined efforts of these bodies. A summary of their functions follows. (For further information on research *see* Chapter 25 Science and Technology).

### Australian Atomic Energy Commission

The Australian Atomic Energy Commission conducts research at its laboratories at Lucas Heights in Sydney on the development of nuclear power, including research on nuclear materials and on metals and ceramics used for nuclear power.

### The Australian Mineral Development Laboratories

Technical consulting, contract research and process design for the mineral and associated industries is undertaken by The Australian Mineral Development Laboratories (Amdel) at Adelaide. This organisation is controlled by a council comprising representatives of the mineral industry, the South Australian Government and the Commonwealth Government. Extensive facilities are available in the fields of analytical chemistry, mineralogy, petrology, chemical metallurgy and mineral engineering, process instrumentation and control, water and waste water treatment and materials technology. Both long and short term applied research is carried out and all investigations are conducted on a strictly confidential basis. Services in the field of pollution and environmental control are also available through the Amdel group, Amdel (Aspect).

### The Baas Becking Geobiological Research Laboratory

In 1965, the Baas Becking Geobiological Research Laboratory was established in the Bureau of Mineral Resources building in Canberra under the joint sponsorship of the Commonwealth Scientific and Industrial Research Organization, the Bureau of Mineral Resources, and the Australian Mineral Industries Research Association (*see* Research by private enterprise, page 360).

Much of the biological research has involved studies on the biology and biochemistry associated with mineralisation processes. The expertise gained is applied to *in situ* examinations of sulphide mineralisation in carbonate-rich sediments. On the geological side, research is co-ordinated with the field programs of the Bureau of Mineral Resources, and includes studies on the McArthur and Georgina Basins and the Adelaide Geosyncline.

### Bureau of Mineral Resources, Geology and Geophysics

The Bureau of Mineral Resources is the largest geoscience research organisation in Australia. Its work is directed towards an integrated study of the origin, composition and structure of the rocks forming the Australian continent to the lower limits of the continental slope, particularly as these

affect the genesis and distribution of mineral deposits. The main effort is in field research supported and complemented by laboratory and office studies. BMR's activities include:

- geological, geophysical, and geochemical surveys to provide the basic information for further studies;
- compilation, review, and synthesis of information on and detailed investigations of sedimentary basins and metallogenic provinces, leading to an understanding of their origin and history, and to assessment of their prospectiveness;
- studies of specific commodities, including research into the occurrence and origin of their deposits, assessment of potential for new discoveries, resource inventories, and market trends;
- engineering geology, urban geology and hydrogeological investigations;
- maintenance of seismological and magnetic observatories, and related studies
- assessment of geophysical techniques in Australian conditions and development of new techniques and equipment;
- fundamental geoscience research with an orientation to the activities listed above; and
- provision and dissemination of the results of BMR's work and information on the geosciences generally.

For details of the functions of the Bureau of Mineral Resources, Geology and Geophysics, *see* page 357.

#### **Commonwealth Scientific and Industrial Research Organization**

Mineral research by the Commonwealth Scientific and Industrial Research Organization is undertaken mainly in the Minerals Research Laboratories comprising the Divisions of Mineral Chemistry, Mineral Engineering, Mineralogy, Mineral Physics, Process Technology and the Fuel Geoscience Unit, and in the Division of Building Research. Major laboratories are located at Clayton and Highett (Vic.), Port Melbourne, Sydney and Perth. Current research program objectives and sub-program titles are:

- Exploration techniques.* To improve and develop procedures for locating mineral deposits (geochemistry, geophysics, geological pattern recognition, isotopic studies);
- Ore deposits.* To elucidate the nature, mode of origin and factors controlling the location of economic mineral deposits (regional studies, nickel deposits, mineralising processes, depositional environment, mineralogical research techniques);
- Mining, beneficiation and control.* To increase the overall efficiency of mining operations and mineral beneficiation processes (mineral dressing, reactive mineral systems, iron ores, coal, phosphate ores);
- Process metallurgy and engineering.* To improve existing technology and initiate new processes in the field of process metallurgy, hydrometallurgy, chemical structures and thermodynamics, pyrometallurgy);
- Environment.* To protect and improve the quality of the human and natural environment (air pollution and abatement, solid and liquid wastes, aquatic environment, urban air quality); and
- Energy.* To support national plans developed to ensure the availability of energy in forms required by consumers and based on indigenous resources (coal conversion, coal and oil resource characterisation, energy conservation, energy conversion and storage and coal utilisation).

The minerals industry provides strong support in the form of co-operative research planning, collaborative investigation of specific projects, and financial grants for appropriate developmental work.

#### **Department of National Development**

The National Coal Research Advisory Committee, established in December 1964, no longer exists as such but has been incorporated into the Energy Research and Development Division of the Department of National Development. For details of this Division's functions and those of the National Energy Advisory Committee (NEAC) which advises the Minister for National Development on matters relating to national energy policy *see* Chapter 25, Science and Technology.

#### **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**

Most large mining and smelting companies have laboratories dealing with their own individual problems. Private industry formed the Australian Mineral Industries Research Association in 1959 to

provide industry with representation in the management of the Australian Mineral Development Laboratories. The Association now finances research work into geology, mining and mineral processing at Universities, the CSIRO and the Australian Mineral Development Laboratories. Membership of the Association at 30 June 1978 was: full members 45, associate members 20, registered divisions 10. Expenditure on research projects during the year 1977-78 was \$551,643.

### 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. This Agreement was subsequently replaced by the Second, Third and Fourth International Tin Agreements, which came into force on 21 February 1962, 21 March 1967 and 1 July 1971 respectively. 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.

Australia has signed and ratified the Fifth International Tin Agreement which came into operation on 1 July 1976 for a period of 5 years. Australia joined the Fourth and Fifth 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.

The objectives and provisions of the present Agreement are essentially the same as for its predecessors. The International Tin Agreement establishes floor and ceiling prices for tin and, by the medium of a buffer stock and remedial trading, aims at confining the prices within these limits. Producing countries are required to contribute to a buffer-stock equivalent in cash or tin up to 20,000 tonnes of tin metal, which is used to buffer short-term fluctuations in the world price market. In addition, consuming countries may also make contributions in either cash or tin metal up to the equivalent of 20,000 tonnes of tin metal. In the event of persistent market disequilibrium through causes beyond the control of the buffer stock mechanism, the agreement also provides for the regulation of exports and stocks to stabilise the market.

The International Tin Agreement is operated by the International Tin Council, which is made up of the following governments: *Producers*—Australia, Bolivia, Indonesia, Malaysia, Nigeria, Thailand, Zaire; *Consumers*—Austria, Belgium-Luxembourg, Bulgaria, Canada, Czechoslovakia, Denmark, France, Germany (Federal Republic of), Hungary, India, Ireland (Republic of), Italy, Japan, Netherlands, Poland, Romania, Spain, Turkey, United Kingdom, United States of America, Union of Soviet Socialist Republics and Yugoslavia. 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.

#### 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 was 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, Australia, Austria, Belgium, Bulgaria, Canada, Czechoslovakia, Denmark, Finland, France, Germany (Federal Republic of), Hungary, India, 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 having regard especially to the desirability of providing continuous, accurate information regarding the supply and demand position and its probable development.

#### Association of Iron Ore Exporting Countries (APEF)

Australia is a founder member of the Association of Iron Ore Exporting Countries (APEF). Other members include Algeria, India, Liberia, Mauritania, Peru, Sierra Leone, Sweden and Venezuela.

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; to ensure the orderly and healthy growth of export trade in iron ore; to assist Member countries to secure fair and

remunerative returns from the exploitation, processing and marketing of iron ore with a view to improving their export earnings and terms of trade; to contribute to the economic and social development of Member countries and, in particular, to encourage further processing of iron ore in Member countries including into iron and steel; and to provide a forum for the exchange of information and effective and meaningful consultations on problems relating to the iron ore export industry with a view to enabling Member countries to take appropriate action.

Although meetings of the Association have been mainly concerned with administrative matters, it has been agreed that the Secretariat's work programme should give priority to the preparation of statistical material. The Association has also discussed APEF's attitude to the UNCTAD Ad Hoc Intergovernmental Group of Experts on Iron Ore.

#### **International Bauxite Association**

Australia joined the International Bauxite Association as a founder member in October 1974. Other members are Dominican Republic, Ghana, Guinea, Guyana, Haiti, Indonesia, Jamaica, Sierra Leone, Surinam and Yugoslavia. Members account for about three-quarters of world bauxite production with Australia accounting for nearly 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 exploration, 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 and is the supreme organ, 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. To date the Association's work has been 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 has received particular attention. In December 1977 the Council adopted a recommendation on a minimum CIF price for bauxite in North America. The Association publishes a Quarterly Review and a bi-monthly newsletter.

## **MINERAL INDUSTRY STATISTICS**

Statistics in the following pages refer mainly to the mining industry, mineral production, mineral exploration, mineral processing and treatment, and overseas trade.

### **Mining industry statistics**

This section contains statistics of the mining industry in Australia obtained from the annual mining censuses. Commencing with the year ended June 1969, the annual mining census has been conducted on an integrated basis with the annual census of manufacturing and with the periodic electricity and gas and retail and wholesale trade censuses; it is therefore on a different basis to those of earlier years.

Further information regarding these differences and mining industry statistics for years prior to 1968-69 is contained in Year Book No. 57, and earlier issues.

The following table shows key items of data for Australia for 1976-77 and summary data for 1971-72 to 1975-1976.

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS BY INDUSTRY CLASS

Industry class ASIC Code (a)	Description	Number of establishments operating at end of June	Persons employed at end of June (b)			Wages and salaries (c)		Stocks at 30 June		Purchases, transfers in and selected expenses	Fixed capital expenditure (outlay on fixed tangible assets less disposals)		
			Males	Fe-males	Persons	\$'000	\$'000	Turnover	1976		1977	Value added	\$'000
1976-77		No.	No.	No.	No.	\$'000	\$'000	\$'000	\$'000	\$'000	\$'000	\$'000	
	<b>Metallic minerals—</b>												
1101	Bauxite	6	1,724	231	1,955	25,249	n.p.	13,296	13,462	n.p.	155,585	16,349	
1102	Copper (incl. copper-gold)	19	4,375	253	4,628	65,734	202,874	23,085	19,784	69,575	129,998	13,806	
1103	Gold	32	1,299	77	1,376	15,900	58,162	10,041	9,956	19,446	38,631	17,155	
1104	Iron ore	26	7,107	913	8,020	118,974	960,857	83,008	95,905	377,566	596,189	63,497	
1105	Mineral sands	24	2,775	231	3,006	37,918	148,302	42,215	41,340	69,355	78,072	11,513	
1106	Nickel	9	3,384	242	3,626	43,215	211,710	12,095	15,643	76,294	138,964	32,131	
1107	Silver-lead-zinc	14	6,247	268	6,515	85,802	361,481	62,349	62,092	84,971	276,253	24,320	
1108	Tin	40	1,503	103	1,606	15,114	85,626	8,407	6,877	26,564	57,532	8,506	
1109	Metallic minerals n.e.c.	14	1,537	160	1,697	20,866	n.p.	20,437	24,113	n.p.	109,070	14,632	
11	<b>Total metallic minerals</b>	184	29,951	2,478	32,429	428,772	2,419,313	274,934	289,173	853,259	1,580,293	201,909	
	<b>Coal and Crude petroleum (incl. natural gas)—</b>												
1201	Black coal	126	22,972	482	23,454	366,626	1,656,291	128,521	169,093	533,887	1,162,976	177,519	
1202	Brown coal	4											
1300	Crude petroleum (incl. natural gas)	9	3,080	98	3,178	42,124	628,116	25,392	34,134	69,117	567,740	97,518	
	<b>Construction materials—</b>												
1401	Sand and gravel	324	1,662	126	1,788	17,585	102,125	5,949	6,572	42,389	60,358	6,119	
1402	Crushed and broken stone	318	3,755	311	4,066	42,252	186,885	21,962	22,703	78,828	108,798	9,901	
1403	Dimension stone and other construction materials n.e.c.	55	146	8	154	795	2,600	278	295	1,240	1,377	178	
14	<b>Total construction materials</b>	697	5,563	445	6,008	60,632	291,610	28,190	29,569	122,456	170,533	16,199	
	<b>Other non-metallic minerals—</b>												
1501	Limestone	51	651	10	661	6,992	29,586	1,997	2,287	13,185	16,690	535	
1502	Clays	103	216	18	234	1,784	15,241	1,666	2,123	9,365	6,333	305	
1503	Non-metallic minerals n.e.c.	113	1,764	160	1,924	20,632	103,327	12,121	21,421	55,362	57,265	19,771	
15	<b>Total other non-metallic minerals</b>	267	2,631	188	2,819	29,408	148,154	15,784	25,831	77,913	80,289	20,612	
	<b>Total Mining (excl. services to mining)</b>	1976-77	1,287	64,197	3,691	67,888	927,563	5,143,484	472,821	547,801	1,656,632	3,561,832	513,757
		1975-76	1,280	63,868	3,741	67,609	782,522	4,315,793	346,272	478,579	1,379,845	3,068,254	548,280
		1974-75	1,315	65,447	3,675	69,122	675,442	3,725,629	242,290	341,432	1,155,702	2,669,069	496,199
		1973-74	1,315	61,006	3,050	64,056	481,006	2,798,062	216,389	242,586	828,164	1,996,096	338,573
		1972-73	1,330	60,140	2,920	63,060	402,894	2,265,129	210,951	211,775	668,651	1,597,301	322,930
		1971-72	1,410	60,222	2,957	63,179	373,999	1,994,261	165,244	211,178	611,888	1,428,307	482,611

(a) Australian Standard Industrial Classification. (b) Includes working proprietors. (c) Excludes amounts drawn by working proprietors.

Mining accidents

Particulars of numbers of persons killed and injured in accidents in mines and associated treatment plants are recorded by State Mines Departments. Numbers injured are not reported on a uniform basis in all States, as varying criteria are used in determining what constitutes injury. A table setting out mining accidents by States is shown below.

MINING ACCIDENTS(a)

	Metal mining		Fuel mining		Construction material quarrying(b)		Non-metal (excluding fuel) mining		Total mining and quarrying	
	Number of casualties		Number of casualties		Number of casualties		Number of casualties		Number of casualties	
	Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured	Killed	Injured
1976-77—										
New South Wales	2	164	11	60	1	8	—	13	14	245
Victoria	—	—	—	32	—	(c)73	—	(c)1	—	106
Queensland	(d)3	(d)166	(d)1	(d)222	(d)15	(d)2	—	(d)14	(d)19	(d)404
South Australia	—	18	—	3	—	27	2	6	2	54
Western Australia	(c)13	(c)594	—	71	1	13	1	22	15	700
Tasmania	—	169	—	—	—	4	—	1	—	174
Northern Territory	3	18	—	—	—	—	—	—	3	18
Australian Capital Territory	—	—	—	—	(b)	(b)	—	—	(b)	(b)
Australia(b)(c)	21	1,129	12	388	17	127	3	57	53	1,701
1975-76	18	1,064	22	455	2	132	4	47	46	1,698

(a) See text regarding comparability between States. (b) Mining accident data for construction material quarrying in the A.C.T. are not available. (c) These figures include some accidents in the mineral processing industry, and, in Western Australia, in electricity generating plants at the mine site. (d) Year ended 31 December 1976.

## Mineral production

This section contains details of the output (quantity and value) of 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 National Resources 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 minerals produced during 1976-77 and earlier years, together with details of the aggregate quantity of each metal, metallic oxide or elements contained in the various metallic minerals produced.

#### QUANTITY OF MINERALS PRODUCED AND METALLIC CONTENTS OF ORES CONCENTRATES, ETC.

Mineral		1974-75	1975-76	1976-77
<b>METALLIC MINERALS</b>				
Antimony concentrate	tonnes	1,555	1,649	n.p.
Antimony content	"	990	1,089	n.p.
Antimony ore	tonnes	n.p.	507	1,230
Antimony content	"	n.p.	n.p.	111
Bauxite	'000 tonnes	22,205	24,861	24,826
Alumina (Al <sub>2</sub> O <sub>3</sub> ) content	"	n.p.	n.p.	n.p.
Beryllium ore	tonnes	6	—	—
Beryllium oxide (BeO) content	mtu	72	—	—
Bismuth concentrate	tonnes	4,388	4,829	5,338
Bismuth content	tonnes	690	817	853
Copper content	tonnes	575	695	1,116
Gold content	kg	974	729	485
Selenium content	tonnes	—	—	28
Silver content	kg	386	286	191
Copper concentrate	tonnes	894,062	788,703	755,714
Copper content	"	220,257	202,865	198,069
Bismuth content	tonnes	484	34	203
Gold content	kg	2,522	2,000	2,369
Lead content	tonnes	599	507	364
Silver content	kg	39,000	32,232	28,362
Zinc content	tonnes	1,800	1,655	1,210
Copper ore	tonnes	(a)15,336	4,364	11,874
Copper content	"	996	372	2,029
Gold content	kg	—	3	1
Silver content	"	18	15	216
Copper ore for fertilizer	tonnes	1,000	—	—
Copper content	"	8	—	—
Copper oxide	tonnes	1,446	2,316	2,735
Copper content	"	1,111	1,784	2,129
Copper precipitate	tonnes	44	68	45
Copper content	"	32	50	29
Gold bullion(b)	kg	12,903	15,964	15,608
Gold content	"	10,022	12,550	11,004
Silver content	kg	2,014	2,383	1,734
Gold ore	tonnes	236	294	115
Gold content	kg	2	59	2
Iron ore(c)	'000 tonnes	98,159	92,687	94,766
Iron content	"	60,860	58,263	60,164
Iron oxide(d)	tonnes	62,886	55,758	56,934
Lead concentrate	tonnes	615,212	576,481	632,210
Lead content	"	390,848	369,466	391,286
Antimony content	"	675	580	535
Cadmium content	"	57	54	64
Copper content	"	3,679	3,347	4,057
Gold content	kg	383	307	260

For footnotes see end of table

QUANTITY OF MINERALS PRODUCED AND METALLIC CONTENTS OF ORES CONCENTRATES,  
ETC.—continued

Mineral		1974-75	1975-76	1976-77
Silver content	"	560,391	559,923	682,578
Sulphur content	tonnes	51,153	45,362	48,536
Zinc content	"	31,127	31,283	34,314
Lead-copper concentrate	tonnes	19,952	19,480	25,709
Lead content	"	4,207	4,823	6,215
Copper content	"	2,652	2,656	3,328
Gold content	kg	913	986	1,132
Silver content	"	45,211	42,780	49,533
Sulphur content	tonnes	6,055	5,527	7,674
Zinc content	"	2,409	1,942	2,490
Lead ore (e)	tonnes	47,562	42,997	34,760
Lead content	"	2,613	2,718	1,923
Silver content	kg	2,939	3,503	2,175
Lead-zinc middlings	tonnes	10,654	9,483	21,656
Lead content	"	2,371	1,745	1,992
Antimony content	"	10	9	—
Cadmium content	"	21	19	43
Copper content	"	128	114	260
Gold content	kg	28	25	58
Silver content	"	16,842	13,674	21,764
Sulphur content	tonnes	3,036	2,702	6,172
Zinc content	"	3,359	3,139	9,334
Manganese ore—				
Metallurgical grade	'000 tonnes	1,410	1,576	1,681
Manganese content	"	667	765	806
Mineral sands (f)—				
Ilmenite concentrate (g)	tonnes	891,090	929,269	990,444
Titanium dioxide content	"	503,582	523,527	541,079
Leucoxene concentrate	tonnes	17,559	14,821	8,818
Titanium dioxide content	"	15,642	13,082	7,700
Monazite concentrate	tonnes	3,371	4,766	7,019
Monazite content	"	3,108	4,392	6,487
Rutile concentrate	tonnes	334,205	367,763	370,532
Titanium dioxide content	"	320,496	352,710	354,966
Xenotime concentrate	tonnes	16	14	13
Yttrium oxide content	kg	4,880	4,200	3,900
Zircon concentrate	tonnes	392,751	386,604	407,603
Zirconium dioxide content	"	322,191	316,075	325,542
Nickel concentrate	tonnes	405,380	471,662	450,224
Nickel content	"	49,106	57,307	54,578
Cobalt content	"	79	135	171
Copper content	"	4,449	4,585	4,438
Palladium content	kg	147	192	213
Platinum content	"	62	79	81
Nickel ore	'000 tonnes	1,042	1,922	2,238
Nickel content	tonnes (a)		23,646	26,521
Pyrite concentrate	tonnes	219,066	213,348	227,532
Sulphur content	"	104,126	101,352	109,807
Tantalite-columbite concentrate	kg	178,700	119,970	104,990
Tantalite-columbite content	"	53,734	52,160	41,050
Tin concentrates	tonnes	19,552	19,143	20,944
Tin content	"	10,095	9,609	10,253
Tin-copper concentrate	tonnes	2,506	2,896	2,610
Tin content	"	73	76	72
Copper content	"	522	628	535
Tungsten concentrates—				
Scheelite concentrate	tonnes	1,672	2,360	3,190
Tungstic oxide content	m.t.u.	120,700	167,000	n.p.
Wolfram concentrate	tonnes	524	641	567
Tungstic oxide content	m.t.u.	36,862	45,422	39,735
Zinc concentrate	tonnes	879,612	839,627	822,367
Zinc content	"	457,700	432,661	426,194
Cadmium content	"	1,523	1,500	1,441
Cobalt content	"	116	103	109
Copper content	"	1,181	1,200	1,226
Gold content	kg	170	204	215

For footnotes see end of table

QUANTITY OF MINERALS PRODUCED AND METALLIC CONTENTS OF ORES CONCENTRATES,  
ETC.—*continued*

<i>Mineral</i>		1974-75	1975-76	1976-77
Lead content . . . . .	tonnes	15,862	17,405	16,446
Manganese content . . . . .	"	6,146	5,785	5,241
Mercury content . . . . .	kg	86	332	21
Silver content . . . . .	kg	62,245	65,072	53,199
Sulphur content . . . . .	tonnes	278,915	268,068	261,861
Zinc ore . . . . .	tonnes	33,493	22,851	4,643
Zinc content . . . . .	"	11,779	8,583	1,764
<b>COAL</b>				
Black coal . . . . .	'000 tonnes	70,142	69,269	75,982
Bituminous . . . . .	"	65,475	63,967	70,467
Sub-bituminous . . . . .	"	4,667	5,302	5,516
Brown coal (lignite)( <i>h</i> ) . . . . .	"	24,441	26,711	28,231
Brown coal briquettes . . . . .	"	1,092	946	1,035
<b>PETROLEUM (<i>l</i>)</b>				
Crude oil . . . . .	'000 cu m	23,096	23,839	24,549
Natural gas . . . . .	mil. cu m	4,633	5,172	6,093
Natural gas condensate( <i>j</i> ) . . . . .	cu m	7,719	6,619	5,612
Ethane . . . . .	'000 cu m	63,677	73,208	103,350
Liquefied petroleum gases ( <i>k</i> )—				
Propane . . . . .	'000 cu m	1,026	1,053	1,208
Butane . . . . .	'000 cu m	1,148	1,182	1,325
<b>CONSTRUCTION MATERIALS(<i>l</i>)</b>				
Sand . . . . .	'000 tonnes	24,807	23,206	24,950
Gravel . . . . .	"	17,315	15,230	15,071
Dimension stone . . . . .	"	163	169	87
Crushed and broken stone . . . . .	"	57,337	53,780	53,012
Other . . . . .	"	33,697	31,826	30,222
<b>OTHER NON-METALLIC MINERALS</b>				
Asbestos . . . . .	tonnes	36,558	57,235	55,814
Barite . . . . .	"	12,013	n.p.	n.p.
Carbon dioxide . . . . .	"	n.p.	n.p.	n.p.
Chlorite . . . . .	"	403	208	—
Clays—				
Brick and shale . . . . .	'000 tonnes	7,844	8,856	8,571
Other( <i>m</i> ) . . . . .	"	1,311	1,202	1,190
Diatomite . . . . .	tonnes	6,035	1,681	1,371
Dolomite . . . . .	"	411,541	515,094	535,330
Felspar (including cornish stone) . . . . .	"	4,278	4,123	2,998
Garnet concentrate . . . . .	"	—	1	658
Gypsum . . . . .	'000 tonnes	1,008	912	992
Limestone (including shell and coral) . . . . .	"	11,209	10,185	10,528
Magnesite, crude . . . . .	tonnes	36,273	n.p.	16,873
Mineral pigments—red ochre . . . . .	"	—	874	166
Peat ( <i>n</i> ) . . . . .	"	3,384	n.p.	n.p.
Pebbles—for grinding . . . . .	"	998	1,799	1,260
Perlite . . . . .	"	3,555	2,136	4,621
Phosphate rock . . . . .	"	35,815	168,601	455,986
Pyrophyllite . . . . .	"	14,264	15,542	12,112
Salt . . . . .	'000 tonnes	5,057	5,350	5,023
Silica . . . . .	"	1,388	1,188	1,406
Sillimanite . . . . .	tonnes	703	567	7,228
Talc (including steatite) . . . . .	"	71,669	74,098	86,222

(a) Includes copper slag. (b) Includes alluvial gold. (c) Includes iron concentrate. (d) For cement manufacture, coal washing. (e) Includes silver-lead ore, silver-lead slimes and lead slag. (f) Details relating to rutile-zircon concentrates produced in one State and finally separated in another State are included in separate form in the data of the State of origin. (g) Includes Beneficiated Ilmenite. Also includes ilmenite from which titanium dioxide is not commercially extractable. (h) Excludes brown coal used for briquette production. (i) Source: Department of National Development and State Mines Departments. (j) Sales—excludes condensate blended and other petroleum products. (k) Excludes refinery production. (l) Incomplete, see individual States. (m) Incomplete owing to difficulties of coverage. (n) Comprises peat for fertiliser and peat moss.

NOTE: Particulars of the production of uranium concentrate are not available for publication.

## CONTENTS OF METALLIC MINERALS PRODUCED

<i>Contents of metallic minerals produced</i>		1974-75	1975-76	1976-77
Alumina (Al <sub>2</sub> O <sub>3</sub> )	'000 tonnes	n.p.	n.p.	n.p.
Antimony	tonnes	n.p.	n.p.	n.p.
Beryllium oxide (BeO)	mtu(a)	72	—	—
Bismuth	kg	1,238,837	890,703	1,056,199
Cadmium	tonnes	1,601	1,573	1,548
Cobalt	"	1,055	2,026	2,210
Copper	"	235,590	218,296	217,216
Gold	kg	15,061	16,901	15,666
Iron(b)	'000 tonnes	60,860	58,263	60,164
Lead	tonnes	416,500	396,664	418,226
Manganese	"	672,926	771,060	811,414
Mercury	kg	86	332	21
Monazite	tonnes	3,108	4,392	6,487
Nickel	"	49,106	80,953	81,099
Palladium	kg	147	192	213
Platinum	"	62	79	81
Selenium	tonnes	—	—	28
Silver	kg	709,913	721,544	840,084
Sulphur	tonnes	443,285	423,011	434,050
Tantalite-columbite (Ta <sub>2</sub> O <sub>5</sub> + Nb <sub>2</sub> O <sub>5</sub> )	'000 grams	53,734	52,160	41,050
Tin	tonnes	10,168	9,685	10,325
Titanium dioxide (TiO <sub>2</sub> )	"	839,720	889,460	903,756
Tungstic oxide (WO <sub>3</sub> )	mtu(a)	157,562	212,422	n.p.
Yttrium oxide (Y <sub>2</sub> O <sub>3</sub> )	kg	4,880	4,200	3,900
Zinc	tonnes	508,174	479,263	475,306
Zirconium dioxide (ZrO <sub>2</sub> )	"	322,229	316,131	325,572

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

NOTE: Particulars of production of uranium oxide (U<sub>3</sub>O<sub>5</sub>) are not available for publication.

## Value of minerals produced

The following table shows the value of minerals produced in the past six years.

VALUE OF MINERALS PRODUCED  
(S'000)

<i>Mineral</i>	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
<b>METALLIC MINERALS</b>						
Antimony—						
Concentrate	176	546	932	1,904	1,462	n.p.
Ore	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Bauxite	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Beryllium ore	16	23	23	1	—	—
Bismuth concentrate	5,066	6,813	7,609	14,085	10,591	12,183
Copper—						
Concentrate	114,956	154,748	267,873	168,047	159,876	182,448
Ore(a)	947	701	n.p.	766	305	1,202
Ore for fertiliser	6	9	5	3	—	—
Oxide	475	757	982	1,406	1,900	2,730
Precipitate	134	101	168	31	42	31
Gold—						
Bullion(b)	21,435	25,730	26,839	43,139	43,735	47,501
Concentrate	n.a.	n.a.	n.a.	—	—	219
Ore	—	—	3	8	10	3
Iron ore	372,483	395,189	427,518	613,169	674,515	746,577
Iron oxide	773	1,150	n.p.	855	915	1,000
Lead concentrate	(c)69,340	(c)72,060	110,875	124,519	117,099	177,760
Lead-copper concentrate	4,444	6,089	8,799	7,609	8,363	10,822
Lead ore(d)	321	494	403	579	566	527
Lead-zinc middlings	1,846	2,560	2,002	2,422	2,094	5,630
Manganese ore	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Mineral sands—						
Ilmenite concentrate(e)	8,071	8,155	7,953	14,270	15,835	17,753
Leucoxene concentrate	1,089	722	1,060	2,079	2,078	1,318
Monazite concentrate	608	551	542	515	774	1,178
Rutile concentrate	41,023	36,510	36,750	53,674	71,750	75,654
Xenotime concentrate	18	22	7	12	9	9
Zircon concentrate	12,503	11,821	16,726	58,128	60,935	42,026

For footnotes see end of table

VALUE OF MINERALS PRODUCED—*continued*

<i>Mineral</i>	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Nickel concentrate . . . . .	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Nickel ore . . . . .	—	n.p.	—	n.p.	n.p.	n.p.
Pyrite concentrate . . . . .	2,230	139	238	441	771	709
Tantalite-columbite concentrate . . . . .	835	670	777	942	1,256	1,127
Tin concentrate . . . . .	30,406	32,282	43,448	49,138	49,060	70,022
Tin-copper concentrate . . . . .	659	516	860	390	435	383
Tungsten ores and concentrates . . . . .	7,979	5,550	5,292	11,385	15,497	34,204
Uranium concentrate . . . . .	n.a.	n.a.	n.a.	—	2,641	15,460
Zinc concentrate . . . . .	63,393	61,820	97,122	138,385	133,340	132,922
Zinc ore . . . . .	—	—	1,551	2,439	1,600	325
Other metallic minerals . . . . .	—	—	—	84	2,928	—
<i>Total metallic minerals</i> . . . . .	<i>921,642</i>	<i>995,416</i>	<i>1,281,782</i>	<i>1,572,746</i>	<i>1,676,273</i>	<i>1,986,680</i>
<b>COAL</b>						
Black coal . . . . .	330,504	390,980	449,855	874,879	1,211,199	1,438,289
Brown coal (lignite) (f) . . . . .	21,768	24,716	27,251	40,556	48,346	55,905
Brown coal briquettes . . . . .	11,280	9,173	11,011	11,391	11,974	14,925
<i>Total coal</i> . . . . .	<i>363,553</i>	<i>424,869</i>	<i>488,116</i>	<i>926,827</i>	<i>1,271,519</i>	<i>1,509,119</i>
<b>PETROLEUM(g)</b>						
<i>Petroleum</i> . . . . .	<i>271,981</i>	<i>311,903</i>	<i>378,750</i>	<i>446,298</i>	<i>488,419</i>	<i>534,815</i>
<b>CONSTRUCTION MATERIALS(h)</b>						
<i>Construction materials</i> . . . . .	<i>159,031</i>	<i>170,484</i>	<i>196,611</i>	<i>238,044</i>	<i>255,836</i>	<i>272,774</i>
<b>OTHER NON-METALLIC MINERALS</b>						
Asbestos . . . . .	(i)453	3,256	4,140	7,960	18,406	20,382
Barite . . . . .	202	208	98	303	n.p.	n.p.
Carbon dioxide . . . . .	38	47	52	45	56	163
Chlorite . . . . .	n.a.	n.a.	n.a.	10,084	8,723	—
Clay—						
Brick clay and shale . . . . .	8,408	9,355	11,153	10,241	12,634	12,821
Other clays . . . . .	2,385	2,682	n.p.	n.p.	4,335	4,774
Diatomite . . . . .	17	43	70	45	60	71
Dolomite . . . . .	844	888	1,087	991	1,262	1,421
Felspar (including cornish stone) . . . . .	38	35	48	87	97	77
Garnet concentrate . . . . .	8	2	2	—	—	11
Gems . . . . .	27,262	40,911	47,262	37,032	41,972	64,006
Gypsum . . . . .	2,819	2,826	3,665	3,176	3,069	4,216
Limestone (including shell and coral) . . . . .	15,135	16,932	20,794	24,221	26,087	30,154
Magnesite, crude . . . . .	236	318	291	722	n.p.	340
Mineral pigments—red ochre . . . . .	—	10	6	—	15	3
Peat(j) . . . . .	87	n.p.	143	146	n.p.	n.p.
Pebbles—for grinding . . . . .	38	36	43	27	38	35
Perlite . . . . .	3	18	11	32	12	45
Phosphate rock . . . . .	10	6	6	894	1,508	4,477
Pyrophyllite . . . . .	58	112	103	156	200	187
Salt . . . . .	11,804	12,655	16,410	21,951	29,394	33,623
Silica . . . . .	3,555	4,484	5,353	6,301	6,559	n.p.
Sillimanite . . . . .	17	17	19	22	18	141
Talc (including steatite) . . . . .	782	n.p.	1,363	1,348	n.p.	n.p.
Vermiculite . . . . .	1	35	n.p.	n.p.	—	n.p.
<i>Total other non-metallic minerals</i> . . . . .	<i>74,253</i>	<i>95,943</i>	<i>116,062</i>	<i>120,097</i>	<i>149,398</i>	<i>188,057</i>
<b>TOTAL</b>						
<b>Total, all minerals and construction materials</b> . . . . .	<b>1,790,460</b>	<b>1,998,615</b>	<b>2,461,320</b>	<b>3,304,012</b>	<b>3,841,444</b>	<b>4,491,445</b>

(a) Includes value of copper slag. (b) Includes alluvial gold. (c) Excludes value of Western Australian production. (d) Includes value of silver-lead ore, silver-lead slimes and lead slag. (e) Includes beneficiated ilmenite. (f) Excludes value of coal used in making briquettes. (g) The values shown are estimates based on prices prescribed in legislation quoted market prices and information from government departments. Includes values for crude oil natural gas, natural gas condensate, ethane, propane and butane. (h) Incomplete owing to difficulties of coverage in some States. (i) Excludes Western Australian production. (j) Comprises peat for fertiliser and peat moss.

## Foreign control of the mining industry in Australia

Summary information on foreign ownership and control of the mining industry in Australia is shown in Chapter 24. More detailed statistics are available in *Foreign Ownership and Control of the Mining Industry* (5317.0) and *Foreign Control in Mineral Exploration* (5230.0).

### Mineral exploration (other than for petroleum)

#### 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* 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 Mines Department).

#### 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:

- (i) State Mines Departments and business undertakings operated by State and local government authorities.
- (ii) the Commonwealth Government (Bureau of Mineral Resources, Geology and Geophysics, The Joint Coal Board, The Atomic Energy Commission and The Mines Branch of the Department of the Northern Territory).

#### Expenditure, metres drilled

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

MINERAL EXPLORATION (OTHER THAN FOR PETROLEUM)

	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
Expenditure (\$'000)—						
On drilling . . . . .	32,864	29,039	28,824	36,172	35,104	40,888
Other . . . . .	91,611	79,088	83,714	88,029	82,033	108,605
Australia . . . . .	124,475	108,127	112,539	124,200	117,137	149,493
Metres drilled ('000)—						
Drilled-core . . . . .	794	769	657	733	530	529
Drilled-non-core . . . . .	2,514	2,181	1,854	1,775	1,589	1,434
Australia . . . . .	3,308	2,949	2,511	2,509	2,119	1,963

### Petroleum exploration

#### Source of statistics

These statistics were collected and compiled by the Bureau of Mineral Resources, Geology and Geophysics, Canberra. Statistical and other information relating to petroleum exploration is published by the Bureau of Mineral Resources in *The Petroleum Newsletter* (issued quarterly) and *The Australian Mineral Industry Annual Review*, and by the Australian Bureau of Statistics in its quarterly bulletin, *Petroleum Exploration* (8409.0).

**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 and 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.

**Operations**

The following table shows particulars of expenditure, and wells and metres drilled in petroleum exploration in recent years.

**PETROLEUM EXPLORATION**

		1974	1975	1976
<b>Expenditure—</b>				
Private sources	\$'000	84,286	57,552	49,031
Government sources	\$'000	9,716	7,379	5,225
<b>Total</b>	<b>\$'000</b>	<b>94,002</b>	<b>64,931</b>	<b>54,257</b>
<b>Wells—</b>				
Drilled (i.e. those which reached final depth)—				
As oil producers	No.	1	—	—
As gas producers	No.	4	3	6
As oil and gas producers	No.	3	1	—
Plugged and abandoned	No.	43	21	11
<b>Total</b>	<b>No.</b>	<b>51</b>	<b>25</b>	<b>17</b>
Average final depth of wells drilled	m	2,321	1,953	2,342
Drilling still in progress at 31 December (uncompleted holes)	No.	2	1	3
Wells drilled or drilling over 3,000 metres	No.	16	5	4
<b>Metres drilled—</b>				
Completed wells	m	118,256	47,617	40,198
Uncompleted holes	m	3,028	620	7,314
<b>Total</b>	<b>m</b>	<b>121,284</b>	<b>48,237</b>	<b>47,512</b>

**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. The sectors of the economy which carry out this work are classified for statistical purposes to Manufacturing Industry (see Chapter 17).

**Principal products**

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

## PRODUCTION OF PRINCIPAL MANUFACTURED PRODUCTS OF MINERAL ORIGIN

Commodity		1974-75(a)	1975-76(a)	1976-77(a)
<b>METALS(b)</b>				
<b>Non-ferrous—</b>				
Alumina . . . . .	'000 tonnes	5,073	5,619	6,474
Refined aluminium . . . . .	tonnes	222,876	220,027	236,943
Blister copper(c) . . . . .	"	189,257	174,230	164,041
Refined copper . . . . .	"	178,451	164,279	157,452
Lead bullion (for export)(c) . . . . .	"	149,876	152,256	158,656
Refined lead . . . . .	"	170,508	168,183	165,582
Refined zinc . . . . .	"	243,209	204,534	261,914
Refined tin . . . . .	"	5,973	5,386	5,373
<b>Ferrous—</b>				
Pig iron(d) . . . . .	'000 tonnes	7,598	7,519	6,958
Steel ingots(d) . . . . .	"	8,063	7,937	7,493
<b>Precious—</b>				
Refined gold(e) . . . . .	'000 grams	10,744	12,829	11,127
Refined silver . . . . .	"	272,855	226,209	253,268
<b>FUELS</b>				
<b>Coal products—</b>				
Metallurgical coke . . . . .	'000 tonnes	5,103	5,253	4,876
Brown coal briquettes . . . . .	"	1,092	946	1,035
<b>Petroleum products—</b>				
Motor spirit . . . . .	mil. litres	12,508	12,501	13,056
Furnace fuel . . . . .	'000 tonnes	4,656	4,340	4,604
Automotive distillate . . . . .	"	4,682	5,003	5,249
Industrial diesel fuel . . . . .	"	1,110	1,216	1,242
<b>BUILDING MATERIALS</b>				
Clay bricks . . . . .	millions	1,722	1,820	2,044
Portland cement . . . . .	'000 tonnes	5,273	5,100	5,039
Plaster of paris . . . . .	"	339	355	381
Plaster sheets . . . . .	'000 sq m	42,372	44,794	50,503
<b>CHEMICALS</b>				
Sulphuric acid . . . . .	'000 tonnes	1,770	1,295	1,721
Caustic soda . . . . .	tonnes	141,430	139,535	129,460
Superphosphate(f) . . . . .	'000 tonnes	3,092	2,278	3,137

(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. (c) Metallic content. (d) Year ended 31 May. (e) Newly-won gold of Australian origin. (f) Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22% P<sub>2</sub>O<sub>5</sub> equivalent.

## Overseas trade

## Exports and imports

Data of imports and exports of minerals and mineral products have been extracted from the official trade statistics compiled in the Australian Bureau of Statistics. Particulars of the quantities and values (\$f.o.b. port of shipment) of the principal minerals and products exported from and imported into Australia during recent years are shown in the following table.

## EXPORTS AND IMPORTS OF PRINCIPAL MINERALS AND MINERAL PRODUCTS

Commodity(a)	Quantity			Value (\$'000 f.o.b.)			
	1975-76	1976-77	1977-78	1975-76	1976-77	1977-78	
<b>EXPORTS(b)</b>							
<b>Non-ferrous—</b>							
<b>Copper—</b>							
Concentrate . . . . .	tonnes	158,891	143,012	109,157	40,838	50,960	31,996
Blister . . . . .	"	9,497	7,247	7,542	13,505	13,254	14,938
Refined . . . . .	"	85,845	75,278	62,671	82,715	90,973	67,157
Matte, slags, etc. . . . .	"	30,548	12,057	11,683	2,546	5,688	5,088
<b>Lead—</b>							
Concentrate . . . . .	"	84,507	68,472	140,572	19,044	20,348	41,988
Bullion . . . . .	"	151,652	156,794	157,915	70,841	106,203	116,897
Refined . . . . .	"	153,675	132,493	138,595	38,103	55,784	71,593
Slags and residues . . . . .	"	19,340	13,403	2,589	1,544	1,655	846
<b>Zinc—</b>							
Concentrate . . . . .	"	424,582	379,113	389,247	62,224	58,950	44,751
Refined . . . . .	"	124,068	170,675	184,290	70,816	109,390	96,066
Slags and residues . . . . .	"	5,304	6,494	5,446	1,482	1,880	1,404
<b>Tin—</b>							
Concentrate . . . . .	"	7,339	11,461	14,682	14,217	28,837	49,841
Refined . . . . .	"	2,351	1,838	2,787	12,131	13,335	27,375
<b>Aluminium—</b>							
Alumina . . . . .	'000 tonnes	5,265	5,877	6,368	436,064	566,976	667,606
Refined . . . . .	tonnes	69,073	75,533	75,921	44,009	60,084	69,270
<b>Ferrous and alloy—</b>							
<b>Iron ore—</b>							
Pellets . . . . .	'000 tonnes	9,040	8,792	8,548	137,553	164,713	175,747
Fines . . . . .	"	34,810	37,443	34,999	270,537	323,717	367,089
Lump . . . . .	"	35,080	34,540	31,143	362,908	413,234	409,087
<b>Tungsten—</b>							
Scheelite concentrate . . . . .	tonnes	2,286	3,101	3,341	12,114	22,450	33,813
Wolfram concentrate . . . . .	"	533	525	767	2,588	3,894	6,861
Pig iron . . . . .	"	593,051	763,421	519,176	40,478	56,813	39,583
Steel ingots, blooms . . . . .	"	1,527,951	1,550,193	1,084,249	159,814	172,545	137,906
<b>Mineral sands—</b>							
Ilmenite concentrate . . . . .	'000 tonnes	628	1,167	1,039	8,406	17,985	22,503
Rutile concentrate . . . . .	"	339	289	315	65,646	63,430	62,031
Zircon concentrate . . . . .	"	286	351	366	51,716	47,727	30,706
<b>Precious—</b>							
Gold, refined . . . . .	'000 grams	7,232	7,924	8,194	27,874	29,642	40,998
Silver, refined . . . . .	"	89,982	129,002	103,411	9,663	16,134	14,262
Coal, black . . . . .	'000 tonnes	29,224	34,432	37,161	1,023,455	1,281,944	1,457,178
Crude oil(c) . . . . .	'000 cu m	243	206	210	17,559	15,462	16,125
<b>IMPORTS</b>							
Tin, refined . . . . .	tonnes	34	17	215	181	117	1959
Nickel (pigs, anodes, etc.) . . . . .	"	962	1,210	2,008	4,081	5,033	8,154
Ferro-alloys . . . . .	"	25,529	28,663	20,048	11,953	16,938	11,378
<b>Gold—</b>							
Unrefined bullion(d) . . . . .	'000 grams	2,876	1,905	1,241	9,769	6,468	5,537
Refined . . . . .	"	13	110	228	49	308	796
Crude oil(e) . . . . .	'000 cu m	8,783	10,092	11,261	516,361	646,499	799,135
Asbestos . . . . .	tonnes	54,495	70,731	58,265	17,930	29,415	25,978
<b>Diamonds—</b>							
Industrial . . . . .	metric carats	744,655	1,015,153	833,964	2,804	4,512	4,263
Gemstone . . . . .	"	86,228	91,336	132,815	17,435	22,717	31,202
Phosphate rock . . . . .	'000 tonnes	1,461	1,329	1,510	53,212	42,227	55,279
Potassium fertilisers . . . . .	tonnes	110,190	165,470	157,397	7,565	9,625	9,137
Sulphur . . . . .	"	156,494	315,432	6,271	4,986	10,697	14,442

(a) In addition to the commodities listed, significant quantities of bauxite and nickel ores and concentrates are exported but details are not available for publication. (b) Quantities shown for metallic minerals are gross quantities, not metallic contents. (c) Includes also partly refined oil, topped crudes and enriched crudes. (d) Gold content. (e) Includes also partly refined oil, topped crudes, enriched crudes and refinery feed stock.

Considerable quantities of metallic ores, concentrates, slags, and residues are exported from Australia for refining overseas. The following table shows selected items exported during 1976-77 and their principal metallic content as estimated by assay.

**PRINCIPAL METALLIC CONTENTS OF SELECTED ORES AND ETC. ETC. EXPORTED FROM AUSTRALIA, 1976-77**

<i>Metallic contents—estimated from assay</i>								
<i>Ores and concentrates, etc.</i>	<i>Copper</i>	<i>Lead</i>	<i>Zinc</i>	<i>Tin</i>	<i>Iron</i>	<i>Tungstic Oxides</i>	<i>Gold</i>	<i>Silver</i>
	tonnes	tonnes	tonnes	tonnes	'000 tonnes	tonnes	kg	kg
Copper concentrate . . .	44,064	—	—	—	—	—	3,363	5,717
Blister copper . . . . .	7,194	—	—	—	—	—	1,723	1,237
Copper matte, slags, etc.(a) . . . . .	2,024	2,614	—	2	—	—	653	3,433
Lead concentrate . . . . .	3,336	32,394	4,915	—	—	—	1,213	75,329
Lead bullion . . . . .	9	155,799	—	—	—	—	—	320,572
Lead slags and residues . . . . .	517	4,849	36	20	—	—	53	9,981
Zinc concentrate . . . . .	—	1,558	195,952	—	—	—	—	26,128
Zinc slags and residues . . . . .	—	—	—	—	—	—	—	—
Tin concentrate . . . . .	5	—	—	4,399	—	—	—	—
Iron ore—								
Pellets . . . . .	—	—	—	—	5,494	—	—	—
Fines . . . . .	—	—	—	—	23,212	—	—	—
Lump . . . . .	—	—	—	—	22,331	—	—	—
Scheelite concentrate . . . . .	—	—	—	—	—	216,650	—	—
Wolfram concentrate . . . . .	—	—	—	—	—	35,966	—	—
<b>Total metallic content . . . . .</b>	<b>57,154</b>	<b>197,214</b>	<b>205,967</b>	<b>4,421</b>	<b>51,037</b>	<b>252,616</b>	<b>7,005</b>	<b>442,397</b>

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

### Prices

The following table shows average prices of some principal refined metals and ores and concentrates on Australian and certain major overseas markets. Prices of minerals such as iron ore, coal and bauxite are not shown as these minerals are commonly sold on a contract basis rather than on an open market basis.

**AVERAGE DAILY PRICES OF SELECTED METALS AND METALLIC ORES AND CONCENTRATES:  
AUSTRALIAN AND OVERSEAS MARKETS**

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

METALS(a)											
Period	Tin			Nickel U.S.A. (\$US-16)	Aluminium			Gold		Silver	
	Aust. (\$A- tonne)	L.M.E. (£Stg- metric ton)	Straits (\$Mal- picul)		Aust. (\$A- tonne)	U.S.A. (USc-lb)	Premium markets (\$A-f.oz) Australia and Overseas	U.K. (\$US-f. oz)	Aust. (\$A-kg)	U.K. (Stg new pence- f.oz)	
1974-75	5,715.8	3,246.7	1,022.3	1.93	671.0	38.1	121.54	167.86	104.9	187.9	
1975-76	5,698.3	3,402.7	1,014.9	2.17	751.7	41.1	110.40	139.32	112.4	221.9	
1976-77	8,404.2	5,263.7	1,344.6	2.38	860.3	46.6	114.8	131.3	127.6	262.9	
1976-77											
Highest	10,812.0	6,435.0	1,660.0	2.41	907.0	51.0	135.8	153.6	141.6	289.7	
Lowest	6,659.0	4,431.0	1,158.8	2.20	787.0	42.5	86.1	103.5	106.5	230.4	
Period	Copper		Lead		Zinc						
	Aust. (\$A- tonne)	L.M.E. (£Stg- metric ton)	Aust. (\$A- tonne)	L.M.E. (£Stg- metric ton)	U.S.A. (USc-lb)	Aust. (\$A- tonne)	L.M.E. (£Stg- metric ton)	Prod. (Stg- ton)	U.S.A. (USc-lb)		
1974-75	1,050.5	598.3	366.6	216.5	23.95	612.8	359.1	353.6	38.55		
1975-76	1,017.9	655.3	300.8	194.9	20.32	628.7	364.3	(b)795.0	37.99		
1976-77	1,239.9	823.6	475.3	323.7	27.5	694.8	390.4	(b)783.8	37.08		
1976-77											
Highest	1,400.0	936.3	625.0	439.0	31.0	793.0	440.5	(b)795.0	40.00		
Lowest	1,020.0	728.5	375.0	248.5	23.0	639.0	294.0	(b)700.0	34.00		
ORES AND CONCENTRATES											
Period	Tin	Wolfram	Ilmenite	Rutile	Zircon						
	Aust. (\$A-mtu)	Europe (\$Stg-mtu)	Europe (\$A-metric ton)	Europe (\$A-metric ton)	Europe (\$A-metric ton)						
1974-75	48.58	37.00-50.25	13.00-18.00	200.00-330.00	170.00-330.00						
1975-76	47.89	36.75-64.00	15.00-18.00	290.00-330.00	140.00-330.00						
1976-77	71.93	(c)143.50-186.50	15.00-18.00	200.00-330.00	90.00-160.00						
1976-77-											
Highest	87.80	(c)186.50	18.00	330.00	160.00						
Lowest	57.35	(c)143.50	15.00	200.00	90.00						

(a) Where a daily price does not actually exist for a commodity, daily prices have been imputed from price data which are available. (b) From 2 January 1976 prices quoted in \$US per tonne. (c) From 1 December 1976 prices quoted in \$US per metric ton unit.

Prices data shown are those quoted in the relevant markets and are mainly derived from information collected and compiled by the Bureau of Mineral Resources. Overseas data are supplied to the Bureau of Mineral Resources by the *Metal Bulletin* and *Metals Week*.

### REVIEW OF RECENT DEVELOPMENTS IN THE AUSTRALIAN MINERAL INDUSTRY

Major developments in the Australian mineral industry, particularly during 1977 and the first half of 1978, are reviewed briefly in subsequent parts of this section. Additional information on developments in the industry is available in *Australian Mineral Industry Annual Review 1976* 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.

#### General Review of 1977

The rate of expansion of the Australian mining industry declined somewhat in 1977 in the face of difficult world trading conditions for a number of mineral commodities. Despite this, the ex-mine index of output at constant prices showed an increase of 4 per cent compared with 3 per cent in 1976. Value added for the mining industry (excluding smelting and refining) increased by 16 per cent to \$3,562 million. Despite the overall rise, the continued recession of demand was reflected in the fact that both quantities and values of production of a number of base metal and other minerals declined.

'Mines and Quarries' was easily the largest single export-earning group in 1977-78, 28.8 per cent of total exports. 'Mines and Quarries', however excludes some exports by the smelting and refining section of the industry which are allocated to 'Manufactures'.

*Imports—1977.* The import bill for mineral primary products rose by 27 per cent to \$916 million, primarily, as in 1976, because of an increase in the value of crude oil imports which rose by 27 per cent from \$563 million to \$717 million. Crude oil was the largest Australian mineral import and accounted for 78 per cent of the total value of mineral primary product imports. Other significant mineral imports were ferro-alloys, asbestos, elemental sulphur, and fertiliser minerals.

*Exports—1977.* Exports of mineral primary products accounted for 8.3 per cent of the total value of merchandise exports compared with 8.0 per cent in 1976; the value of mineral exports rose by 15 per cent to \$4,743 million. However, there was a decline in the export of the minerals and metals which have traditionally been growth commodities in the export trade due mainly to their oversupply in world markets, and the continued sluggishness in most western industrial economies. This decline was in the quantity and value of copper ores and concentrates, and the quantities of refined and blister copper; the quantity of iron ore, the quantities and values of pig iron ingots, and steel ingots and blooms; the quantity and value of manganese ore; the values of nickel metal and alloys, nickel powder, and nickel ores and concentrates; the quantities and values of the mineral sands, rutile and zircon; and the quantity and value of zinc ores and concentrates, and zinc slabs.

Black coal remained the largest mineral export earner, increasing in value by 17 per cent to \$1,398 millions and accounting for 29 per cent of the total value of mineral primary products exports.

Second was iron ore, which increased in value by 15 per cent to \$952 million (the quantity however decreased by 3 per cent), and alumina which increased in quantity by 5 per cent and in value by 20 per cent to \$629 million. These three items accounted for 63 per cent of the total value of exports of mineral primary products. Other major commodities which recorded value increases were ilmenite (24 per cent), lead ores and concentrates (87 per cent), lead bullion (47 per cent), salt (10 per cent) and refined silver (56 per cent).

Reflecting buoyant world demand and rising prices, significant increases were also recorded in the value of refined gold, and the quantities and values of tin and tungsten ores. For the first time uranium made a significant contribution (\$74 million) to mineral exports.

*National sufficiency in minerals—1977.* The mineral industry's contributions to the national economy can also be assessed by considering the ability of the industry to satisfy domestic mineral, metal, and fuel requirements. Crude oil, phosphate rock, asbestos, diamonds, ferro-alloys, elemental sulphur and potassium fertilisers were the main mineral deficiencies. Australia is a net exporter of nickel, but refined nickel is still imported to meet demand for forms not produced locally. Domestic production supplied only about 72 per cent of estimate consumption of crude oil. Asbestos production went mainly to the export market and about 74 000 tonnes of asbestos were imported.

### **Bauxite and Alumina**

The history of the aluminium industry and recent significant developments in the industry were reviewed in previous issues of the Year Book (No. 51, page 1168 and No. 52 page 1048).

In 1977 production of bauxite increased to more than 26 million tonnes, alumina production to 6.7 million tonnes, and aluminium to 247,577 tonnes. Australia was again the world's largest producer of bauxite and alumina.

An alumina refinery of initial rated capacity of 200,000 tonnes/year will be commissioned in 1981 at Wagerup, W.A. Capacity will be increased over 15 years to 2 million tonnes/year. Bauxite will be supplied from Mount William, W.A. All alumina produced will be exported.

The first stage of the alumina refinery at Worsley, W.A., will be completed in 1981. Initial rated capacity is one million tonnes/year, and ultimate capacity two million tonnes/year. Bauxite will be supplied from Mount Saddleback, W.A. All alumina produced will be exported.

The production capacity of the aluminium smelter at Kurri Kurri, N.S.W., is to be increased from 45,000 tonnes to 67,900 tonnes/year by late 1979. New furnaces commissioned at the Bell Bay, Tasmania, aluminium smelter in mid-1977 increased capacity from 93,000 to 112,000 tonnes/year. It was announced in 1978 that an aluminium smelter will be constructed at Gladstone, Queensland; the first stage will have a design capacity of 180,000 tonnes/year. The rated capacity of the other Australian aluminium smelter, at Point Henry, Victoria, supplied with Western Australian alumina, is 91,500 tonnes/year.

### **Copper**

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

The Commonwealth Government continued its assistance to the Mount Lyell mine, Tasmania, in the form of our interest-free loan, to June 1980.

Drilling at Teutonic Bore, W.A., has revealed a deposit of between 2-3 million tonnes of ore containing 3.5 per cent copper, 9.5 per cent zinc, and 150g/t silver. The SECOR copper rod line at Townsville, Queensland, was commissioned in December 1971. A substantial copper-zinc deposit has been indicated by drilling near Benambra, Victoria.

### Iron

A summary of growth of the Australian iron ore industry 1965 to 1975 has been published in the *Australian Mineral Industry Quarterly Review*, Vol. 29 No. 1.

A heavy-media beneficiation plant is being constructed at Mount Whaleback, W.A., near Newman. It will have the capacity to treat seven million tonnes/year of low-grade ore to produce five million tonnes/year of high-grade concentrates. Completion date is late 1979.

Hamersley Iron Pty Ltd is increasing production capacity from 40 to 46 million tonnes per annum of saleable iron ore by construction of a concentration plant to treat low grade ore at Mount Tom Price. Cliffs Robe River Iron Associates is expanding mine production capacity at Robe River from 16 to 20 million tonnes per annum.

### Silver, lead and zinc

Mine production of lead and zinc metal in 1977 was 432,204 tonnes and 491,608 tonnes respectively.

A summary of the Australian lead and zinc industry from 1953 to 1973 was published in the *Australian Mineral Industry Quarterly Review*, Vol. 27 No. 4.

Production from the Woodlawn, N.S.W., mine commenced in 1978. A decline shaft is being sunk at the Sorby Hills, W.A., lead deposit.

### Black coal

There has been a significant revival in the Australian black coal industry in recent years as a result of increased exports and increased consumption of black coal in iron and steel production and electricity generation. These increases have more than balanced reduced consumption in some applications due to competition from fuel oil.

The expansion of the export trade has been of major significance. In 1955 exports were about 200,000 tonnes valued at about \$1.7 million; in 1977 exports were 36.0 million tonnes valued at \$1,398 million. These increased exports have been largely to Japan for use in the iron and steel industry and to Europe as steaming coal. As a result of this increased demand, new mines have been opened and others are under development in Queensland and New South Wales, and many established mines are being expanded. Exploration for coal has been stimulated and further rich deposits of coking coal and steaming coal have been located. Raw coal production in 1977 increased to 87.5 million tonnes; saleable coal output totalled 70.9 million tonnes.

### Petroleum

At the end of 1976, there were nine oil fields in production: Moonie, Alton and Bennett in Queensland; Barrow Island, Yardarino and Dongara in Western Australia; and Barracouta, Halibut, Mackerel and Kingfish offshore from Victoria in Bass Strait. The production of crude oil (excluding condensate and LPG) in 1977 amounted to 24,986,000 cubic metres representing 71 per cent of the year's total input to Australian refineries. The average daily production of 68,454 cubic metres in 1977 was one per cent higher than in 1976. Natural gas production in 1976 amounted to 6,728 million cubic metres, 13.5 per cent more than in 1976. About 10 per cent of this was used in the field and processing plants and the balance was sold, mainly as fuel, to markets in Victoria, South Australia, Western Australia, New South Wales and Queensland.

During 1977 the major onshore discovery was gas in the Kidman No. 1 well in the Cooper Basin, South Australia. Offshore there were no major discoveries but shows of gas were reported in Haycock No. 1 and Scott Reef No. 2A, both on the Northwest Shelf, off Western Australia. In the first nine months of 1978, there have been major onshore discoveries of gas in Kirby No. 1, in South Australia, Wackett No. 1 and Ashby No. 1, in Queensland, and significant oil discoveries in Boggo Creek No. 2 (No. 1 was dry) in Queensland, and Strzelecki No. 3, South Australia. Offshore new oil discoveries have been made in Seahorse No. 1 and West Halibut No. 1 (the Fortescue Field), both in the Gippsland Basin, offshore from Victoria.

The provisional figure for metres drilled in petroleum exploration and development in Australia in 1977 was 11,489 metres, 42.8 per cent more than that drilled in 1976; 60,562 metres were in exploration drilling, including 35,826 metres offshore. Of the forty-one wells completed in 1977, twenty-one were exploration wells, including thirteen offshore. Compared with 1976, there was a rise of two in the number of exploration wells and an increase of seven in the number of development wells

drilled. There was also an increase of ten in the number of offshore exploration wells. Two exploration wells were completed as gas producers and two as oil producers. Of the twenty development wells, seventeen were completed as gas producers and two as oil producers; one was abandoned.

#### **Nickel**

A summary of the growth of the Australian nickel industry was published in the *Australian Mineral Industry Quarterly Review*, Vol. 28 No. 4.

Mine production of nickel in ore and concentrates was 85,868 tonnes in 1977, about 11 per cent of world mine production. Production commenced at Agnew, W.A., in 1978. The concentrates are toll-smeltered at the Kalgoorlie smelter, the capacity of which was increased. Australia's major nickel producer, Western Mining Corporation Ltd, cut back production in late 1977 because of excess world nickel supplies and the very large nickel stockpiles held by major producers.

#### **Mineral sands**

The history of the mineral sands industry is presented in the *Australian Mineral Industry Quarterly Review*, Vol. 25 No. 1.

#### **Phosphate**

Australia's only phosphate mine, at Duchess, Qld, closed for economic reasons on 30 June 1978. It is now on care and maintenance.

#### **Uranium**

The Australian Government has announced that uranium mining will go ahead, subject to controls.

#### **Diamonds**

Diamond exploration in the Kimberley region of Western Australia has resulted in the discovery of a number of kimberlite pipes. On the basis of diamonds found, Conzinc Riotinto of Australia is setting up a pilot plant to treat kimberlite at Ashton, W.A.

### **REFERENCES**

Further detailed statistics and information on the subjects dealt with in this chapter are contained in the annual printed publication *The Australian Mineral Industry Annual Review* and other publications issued by the Bureau of Mineral Resources, Geology and Geophysics, which also issues, in conjunction with the ABS a quarterly publication, *The Australian Mineral Industry, (Quarterly Review and Statistics)* (8403.0). The annual ABS statistical publications, *Mining Establishments, Summary of Operations (Preliminary)* (8401.0), *Mining Establishments, Details of Operations* (8402.0); *Mineral Production* (8405.0); *Mineral Exploration* (8407.0) and the irregular publications *Mining Industry, Foreign Ownership and Control* (5317.0) and *Foreign Control in Mineral Exploration* (5323.0), contain economic statistics of the industry prepared and published as soon as possible after the data have been compiled. A monthly statistical publication, *Minerals and Mineral Products* (8404.0) is issued also, and other current statistics on mining or mine products are contained in the *Monthly Review of Business Statistics* (1304.0), the *Digest of Current Economic Statistics* (1305.0), and the monthly publication *Production Statistics* (8302.0).

