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 kilometres wide extending from north Queensland to Tasmania. Mesozoic platform sediments form a broad zone separating the Palaeozoic and Precambrian rocks and extending from the Gulf of Carpentaria to central New South Wales. Cainozoic rocks occur mainly in Victoria, south-western New South Wales and southern South Australia, and as residual basalt cappings over extensive areas of the Palaeozoic rocks of eastern Australia.

Economic geology

Minerals of economic significance occur 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, uranium and zinc. Adequate reserves sufficient for domestic demand include clays (except light grade china clay), brown coal, dolomite and felspar.

For further details of principal Australian mineral deposits, and notes on principal mineral resources, *see* Year Book No. 61, pages 925–932 and the Australian Mineral Industry Review.

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. On 1 July 1980, executive authority with respect to mining and minerals except in relation to certain prescribed substances within the meaning of the Atomic Energy Act (principally uranium) was transferred from the Commonwealth Government to the Northern Territory Government. Private mineral rights in the Australian Capital Territory are vested in the Commonwealth Government. The Commonwealth Government is able also to influence 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.

Mineral exploration and development

Onshore. Each State or Territory has its own mining Acts or Ordinances and regulations governing the prospecting for and working of mineral deposits. These Acts, etc., are similar in principle but different in detail. They all make provision for a miner's right to prospect and for small mining leases for mineral production. The principles embodied were established many years ago when mining operations were generally small scale and labour-intensive. Although amendments have been enacted to modernise the legislation, it is generally inadequate for the large-scale capital-intensive operations often involved with modern mineral development. For this reason a large enterprise may take the course of acquiring mining titles by negotiations with the appropriate Minister for Mines and having

the agreed terms and conditions embodied in an Act of the State Parliament. This method of acquisition has been used in several cases where the leasing company undertook an obligation (such as the erection of a large treatment works) in return for leases over large areas for a long period, and has become more common in recent years (e.g. iron ore in Western Australia, coal and bauxite in Queensland, bauxite in the Northern Territory). Mining legislation enacted in recent years is simpler and more suited to modern conditions.

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

The tenure of such areas is limited (usually to one or two years 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.

Off-shore. Following the enactment of the *Seas and Submerged Lands Act* 1973 the High Court confirmed that the Commonwealth has sovereignty over the territorial sea and sovereign rights over the resources of the whole of Australia's continental shelf. However, in the offshore constitutional settlement between the Commonwealth and the States reached in June 1979, it was agreed that responsibility for mining within the outer boundary of the 3 mile territorial sea should lie with the States, while the Commonwealth should have responsibility for areas beyond.

The Minerals (Submerged Lands) Act 1981 passed by the Commonwealth Parliament in June 1981 follows the scheme of the offshore petroleum legislation amendments passed in 1980 and provides for Joint Commonwealth/State Authorities to be responsible for major matters under the legislation with the States being responsible for day-to-day administration. The legislation will be proclaimed to come into effect when complementary State legislation in respect of the 3 mile territorial sea, currently in preparation, is enacted. In the meantime administration of offshore mining is carried out under the States' onshore mining legislation on an interim basis.

The mining code under the new legislation provides for a two-stage system of titles: the exploration permit, which covers all forms of exploration, and the production licence, which covers development. The sharing of royalty between the State and the Commonwealth Governments is to be on a 60-40 basis for all offshore mining, including land-based underground mining.

Petroleum exploration and development

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.

Off-shore. In the offshore constitutional settlement between the Commonwealth and the States reached in June 1979, it was agreed that, as in the case of mining for other minerals, responsibility for administering petroleum exploration and production within the outer boundary of the 3 mile territorial sea would be a State responsibility, while the Commonwealth would have responsibility for the continental shelf beyond the 3 mile territorial sea.

Amendments to the *Petroleum (Submerged Lands) Act* 1967 passed by the Commonwealth Parliament in May 1980 made provision for a Joint Authority for the adjacent area of each State (beyond the 3 mile Territorial Sea limit) consisting of the Commonwealth Minister and the State Minister. The Joint Authorities will be concerned with major matters arising under the legislation, and in the case of disagreement the view of the Commonwealth Minister will prevail. Day-to-day administration will continue to be in the hands of the State Minister as the Designated Authority and State officials. The

amended legislation will be proclaimed to come into effect when complementary State legislation in respect of the 3 mile Territorial Sea, currently in preparation, is enacted. In the meantime administration of offshore petroleum continues to be carried out under the 1967 legislation.

The mining code applicable under 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. The sharing of royalty between the State and the Commonwealth Governments is to continue on a 60-40 basis, and any override royalty payments will continue to be retained by the States.

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)

	1974–75	*1975–76*	*1976–77*	*1977–78*	*1978–79*	*1979–80*
New South Wales(*a*)	37,864	32,660	46,354	49,062	35,651	86,797
Victoria(*b*)	26,657	29,893	32,696	48,446	60,111	90,554
Queensland(*a*)	34,867	36,753	50,842	53,651	57,981	73,522
South Australia	2,500	2,788	3,346	4,109	4,543	5,869
Western Australia	39,385	43,111	51,638	54,519	57,810	66,713
Tasmania	342	576	1,496	2,093	2,193	5,261
Northern Territory(*c*)	99	545	362	277	120	2,549
Commonwealth Government(*d*)	12,155	13,440	13,805	23,002	28,031	43,337
Total	**153,869**	**159,766**	**200,539**	**235,159**	**246,440**	**374,602**

(*a*) Includes royalty on sand and gravel from Crown lands. (*b*) Includes royalty on brown coal paid by State Electricity Commission. (*c*) Excludes Aboriginal Benefits Trust Fund royalties from mining operations prior to 1978–79. (*d*) Includes royalties received under the *Petroleum (Submerged Lands) (Royalty) Act* 1967.

Control of Exports

The Commonwealth Government has constitutional power over exports from Australia. Under the Customs (Prohibited Exports) Regulations exports of nuclear sensitive material, hydrocarbons and certain raw or semi processed minerals are prohibited unless permission is granted by the Minister for Trade and Resources or an authorised person.

The fundamental objectives of the controls are:

(i) to protect the national interest and ensure fair and reasonable market prices are achieved;
(ii) to ensure adequate supplies are available for the domestic market;
(iii) to meet international and strategic obligations; and
(iv) to ensure the Government's nuclear safeguards and physical protection requirements on exports are met, consistent with Australia's international obligations in relation to uranium and nuclear materials.

Export controls are administered on coal, iron ore, bauxite, alumina, petroleum and petroleum products, tin, salt, uranium and materials of nuclear significance. Controls on tin concentrates are being phased out over calendar years 1980 and 1981, except for International Tin Agreement purposes.

Ores, concentrates, oxides, etc. of nickel, lead, zinc, copper, manganese, tungsten and blister and refined copper are subject to blanket approvals.

With regard to mineral sands, approvals to export are freely issued except where the Commonwealth considers there are environmental reasons which would make such exports undesirable. Exports of copper scrap and copper alloy scrap are embargoed and quotas apply to secondary copper ingots and basic shapes made from scrap material. All other minerals are not subject to control.

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

For details of the functions of the Australian Atomic Energy Commission *see* Chapter 18, Energy.

Government assistance

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

Commonwealth Government assistance

Assistance provided by the Commonwealth Government takes the form of income taxation concessions, subsidies, bounties, and technical assistance, mainly through the work of the Bureau of Mineral Resources (BMR) and the Commonwealth Scientific and Industrial Research Organization (CSIRO).

Income taxation concessions. As at 30 June 1981 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 six 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 six 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 18 per cent of the cost of certain new plant.

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 27 cents for each dollar of share capital subscribed may be available to shareholders of petroleum mining companies exploring or mining for petroleum in Australia, including off-shore areas, where those companies lodge appropriate declarations with the Commisioner 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.

Oil Supply Emergencies

The National Petroleum Advisory Committee (NPAC) was established in September 1979, to advise Commonwealth, State and Territory Governments on:

- appropriate arrangements for the equitable allocation of liquid fuels, during any period of supply shortage.
- priorities for the allocation of liquid fuels during periods of shortage.

Membership of NPAC is drawn from agricultural, general aviation, fishing, manufacturing, mining, shipping and transport industries, oil industry, trade union movement and motorists organisations as well as Commonwealth, State and Territory Governments. The Department of National Development and Energy provides the Secretariat for NPAC.

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 role of BMR is:

(i) to develop an integrated, comprehensive, scientific understanding of the geology of the Australian continent, the Australian offshore area and the Australian Antarctic Territory, as a basis for minerals exploration; this to be done where appropriate in co-operation with State Geological Surveys and other relevant organisations and having regard to priorities for the search for minerals approved by the Minister for National Development and Energy;

(ii) to be the primary national source of geoscience data and to publish and provide information; and

(iii) to undertake mineral resource assessments in accordance with programs and priorities approved by the Minister for National Development and Energy with the advice of the BMR.

At 31 August 1981, 494 officers were employed at the BMR, this included 190 professional officers (geologists, geophysicists, chemists, engineers and mineral economists).

BMR's research program is carried out by four Divisions—Geophysics, Continental Geology, Marine Geoscience and Petroleum Geology and Petrology and Geochemistry. Mineral and petroleum resource assessments are undertaken by the Resource Assessment Division which includes Mineral Assessment and Petroleum Assessment Branches and a Geoscience Data Branch. There is also an Operations Branch which carries out Cental functions. Further restructuring of BMR is in progress.

The 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 Department of Mineral Resources 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 payable 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 exploration and prospecting in 1980–81 amounted to $2,493,348, including $708,504 on grants and $1,764,585 on the Department's own drilling program.

Victoria. The Department of Minerals and Energy comprises the Divisions of Administration, Energy, Geological Survey, Hazardous Materials, Oil and Gas and Mining. The Department conducts geological and mineral surveys, produces geological maps, and issues scientific and technical reports thereon. Rotary, percussion and auger drilling operations are carried out and the results are used in sedimentary basin studies and to evaluate petroleum, mineral and groundwater 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, hazardous materials, mining and extractive industry legislation ensures that mineral and petroleum exploration and production (both on-shore and off-shore), mining and quarrying; the manufacture, transport, storage and use of explosives and the storage and transportation of inflammable liquids and liquefied gases are carried on in a safe and effective manner. Technical assistance and limited loans and grants are available for mineral exploration and prospecting and for approved development operations. Five stamp batteries located throughout the State provide an ore-crushing service to enable test crushing to be made at nominal cost. Information is available on mining law and mineral statistics. Assays of ores; analytical services; advice on metallurgical treatments, industrial pollution and chemical problems are available. Information on the manufacture, handling and use of explosives, inflammable liquids and liquefied gases is also provided. Financial assistance is available to municipalities to reclaim mine-damaged land in areas where a reclamation committee recommends such action. Through the Energy Division the Department advises on, and monitors and co-ordinates, energy policies for the Victorian Government; it also carries out investigations into a broad range of energy matters and co-ordinates and monitors energy conservation matters in Victoria.

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 of 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 and Energy has as its principal functions the administration of mining and petroleum legislation including the granting of mineral leases and collection of royalties and fees; geological and geophysical investigations to ascertain the extent and nature of the State's mineral resources; drilling to test mineral deposits, petroleum reserves and underground water supplies; the testing and treatment of minerals, generally in arrangement with the Australian Mineral Development Laboratories; control of mining and rehabilitation; co-ordinating State Government activities and formulating policy advice in the discovery, assessment and development of all energy resources within the State.

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. 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. The Department of Mines and Energy provides a wide range of services through its Geological Survey and Mines Divisions. The Geological Survey Division is examining the regional geology and geophysics of the Territory, with a view to facilitating the search for mineral, energy and ground water resources. It provides geological and geophysical advice, undertakes and promotes research into new techniques for mapping, geophysical surveys and mineral search. A Technical Library service is provided in Darwin and Alice Springs. Drill cores and cuttings are maintained at Darwin, Alice Springs and Tennant Creek.

The Mines Division provides expertise in mining, occupational hygiene, environment protection, metallurgy, economics and assaying. Services include a plant at Tennant Creek to process ore at subsidised rates; hire of mining equipment at nominal rates; funding of mine access road construction and maintenance, water supply, drilling, mine development and ore haulage; advice on mining techniques, mineral processing, project assessment, finance and marketing.

Rehabilitation of abandoned mine areas and preservation of historical mine items are programmed.

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

For a more detailed description of the activities of the Australian Atomic Energy Commission *see* Chapter 18, Energy.

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 Laboratory

In 1965, the Baas Becking Geobiological 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 376).

Much of the biological research has involved studies on the biology and biochemistry associated with mineralisation processes. More particularly, the investigation of biogeological controls on base metal sulphide mineralisation. On the geological side, research is co-ordinated with the field programs of the Bureau of Mineral Resources, and includes studies on the McArthur Basin 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 role is to develop an integrated scientific understanding of the geology of the Australian continent, its Territories and offshore areas, as a basis for mineral exploration and resource assessment. BMR's activities include:

- Studies of sedimentary basins and of sedimentary systems, which have continental development in Australia and which may be host to fossil fuels or mineral deposits. These include studies of the characteristics and origin of fossil fuels, and studies of the effects of surface processes on the bedrock of the Australian continent.
- Studies of the structure and characteristics of the crust and upper mantle relevant to the understanding of the evolution of the Australian continent and its mineral deposits.
- Research into geophysical exploration techniques and their application.
- Carrying out of airborne radiometric and magnetic surveys and their interpretation as a basis for mineral exploration.
- Carrying out a wide range of marine geological and geophysical investigations.

- The undertaking of basic geochemical, petrological, and mineralogical studies of major sedimentary and igneous rock suites.
- Studies of metalliferous deposits and of their environments.
- Multi-disciplinary studies of metallogenic provinces.
- Assessment of Australia's mineral resources, including petroleum.
- Establishment and maintenance of the National Geoscience Data Base.

Commonwealth Scientific and Industrial Research Organization

Minerals Research

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

Department of National Development and Energy

The National Coal Research Advisory Committee which was established in 1964 no longer exists. Its functions have been incorporated into the National Energy Research, Development and Demonstration Council (NERDDC) which is administered by the Department of National Development and Energy. For details of NERDDC and the National Energy Advisory Committee (NEAC), which advises the Minister for National Development and Energy on matters relating to national energy policy *see* Chapter 18, Energy and 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

Many of the large companies in the mineral industry conduct their own research in dealing with their particular Company's interests. In 1959 the major companies in the industry, formed the Australian Mineral Industries Research Association Limited to co-ordinate and manage sophisticated research programmes on a co-operative basis, carried out by the Australian Mineral Development Laboratories, CSIRO, Universities and by other research organisations.

Since then, the research activity has grown considerably in magnitude and currently involves many of the ninety three companies which comprise the Company, Associate and Division members within the Association.

Fields of research cover geology, ore genesis and exploration techniques, mining and rock mechanics, mineral processing, ecology, energy, analytical methods and miscellaneous other items and the expenditure in these fields in 1980–81 was approximately $2,104,455.

International relations

Because Australia is a large supplier of certain minerals to the rest of the world, and because the welfare of the domestic industry depends to a large extent on the maintenance of a high level of exports, international relations are of considerable importance to the industry, and the Commonwealth Government takes an active role in international consultations and discussions relating to minerals. The most important international commitments are discussed below.

International Tin Agreement

The First International Tin Agreement (of the post-war period) was in operation for five years from 1 July 1956 to 30 June 1961. It was followed by the Second, Third, Fourth and Fifth International Tin Agreements, which came into force on 21 February 1962, 21 March 1967, 1 July 1971 and 1 July 1976 respectively. 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. 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.

The objectives and provisions of the present (Fifth) 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, Norway, 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.

The text for a Sixth International Tin Agreement which it is proposed will enter into force on 1 July 1982 (upon expiry of the Fifth Agreement) has been negotiated at a series of sessions which concluded in June 1981. This text is open for signature until 30 April 1982.

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, Argentina, 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 and to provide a forum for consultations and the exchange of information on problems relating to the iron ore export industry.

The Association consists of a Conference of Ministers, which meets biennially and is the supreme authority of the Association, a Board comprising representatives of member countries which meets twice a year, and a Secretariat which is located in Geneva.

Intergovernmental Council of Copper Exporting Countries (CIPEC)

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

Australia and Papua-New Guinea were admitted as Associate Members and Indonesia as a Full Member in 1975; Yugoslavia was admitted as an Associate Member in 1977. Associate Members may participate in meetings but have no voting rights and are not bound by CIPEC's decisions.

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

International Bauxite Association

Australia joined the International Bauxite Association (IBA) 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 1980 the Council adopted recommendations on minimum CIF prices for bauxite and alumina sold by member countries in 1981. Australia was not included in the majority that voted for the recommendations and is not bound by them. The Association publishes a Quarterly Review and a bi-monthly newsletter.

The 1981 meeting of the Council of Ministers was held in Australia (Canberra) in November.

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 census of mining establishments. The annual mining census is conducted throughout Australia on an integrated basis with other economic censuses, e.g. the annual census of manufacturing establishments, electricity and gas establishments and the periodic censuses of retail and wholesale trade establishments.

Statistics are also available for *enterprises* engaged in the mining industry. The latest statistics for mining are in respect of 1978–79 and were published in *Enterprise Statistics: Details by Industry Class, Australia,* 1978–79 (8103.0). Enterprise statistics for mining are now produced annually and should be available within two years of the end of the financial year to which they relate. A description of the statistics and broad summary tables, in respect of the 1977–78 and 1978–79 censuses and surveys are given in Chapter 17.

The following table shows key items of data for establishments in Australia for 1979–80 based on the 1978 edition of the *Australian Standard Industrial Classification* (ASIC). The 1978 edition of the classification replaces the 1969 preliminary edition which has been in use since the 1968–69 census.

A document fully describing the differences between the 1969 and 1978 editions of the ASIC is available on request.

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS BY INDUSTRY CLASS, 1979–80

Industry 1978 ASIC code	*Description*	*Establishments at 30 June*	*Average employment over whole year(a)* Males	Females	Persons	*Wages and salaries (b)*	*Stocks* Turnover	Opening	Closing	*Total purchases, transfers in and selected expenses*	*Value added*	*Fixed capital expenditure less disposals*
		No.	No.	No.	No.	$'000	$'000	$'000	$'000	$'000	$'000	$'000
	Metallic minerals—											
	Ferrous metal ores—											
1111	Iron ores	25	6,884	1,000	7,884	151,761	1,058,050	89,159	107,187	477,051	599,027	63,408
1112	Iron ore pelletising	4	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
	Non-ferrous metal ores—											
1121	Bauxite	5	1,856	176	2,032	33,013	266,316	13,136	15,193	43,686	224,687	34,347
1122	Copper ores	16	3,955	246	4,201	67,862	324,426	30,749	49,703	90,221	253,158	16,501
1123	Gold ores	48	1,793	117	1,910	29,892	207,593	14,628	26,018	50,332	168,650	35,514
1124	Mineral sands	17	1,918	141	2,059	29,294	163,484	32,933	31,522	72,954	89,118	6,140
1125	Nickel ores	6	2,324	215	2,539	45,785	226,177	16,429	29,298	80,276	158,769	30,903
1126	Silver-lead-zinc ores	9	6,678	325	7,003	130,630	917,698	72,757	75,428	134,785	785,584	43,921
1127	Tin ores	70	1,705	132	1,837	26,078	150,572	8,413	11,159	42,311	111,007	25,451
1128	Uranium ores	2	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
1129	Non-ferrous metal ores n.e.c.	16	1,406	191	1,597	26,644	150,645	17,611	26,723	52,823	106,933	10,749
11	*Total metallic minerals*	*218*	*30,220*	*2,688*	*32,908*	*576,056*	*3,715,084*	*322,594*	*417,590*	*1,277,224*	*2,532,857*	*442,885*
	Coal, oil and gas—											
1201	Black coal	120	25,793	632	26,425	514,874	2,214,358	222,612	231,488	813,790	1,409,444	406,054
1202	Brown coal	4	3,356	107	3,463	67,436	1,431,559	42,174	77,042	147,219	1,319,209	146,827
1300	Oil and gas	11										
	Construction materials—											
1401	Sand and gravel	327	1,533	203	1,736	21,750	146,242	7,479	8,842	69,293	78,311	6,705
1404	Construction materials n.e.c.	424	3,997	392	4,389	61,681	327,131	27,948	31,443	154,589	176,037	29,239
14	*Total construction materials*	*751*	*5,530*	*595*	*6,125*	*83,432*	*473,373*	*35,427*	*40,285*	*223,882*	*254,348*	*35,944*
	Other non-metallic minerals—											
1501	Limestone	48	671	11	682	10,180	42,082	2,854	3,080	20,130	22,179	38,994
1502	Clays	132	298	27	325	3,667	26,597	3,154	4,009	16,892	10,561	2,103
1504	Salt	22	570	78	648	10,785	46,191	8,356	7,411	17,661	27,586	6,744
1505	Non-metallic minerals n.e.c.	138	1,139	101	1,240	17,716	89,888	13,882	14,241	57,844	32,403	6,686
15	*Total other non-metallic minerals*	*340*	*2,678*	*217*	*2,895*	*42,347*	*204,759*	*28,245*	*28,741*	*112,526*	*92,728*	*54,528*
	Total mining (excl. services to mining)	**1,444**	**67,577**	**4,239**	**71,816**	**1,284,146**	**8,039,133**	**651,052**	**795,146**	**2,574,641**	**5,608,586**	**1,086,237**

(a) Includes working proprietors. (b) Excludes amounts drawn by working proprietors.

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 Development and Energy and from other sources.

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

Quantity of minerals produced

The following tables show particulars of the quantities of minerals produced during 1979–80 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		*1977–78*	*1978–79*	*1979–80*
	METALLIC MINERALS			
Antimony concentrate	tonnes	n.p.	1,518	1,270
Antimony content	„	n.p.	n.p.	n.p.
Antimony ore	tonnes	464	3	7
Antimony content	„	61	2	4
Bauxite	'000 tonnes	24,642	25,541	27,629
Alumina (Al_2O_3) content	„	n.p.	n.p.	n.p.
Beryllium ore	tonnes	—	—	—
Beryllium oxide (BeO) content	mtu(*a*)	—	—	—
Bismuth concentrate	tonnes	5,743	n.p.	—
Bismuth content	tonnes	756	n.p.	n.p.
Copper content	tonnes	1,227	831	—
Gold content	kg	533	140	—
Selenium content	tonnes	31	—	—
Silver content	kg	210	122	—
Copper concentrate	'000 tonnes	750	819	812
Copper content	tonnes	198,290	216,714	206,130
Bismuth content	„	183	n.p.	n.p.
Gold content	kg	2,210	1,717	1,651
Lead content	tonnes	363	1,625	2,952
Silver content	kg	27,477	32,976	36,151
Zinc content	tonnes	1,259	2,680	3,877
Copper ore	tonnes	1,271	2,433	33,969
Copper content	„	101	174	9,312
Gold content	kg	—	—	2
Silver content	„	231	24	29
Copper ore for fertilizer	tonnes	—	—	—
Copper content	„	—	—	—
Copper oxide	tonnes	3,810	3,403	3,871
Copper content	„	2,953	2,632	2,993
Copper precipitate	tonnes	51	21	524
Copper content	„	36	16	430
Gold bullion(*b*)	kg	21,127	18,765	16,805
Gold content	„	16,291	15,902	14,405
Silver content	kg	1,407	1,577	1,512
Gold ore	tonnes	25	197	1,099
Gold content	kg	1	1	19
Iron ore(*c*)	'000 tonnes	89,872	84,595	96,998
Iron content	„	54,739	53,248	61,319
Iron oxide(*d*)	tonnes	51,156	47,711	46,870
Lead concentrate	'000 tonnes	622	658	654
Lead content	tonnes	385,510	394,913	n.p.
Antimony content	„	513	570	531
Cadmium content	„	51	101	128
Copper content	„	4,235	5,211	6,544
Gold content	kg	276	345	331
Silver content	kg	662,685	692,355	633,900
Sulphur content	tonnes	49,576	57,314	63,297
Zinc content	„	32,424	38,777	42,881
Lead-copper concentrate	tonnes	46,654	24,719	24,185
Lead content	„	12,845	5,155	5,562
Copper content	„	3,658	3,343	3,077
Gold content	kg	1,333	1,038	1,049
Silver content	„	67,382	49,995	43,765
Sulphur content	tonnes	11,478	7,558	7,193
Zinc content	„	6,685	2,546	2,984
Lead ore (*e*)	tonnes	51,066	5,367	18,786
Lead content	„	2,857	726	1,174
Silver content	kg	3,234	1,778	1,559

For footnotes *see* end of table.

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

Mineral		*1977–78*	*1978–79*	*1979–80*
Lead-zinc middlings	tonnes	628	—	—
Lead content	,,	208	—	—
Antimony content	,,	1	—	—
Cadmium content	,,	1	—	—
Copper content	,,	8	—	—
Gold content	kg	2	—	—
Silver content	,,	200	—	—
Sulphur content	tonnes	179	—	—
Zinc content	,,	188	—	—
Manganese ore—				
Metallurgical grade	'000 tonnes	1,325	1,385	2,173
Manganese content	,,	628	656	1,034
Mineral sands (*f*)—				
Ilmenite concentrate (*g*)	,,	1,137	1,207	1,336
Titanium dioxide content	tonnes	626,662	683,155	715,991
Leucoxene concentrate	'000 tonnes	17	19	27
Titanium dioxide content	tonnes	16,284	16,873	24,156
Monazite concentrate	'000 tonnes	9	19	15
Monazite content	tonnes	8,646	17,385	14,033
Rutile concentrate	'000 tonnes	274	269	301
Titanium dioxide content	tonnes	262,990	258,471	288,712
Xenotime concentrate	'000 tonnes	—	—	—
Yttrium oxide content	kg	4,848	6,060	7,273
Zircon concentrate	'000 tonnes	365	454	447
Zirconium dioxide content	tonnes	284,956	347,474	331,190
Nickel concentrate	'000 tonnes	467	353	347
Nickel content	tonnes	56,850	43,944	43,182
Cobalt content	,,	234	145	258
Copper content	,,	4,839	3,474	3,117
Palladium content	kg	356	175	202
Platinum content	,,	141	69	83
Nickel ore	'000 tonnes	2,560	2,586	2,163
Nickel content	tonnes	30,141	36,441	21,211
Pyrite concentrate	'000 tonnes	252	111	16
Sulphur content	tonnes	114,690	52,986	7,637
Tantalite-columbite concentrate	tonnes	207	127	166
Tantalite-columbite content	kg	89,040	63,771	69,113
Tin concentrates	tonnes	22,684	22,618	23,083
Tin content	,,	11,726	11,964	12,312
Tin-copper concentrate	tonnes	1,806	1,980	2,239
Tin content	,,	45	47	45
Copper content	,,	390	457	480
Tungsten concentrates—				
Scheelite concentrate	tonnes	n.p.	3,129	3,864
Tungstic oxide content	mtu(*a*)	n.p.	228,539	280,339
Wolfram concentrate	tonnes	n.p.	1,840	2,411
Tungstic oxide content	mtu(*a*)	n.p.	127,232	166,433
Zinc concentrate	'000 tonnes	850	879	903
Zinc content	tonnes	441,888	453,260	466,152
Cadmium content	,,	1,472	1,559	1,616
Cobalt content	,,	108	86	84
Copper content	,,	1,228	1,587	1,932
Gold content	kg	227	297	251
Lead content	tonnes	16,943	18,647	20,140
Manganese content	,,	5,534	5,856	5,297
Mercury content	kg	—	—	—
Silver content	kg	59,512	65,532	68,243
Sulphur content	tonnes	269,214	280,758	289,411
Zinc ore	tonnes	4,137	—	—
Zinc content	,,	1,874	—	—

For footnotes *see* end of table.

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

Mineral		*1977–78*	*1978–79*	*1979–80*
COAL				
Black coal	'000 tonnes	79,338	81,197	81,249
Bituminous	"	73,654	75,332	74,402
Sub-bituminous	"	5,684	5,865	6,847
Brown coal (lignite)(*h*)	"	27,644	29,095	32,895
Brown coal briquettes	"	1,064	1,131	1,253
OIL AND GAS (*i*)				
Crude oil (stabilised)	'000 cu m	24,941	24,839	23,647
Natural gas	mil. cu m	6,720	7,686	8,876
Natural gas condensate(*j*)	'000 cu m	6	13	21
Ethane	"	110,455	144,025	147,098
Liquefied petroleum gases (*k*)—				
Propane	"	1,269	1,544	1,555
Butane	"	1,388	1,683	1,563
CONSTRUCTION MATERIALS(*l*)				
Sand	'000 tonnes	24,345	23,855	26,241
Gravel	"	14,394	13,958	14,998
Dimension stone	"	91	147	123
Crushed and broken stone	"	60,576	54,223	56,294
Other	"	26,905	32,899	38,072
OTHER NON-METALLIC MINERALS				
Asbestos	tonnes	50,590	67,514	90,524
Barite	"	11,035	n.p.	n.p.
Carbon dioxide	..	..	..	..
Chlorite	tonnes	—	—	—
Clays—				
Brick and shale	'000 tonnes	8,549	8,028	9,005
Other(*m*)	"	1,412	1,162	1,107
Diatomite	tonnes	2,630	2,815	4,559
Dolomite	"	622,939	684,278	760,000
Felspar (including cornish stone)	"	2,505	3,506	3,396
Garnet concentrate	"	1,187	1,333	n.p.
Gypsum	'000 tonnes	900	1,074	1,349
Limestone (including shell and coral)	"	10,750	10,813	11,521
Magnesite, crude	tonnes	18,138	26,560	29,034
Mineral pigments—red ochre	"	193	737	242
Peat(*n*)	"	n.p.	n.p.	n.p.
Pebbles—for grinding	"	1,673	1,473	1,941
Perlite	"	829	1,971	2,516
Phosphate rock	"	397,041	6,986	7,458
Pyrophyllite	"	12,774	13,318	18,519
Salt	'000 tonnes	5,410	5,339	5,335
Silica	"	1,314	1,618	1,846
Sillimanite	tonnes	589	545	532
Talc (including steatite)	'000 tonnes	123	142	177

(*a*) Metric ton unit (mtu) equals 10 kilograms. (*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 Energy and State Mines Departments. (*j*) Sales—excludes condensate blended and other petroleum products. (*k*) Excludes refinery production. (*l*) Incomplete. (*m*) Incomplete owing to difficulties of coverage. (*n*) Comprises peat for fertiliser and peat moss.

CONTENTS OF METALLIC MINERALS PRODUCED

Contents of metallic minerals produced		*1977–78*	*1978–79*	*1979–80*
Alumina (Al_2O_3)	'000 tonnes	n.p.	n.p.	n.p.
Antimony	tonnes	n.p.	1,588	1,435
Beryllium oxide (BeO)	mtu(*a*)	—	—	—
Bismuth	kg	890,703	n.p.	n.p.
Cadmium	tonnes	1,545	1,660	1,757
Cobalt	"	2,646	3,451	3,133
Copper	"	217,083	238,688	235,122
Gold	kg	21,047	19,584	18,273
Iron(*b*)	'000 tonnes	54,739	53,248	61,319
Lead	tonnes	418,801	423,492	n.p.
Manganese	"	633,047	662,326	1,039,141
Mercury	kg	—	—	—
Monazite	tonnes	8,646	17,385	14,033
Nickel	"	86,991	80,385	64,393
Palladium	kg	356	175	202
Platinum	"	141	69	83
Selenium	tonnes	31	—	—
Silver	kg	837,315	874,075	791,760
Sulphur	tonnes	445,137	398,616	369,358
Tantalite-columbite ($Ta_2O_5 + Nb_2O_5$)	kg	89,040	63,771	69,113
Tin	tonnes	11,771	12,011	12,379
Titanium dioxide (TiO_2)	"	905,936	958,499	1,028,859
Tungstic oxide (WO_3)	mtu(*a*)	n.p.	355,771	449,372
Yttrium oxide (Y_2O_3)	kg	4,848	6,060	7,273
Zinc	tonnes	484,376	498,484	518,040
Zirconium dioxide (ZrO_2)	"	284,956	347,474	331,190

(*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.

Value of minerals produced

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

VALUE OF MINERALS PRODUCED
($'000)

Mineral	*1974–75*	*1975–76*	*1976–77*	*1977–78*	*1978–79*	*1979–80*
METALLIC MINERALS						
Antimony—						
Concentrate	1,904	1,462	n.p.	n.p.	1,409	1,530
Ore	n.p.	n.p.	n.p.	n.p.	2	4
Bauxite	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Beryllium ore	1	—	—	—	—	n.p.
Bismuth concentrate	14,085	10,591	12,183	7,923	n.p.	—
Copper—						
Concentrate	168,047	159,876	182,448	151,487	256,469	327,471
Ore(*a*)	766	305	1,202	109	200	9,937
Ore for fertiliser	3	—	—	—	—	—
Oxide	1,406	1,900	2,730	3,656	4,409	5,745
Precipitate	31	42	31	27	14	598
Gold—						
Bullion(*b*)	43,139	43,735	47,501	82,122	101,592	203,337
Concentrate	—	—	219	215	746	2,522
Ore	8	10	3	3	9	228
Iron ore	613,169	674,515	746,577	769,408	801,636	1,004,308
Iron oxide	855	915	1,000	1,020	932	988
Lead concentrate	124,519	117,099	177,760	208,343	339,400	623,973
Lead-copper concentrate	7,609	8,363	10,822	15,745	16,531	41,193
Lead ore(*d*)	579	566	527	964	1,541	1,458
Lead-zinc middlings	2,422	2,094	5,630	110	—	—
Manganese ore	n.p.	n.p.	n.p.	n.p.	60,563	95,877
Mineral sands—						
Ilmenite concentrate(*e*)	14,270	15,835	17,753	21,860	23,768	27,252
Leucoxene concentrate	2,079	2,078	1,318	2,265	2,497	4,471
Monazite concentrate	515	774	1,178	1,621	4,205	4,350
Rutile concentrate	53,674	71,750	75,654	50,631	51,267	76,481
Xenotime concentrate	12	9	9	15	19	29
Zircon concentrate	58,128	60,935	42,026	25,729	27,189	28,175
Nickel concentrate	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
Nickel ore	—	n.p.	n.p.	n.p.	n.p.	n.p.
Pyrite concentrate	441	771	709	833	710	99
Tantalite-columbite concentrate	942	1,256	1,127	3,670	5,202	12,339
Tin concentrate	49,138	49,060	70,022	108,927	135,365	166,674
Tin-copper concentrate	390	435	383	287	332	565
Tungsten ores and concentrates	11,385	15,497	34,204	n.p.	43,253	54,691
Uranium concentrate	—	2,641	15,460	24,077	47,832	62,342
Zinc concentrate	138,385	133,340	132,922	120,217	138,464	174,065
Zinc ore	2,439	1,600	325	362	—	—
Other metallic minerals	84	2,928	n.p.	n.p.	n.p.	n.p.
Total metallic minerals	*1,572,746*	*1,676,273*	*1,986,680*	*2,059,716*	*2,407,524*	*3,431,887*
COAL						
Black coal	874,879	1,211,199	1,438,289	1,576,914	1,646,549	1,760,095
Brown coal (lignite) (*f*)	40,556	48,346	55,905	64,925	79,630	91,821
Brown coal briquettes	11,391	11,974	14,925	16,536	25,063	24,938
Total coal	*926,827*	*1,271,519*	*1,509,119*	*1,658,375*	*1,751,242*	*1,876,854*
OIL AND GAS(*g*)						
Oil and Gas	*446,298*	*488,419*	*534,815*	*671,233*	*919,793*	*1,920,260*

For footnotes *see* end of table.

VALUE OF MINERALS PRODUCED—*continued*

Mineral	*1974–75*	*1975–76*	*1976–77*	*1977–78*	1978–79	1979–80
CONSTRUCTION MATERIALS(*h*)						
Construction materials	*238,044*	*256,328*	*272,774*	*308,174*	*353,062*	*439,385*
OTHER NON-METALLIC MINERALS						
Asbestos	7,960	18,406	20,382	20,514	21,149	27,240
Barite	303	n.p.	n.p.	404	n.p.	n.p.
Carbon dioxide	45	56	163	180	208	228
Chlorite	10,084	8,723	—	—	—	—
Clay—						
Brick clay and shale	10,241	12,634	12,821	13,676	15,513	23,092
Other clays	n.p.	4,335	4,774	7,085	8,059	10,802
Diatomite	45	60	71	310	380	730
Dolomite	991	1,262	1,421	1,654	2,107	2,370
Felspar (including cornish stone)	87	97	77	63	89	138
Garnet concentrate	—	—	11	21	45	n.p.
Gems	37,032	41,972	64,066	70,219	67,292	89,171
Gypsum	3,176	3,069	4,216	4,061	4,844	6,118
Limestone (including shell and coral)	24,221	26,087	30,154	34,159	39,193	42,585
Magnesite, crude	722	n.p.	340	411	1,503	1,979
Mineral pigments—red ochre	—	15	3	4	11	4
Peat(*i*)	146	n.p.	n.p.	n.p.	n.p.	n.p.
Pebbles—for grinding	27	38	35	27	53	65
Perlite	32	12	45	17	15	20
Phosphate rock	894	1,508	4,477	1,672	44	47
Pyrophyllite	156	200	187	229	345	519
Salt	21,951	29,394	33,623	38,558	38,091	40,817
Silica	6,301	6,559	n.p.	n.p.	11,531	14,103
Sillimanite	22	18	141	27	31	33
Talc (including steatite)	1,348	n.p.	n.p.	n.p.	n.p.	n.p.
Vermiculite	n.p.	—	n.p.	7	2	—
Total other non-metallic minerals	*120,097*	*149,398*	*188,057*	*205,143*	*215,316*	*269,326*
TOTAL						
Total, all minerals and construction materials	**3,304,012**	**3,841,444**	**4,491,445**	**4,902,640**	**5,646,937**	**7,207,712**

(*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*) Comprises peat for fertiliser and peat moss.

Foreign participation of the mining industry in Australia

Summary information on foreign participation in the mining industry in Australia is shown in Chapter 24, Overseas Transactions. More detailed statistics are available in *Foreign Ownership and Control of the Mining Industry* (5317.0) and *Foreign Control in Mineral Exploration* (5323.0).

Mineral exploration (other than for petroleum and oil shale)

Definition

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

Sources of statistics

The statistics of exploration for minerals *other than petroleum and oil shale* are derived from the annual mineral exploration census conducted by the Australian Bureau of Statistics in each State and the Northern Territory (in New South Wales the census is conducted jointly with the State 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 Federal and State Government Departments, local government authorities and business undertakings operated by those departments or authorities.

Expenditure, metres drilled

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

MINERAL EXPLORATION (OTHER THAN FOR PETROLEUM AND OIL SHALE)

	1974–75	*1975–76*	*1976–77*	*1977–78*	*1978–79*	*1979–80*
Expenditure ($'000)—						
On drilling	36,172	35,104	40,888	56,277	57,913	78,837
Other	88,029	82,033	108,605	120,058	144,067	231,596
Australia	**124,200**	**117,137**	**149,493**	**176,336**	**201,980**	**310,433**[a]
Metres drilled ('000)—						
Drilled-core	733	530	529	638	642	942
Drilled-non-core	1,775	1,589	1,434	1,893	1,871	2,133
Australia	**2,509**	**2,119**	**1,963**	**2,531**	**2,513**	**3,076**

Oil shale exploration

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

Exploration consists of the search for and/or appraisal of new ore occurrences and known deposits of oil shale (including extensions to deposits being worked) by geological, geophysical, geochemical and other methods (including drilling). 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 operations (including the construction of drives, shafts, winzes, etc. in underground mines, and overburden removal, for open-cut extraction).

In 1970-80 expenditure in Australia on private exploration for oil shale amounted to $7,125,000 with 32,000 metres being drilled.

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 publication *Mineral Exploration, Australia* (8412.0).

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 of access roads, site construction, permits, licences and similar fees, relevant office buildings and furniture, transportation equipment, storage facilities, plant and equipment, and review work where these are undertaken primarily for purposes of exploration for deposits of petroleum. Details of developmental oil and/or gas wells are excluded.

Operations

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

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

		1977	*1978*	*1979*
Expenditure—				
Private sources	$'000	84,970	111,566	222,616
Government sources	$'000	4,704	4,915	4,870
Total	**$'000**	**89,674**	**116,481**	**227,486**
Wells—				
Drilled (i.e. those which reached final depth)—				
As oil producers	No.	2	7	1
As gas producers	No.	2	3	8
As oil and gas producers	No.	—	—	—
Plugged and abandoned	No.	17	43	43
Total	**No.**	**21**	**53**	**52**
Average final depth of wells drilled	m	2,577	1,973	2,460
Drilling still in progress at 31 December (uncompleted holes)	No.	3	3	4
Wells drilled or drilling over 3,000 metres	No.	10	10	14
Metres drilled—				
Completed wells	m	49,307	104,583	127,403
Uncompleted holes	m	10,176	5,026	10,205
Total	**m**	**59,483**	**109,609**	**137,608**

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, Manufacturing and Internal Trade).

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		*1977–78(a)*	*1978–79(a)*	*1979–80(a)*
METALS(b)				
Non-ferrous—				
Alumina	'000 tonnes	6,694	6,921	7,290
Refined aluminium	tonnes	259,592	264,798	283,006
Blister copper(c)	„	167,947	170,458	163,608
Refined copper	„	155,353	137,863	137,000
Lead bullion (for export)(c)	„	155,641	162,185	167,744
Refined lead	„	207,939	217,992	204,000
Refined zinc	„	262,615	308,622	300,000
Refined tin	„	5,994	4,857	5,249
Ferrous—				
Pig iron	'000 tonnes	7,096	7,345	7,276
Steel ingots	„	7,532	7,541	7,895
Precious—				
Refined gold(d)	kg	17,869	15,563	15,038
Refined silver	„	259,217	302,032	293,966
FUELS				
Coal products—				
Metallurgical coke	'000 tonnes	4,310	4,620	4,302
Brown coal briquettes	„	1,064	1,131	1,253
Petroleum products(e)—				
Motor spirit	mil. litres	14,073	14,018	14,623
Furnace fuel	„	4,445	4,676	4,113
Automotive distillate	„	6,717	6,998	7,592
Industrial diesel fuel	„	1,523	1,312	1,092
BUILDING MATERIALS				
Clay bricks	millions	1,911	1,914	2,173
Portland cement	'000 tonnes	5,016	5,085	5,201
Plaster of paris	„	348	347	n.p.
Plaster sheets	'000 sq m	48,034	48,508	54,700
CHEMICALS				
Sulphuric acid	'000 tonnes	1,837	1,940	2,153
Caustic soda	tonnes	130,830	n.p.	n.p.
Superphosphate(f)	'000 tonnes	3,430	3,680	4,202

(*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*) Newly-won gold of Australian origin. (*e*) Produced by Australian refineries from imported and indigenous petroleum. *Source:* Department of National Development and Energy. (*f*) Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22% P_2O_5 equivalent.

Overseas trade

Exports and imports

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 f.o.b. ($'000)		
		1978–79	1979–80	1980–81	1978–79	1979–80	1980–81
EXPORTS(b)							
Non-ferrous—							
Copper—							
Concentrate	tonnes	131,661	157,481	133,046	43,845	88,560	75,924
Blister	"	12,094	24,664	24,387	26,244	48,907	57,237
Refined	"	53,677	47,737	72,204	76,816	93,396	114,880
Matte, slags, etc.	"	4,472	8,719	3,622	2,560	11,700	3,251
Lead—							
Concentrate	"	71,996	65,271	75,303	31,682	56,874	39,161
Bullion	"	159,637	179,845	121,600	150,618	366,196	200,586
Refined	"	152,240	166,714	146,833	101,400	171,980	97,758
Slags and residues	"	18,560	12,354	8,387	2,459	6,863	4,761
Zinc—							
Concentrate	"	453,118	459,994	444,246	57,127	77,856	81,332
Refined	"	193,826	173,761	349,507	110,963	115,844	132,130
Slags and residues	"	6,441	11,872	7,114	1,072	1,566	2,050
Tin—							
Concentrate	"	14,244	13,963	14,801	74,678	90,201	84,885
Refined	"	1,288	1,991	1,331	14,674	28,101	19,034
Aluminium—							
Alumina	'000 tonnes	6,408	7,236	6,414	718,939	970,865	992,726
Refined	tonnes	81,026	55,049	64,483	82,219	68,448	99,447
Ferrous and alloy—							
Iron ore—							
Pellets	'000 tonnes	8,130	5,797	2,325	165,390	123,827	50,309
Fines	"	38,851	41,696	42,993	391,287	492,207	571,250
Lump	"	32,565	31,474	29,554	411,021	460,361	495,405
Tungsten—							
Scheelite concentrate	tonnes	3,853	3,547	4,276	38,448	31,970	37,852
Wolfram concentrate	"	1,578	1,850	2,503	12,101	21,481	19,918
Pig iron	"	784,415	618,818	349,542	70,546	76,202	41,905
Steel ingots, blooms	"	1,241,224	653,918	255,674	193,911	138,164	50,392
Mineral sands—							
Ilmenite concentrate	'000 tonnes	977	1,115	911	22,421	19,959	19,505
Rutile concentrate	"	336	342	208	63,499	86,809	63,079
Zircon concentrate	"	423	490	496	29,920	33,638	37,898
Precious—							
Gold, refined	kg	13,900	5,507	3,443	22,329	94,105	55,698
Silver, refined	"	89,074	75,276	172,178	16,767	50,888	62,883
Coal, black	'000 tonnes	38,888	42,567	47,187	1,519,198	1,675,045	1,964,740
Crude oil(c)	'000 cu m	(d)370	(d)127	(d)151	40,475	18,818	25,163
IMPORTS							
Tin, refined	tonnes	204	38	106	2,701	572	1,256
Nickel (pigs, anodes, etc.)	"	1,532	600	591	5,905	3,228	5,041
Ferro-alloys	"	26,300	54,861	91,745	15,451	39,799	26,363
Gold—							
Unrefined bullion(e)	kg	512	973	357	2,737	12,921	5,528
Refined	"	40	38	703	267	631	10,035
Crude oil(c)	'000 cu m	10,293	11,240	15,855	762,843	1,404,266	1,490,616
Asbestos	tonnes	29,443	23,490	27,938	13,038	11,874	15,442
Diamonds—							
Industrial	metric carats	1,187,540	1,096,450	480,584	6,501	8,243	7,972
Gemstone	"	63,337	61,121	78,118	31,375	46,198	40,007
Phosphate rock	'000 tonnes	2,380	2,181	n.a.	83,266	80,324	101,895
Potassium fertilisers	tonnes	168,527	215,540	190,668	9,839	15,486	17,837
Sulphur	"	424,660	597,128	670,877	15,077	30,832	57,473

(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, enriched crudes and refinery feed stock. (d) Million litres. (e) Gold content.

Considerable quantities of metallic ores, concentrates, slags, and residues are exported from Australia for refining overseas. The following table shows selected items exported during 1980 and their principal metallic content as estimated by assay.

PRINCIPAL METALLIC CONTENTS OF SELECTED ORES AND CONCENTRATES ETC. EXPORTED FROM AUSTRALIA, 1980

	Metallic contents—estimated from assay							
Ores and concentrates, etc.	*Copper*	*Lead*	*Zinc*	*Tin*	*Iron*	*Tungstic Oxides*	*Gold*	*Silver*
	tonnes	tonnes	tonnes	tonnes	'000 tonnes	tonnes	kg	kg
Copper concentrate	45,963	1,903	2,046	—	—	—	102	7,536
Blister copper	17,304	—	—	—	—	—	226	1,493
Copper matte, slags, etc.(*a*)	5,027	3,663	927	—	—	—	2	2,540
Lead concentrate	4,477	15,593	5,435	—	—	—	779	30,100
Lead bullion	—	153,930	—	—	—	—	83	385,270
Lead slags and residues	—	2,678	—	33	—	—	23	1,217
Zinc concentrate	—	4,424	261,613	—	—	—	—	9,398
Zinc slags and residues	—	—	6,404	—	—	—	—	—
Tin concentrate	—	—	—	7,420	—	—	—	—
Iron ore—								
Pellets	—	—	—	—	1,896	—	—	—
Fines	—	—	—	—	27,613	—	—	—
Lump	—	—	—	—	20,681	—	—	—
Scheelite concentrate	—	—	—	—	—	2,647	—	—
Wolfram concentrate	—	—	—	—	—	1,533	—	—
Total metallic content	**72,771**	**182,191**	**276,425**	**7,453**	**50,190**	**4,180**	**1,214**	**437,554**

(*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(*a*)

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

METALS(*a*)

	Tin				*Aluminium*		*Gold*		*Silver*	
Period	*Aust. ($A—tonne)*	*L.M.E. (£Stg—metric ton)*	*Straits ($Mal-picul)*	*Nickel U.S.A. ($US—lb)*	*Aust. ($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)*
1979	14,157.08	7,287.52	1,960.12	2.72	1,160.59	70.33	266.32	307.19	360.54	519.15
1980	15,440.51	7,225.74	2,160.36	3.43	1,501.83	76.76	547.45	606.11	615.92	898.11
1980										
Highest	18,131.00	8,455.00	2,471.00	3.47	1,545.00	89.59	752.50	843.00	1,162.68	2,165.05
Lowest	13,064.00	6,135.00	1,881.00	3.22	1,364.00	68.18	436.15	474.00	388.48	467.80

	Copper		*Lead*			*Zinc*			
Period	*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)*
1979	1,767.48	936.42	1,030.97	567.06	53.58	712.55	350.43	792.92	37.67
1980	1,959.15	941.21	843.27	388.68	42.87	713.10	327.37	798.00	38.61
1980									
Highest	2,800.00	1,375.00	1,150.00	588.00	55.00	745.00	403.00	825.00	42.00
Lowest	1,600.00	756.00	650.00	301.00	34.00	695.00	282.00	780.00	36.50

For footnotes *see* next page.

AVERAGE DAILY PRICES OF SELECTED METALS AND METALLIC ORES AND CONCENTRATES: AUSTRALIAN AND OVERSEAS MARKETS(a)—*continued*

	ORES AND CONCENTRATES				
Period	*Tin Aust. ($A–mtu)*	*Wolfram Europe (£Stg–mtu)*	*Ilmenite Europe ($A–metric ton)*	*Rutile Europe ($A–metric ton)*	*Zircon Europe ($A–metric ton)*
1979	124.60	136.83–142.16	17.00–19.00	260.00–290.00	53.75–63.75
1980	135.99	142.70–146.79	18.50–20.50	320.00–350.00	53.33–62.50
1980					
Highest	161.98	153.00	22.00	350.00	75.00
Lowest	112.72	136.00	17.00	320.00	50.00

(*a*) Where a daily price does not actually exist for a commodity, daily prices have been imputed from price data which are available.
NOTE: 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

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

Major developments in the Australian mineral industry, particularly during 1980 and the first half of 1981, are reviewed briefly in subsequent parts of this section. Additional information on developments in the industry is available in *Australian Mineral Industry Annual Review* 1979 published by the Bureau of Mineral Resources, Geology and Geophysics. That publication contains comprehensive reviews of mineral commodities of importance to the Australian economy, as well as a general review of the industry's performance during the year. The *Australian Mineral Industry Quarterly*, Volume 33, Number 4, details Australia's identified mineral resources, 1980.

General Review of 1980

The gross domestic product (GDP) of Australia in 1980 was $122,745 million, of which an estimated $4,500 million was generated by the mineral industry, excluding smelting and refining. If smelting and refining were included, an estimated $2,300 million could be added to this figure, thus making the mineral industry the largest primary sector contributor to the GDP. Australia's export trade continues to expand to record levels, with Japan, USA and EEC being the main markets for mineral commodities.

The ex-mine value of minerals produced in 1980 increased to an estimated $7,556 million, 18 per cent higher than in 1979; this was again the second largest rise ever recorded, generally reflecting a buoyant world demand for Australian mineral commodities. Quantity and value increases were recorded for most major commodities including black coal, brown coal, copper, mineral sands, iron ore, manganese ore, nickel concentrates, and uranium oxide (yellowcake). World demand for zinc declined, resulting in a fall in both the quantity and value of production. This decline may be attributed to recession in the steel and automobile industries, and the continuing trend of substitution for zinc end-use commodities. The USA automobile industry recession was also largely responsible for a decline in the production of lead, although both the value of production and the price increased.

The increase in the quantity and value of uranium was accounted for by the Nabarlek deposits in the Northern Territory.

The value of black coal production ($2,050 million estimated) again exceeded that of any other single commodity, accounting for 27.1 per cent of the total value of mine output, and was 15.3 per cent greater than in 1979.

Iron ore ($1,051 million) accounted for 13.9 per cent of the total value of mine output; silver, lead and zinc together ($723 million) 9.6%, crude oil ($757 million) 10.0 per cent, construction materials ($448 million) 5.9 per cent, copper ($407 million) 5.4 per cent, gold ($227 million) 3.0 per cent, natural gas ($176 million) 2.3 per cent, tin ($157 million) 2.1 per cent and mineral sands ($153 million) 2.0 per cent. The values of mine output of nickel and bauxite are confidential and are not available for publication. However, in quantitative terms, bauxite production declined slightly (1 per cent), and the nickel content of nickel ores and concentrates rose in 1980 by 7 per cent.

Overseas demand for Australian mineral products remains strong. 'Mines and quarries' was again the largest single export earning group in 1980-81. As with production, however, most exports of the smelting and refining section of the industry are attributed to 'Manufactures'. In terms of Bureau of Mineral Resources' coverage of the mineral industry, export values are therefore substantially understated by ABS statistics.

Imports—1980

The value of imports for mineral products rose by 63 per cent to $2,131 million. Crude oil was the largest single mineral import, rising by 31 per cent to $1,351 million, despite a fall in quantity of 23 per cent. Other significant mineral imports were gem diamonds, and fertiliser minerals (phosphate rock, elemental sulphur, and potassium salts). Imports of mineral primary products accounted for 12 per cent of the total value of merchandise imports compared with 8.9 per cent in 1979. Although the value of imports rose substantially, so also did the surplus in the balance of mineral trade which increased from $4,557 million in 1979 to $4,671 million in 1980.

Exports—1980

Australia's mineral exports rose in value by 16 per cent to $6,803 million, a record of similar magnitude to the 19 per cent increase in 1979. In response to conditions of strong demand and rising prices early in the year, most major commodities performed strongly. Average price and value increases were recorded for coal, alumina, iron ore, copper, lead, zinc, nickel, tin, gold, silver and the mineral sands ilmenite and rutile. However, iron and steel exports again declined in response to increases in local demand.

Black coal remained the largest single mineral export earner, accounting for 25 per cent of the total value of mineral primary products exported. Iron ore was next, increasing in value by 15 per cent to $1,164 million, followed closely by alumina, whose value increased by 30 per cent to $1,021 million. These three items accounted for 57 per cent of the total value of exports of mineral primary products.

The index of exports of mineral primary products at constant prices, increased.

Pattern of mineral trade—1980. Australia exported metals and minerals to more than 100 countries, mostly to Japan and to a lesser extent, USA and countries of the EEC. Japan accounted for 65 per cent of Australian mineral exports by quantity and 42 per cent by value. Principal exports of mineral primary products to Japan were black coal, iron ore, aluminium, alumina, bauxite, copper, nickel, manganese ore, and mineral sands.

The proportion by value of Australian mineral exports to UK was 10 per cent, to the EEC (excluding UK) 12 per cent, and to the USA 13 per cent. Exports to UK and other EEC countries were mainly iron ore, black coal, lead and copper, and to USA alumina, nickel, bauxite, manganese ore, mineral sands, iron ore, lead and zinc.

Bauxite and Alumina

In 1980, production of bauxite decreased slightly to 27.2 million tonnes, alumina production to 7.2 million tonnes, while aluminium output was up 12.6 per cent to 303,494 tonnes. Australia was again the world's largest producer of bauxite and alumina.

An alumina refinery of initial rated capacity of 500,000 tonnes per year will be commissioned in 1982 at Wagerup, W.A. Capacity will be increased in stages to 2 million tonnes per year. Bauxite will be supplied from Willowdale, W.A. All alumina produced will be exported.

The first stage of the alumina refinery at Worsley, W.A., will be completed in 1983. Initial rated capacity is one million tonnes per year, with ultimate capacity of two million tonnes per 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., was increased from 68,000 tonnes to 90,000 tonnes per year in 1981. The aluminium smelter to be constructed at Gladstone, Queensland, by Comalco Ltd, will have a first stage design capacity of 103,000 tonnes per year and will expand to 412,000 tonnes capacity by the end of the decade. The rated capacity of the other Australian aluminium smelter, at Point Henry, Victoria, supplied with Western Australian alumina, is now 165,000 tonnes per year, expansion from 100,000 tonnes being completed by the end of 1980.

The smelter to be built at Portland (Victoria) will have an initial capacity of 132,000 tonnes per year to be completed in 1983. Ultimate capacity will be about 528,000 tonnes per year by 1990. A smelter planned for Bundaberg (Queensland) will have an initial capacity of 99,000 tonnes per year; it will expand to 296,000 tonnes per year in the late 1980s. Construction of this smelter has been deferred pending improvement in demand for aluminium. Two smelters will be constructed near Newcastle (New South Wales). The Tomago smelter, to be completed in 1984, will have an initial capacity of 110,000 tonnes annually, and will be expanded to 220,000 tonnes per year in 1986. The Lochinvar smelter will have capacity of 236,000 tonnes per year and is planned to be completed in the mid-1980s, although a major partner, Alumax Inc. of USA, has withdrawn from the project.

Copper

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

In 1980, mine production of copper increased to 243,540 tonnes.

Production commenced at an annual rate of 300,000 tonnes of ore in early 1981 at the Teutonic Bore copper-zinc mine, W.A. Work on two significant copper-zinc deposits near Benambra, Victoria, continues to delineate further base-metal resources.

Exploration drilling is continuing at the copper-uranium-gold prospect at Olympic Dam on Roxby Downs, S.A. where an exploration shaft is being sunk. Additional drilling at Balcooma, in northwest Queensland continues to outline further resources of copper, and copper-lead-zinc ore. At Scuddles, 4 km north of the main Gossan Hill deposit at Golden Grove in W.A., further copper-silver-zinc ore has been discovered.

At Tennant Creek, N.T., the Warrego and Gecko mine expansion continues in order to service the recommissioning of the flash smelter although the planned annual throughput has been reduced from 900,000 to 600,000 tonnes of ore.

Iron

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

Mine production of iron ore in 1980 was 95.5 million tonnes, nearly 4 per cent higher than in 1979. Export of iron ore and iron ore pellets was 79.8 million tonnes valued at $1,164 million. Australia was the world's largest exporter of iron ore in 1980 and the third largest producer.

Production of iron ore pellets fell substantially in 1980 following the closure of Hamersley Iron Pty Ltd's Dampier plant in February 1980 and Cliffs Robe River Iron Associates' Cape Lambert plant at the end of April 1980. Cost increases had made production uneconomic at prevailing prices. Both companies negotiated contracts for the sale of fines to replace exports of pellets.

Silver, lead and zinc

Mine production of lead and zinc metal in 1980 was 397,491 tonnes and 495,312 tonnes respectively, both less than the 1979 production.

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

Production from the Que River lead-zinc-silver mine (Tasmania) commenced in February 1981. Ore is treated at the Rosebery concentrator, and zinc concentrates refined at the Risdon refinery. The Elura lead-zinc-silver deposit near Cobar, N.S.W., is to be developed. A decline shaft was begun in mid-1981 and production is expected to commence in 1982. Zinc concentrates will be shipped to the Risdon (Tasmania) refinery. Published reserves are 27 million tonnes averaging 8.3 per cent zinc, 5.6 per cent lead and 139 g/t silver. The modernisation of the lead concentrating plant at Mount Isa (Queensland) continues; production will increase from 150,000 to 180,000 tonnes annually.

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 1980, exports were 42.3 million tonnes, valued at $1,680 million. These increased exports have largely been to Japan and to a lesser extent other Asian countries and Europe. Increasing demand for steaming coal, particularly from Japan, has resulted in exports of steaming coal rising to almost nine million tonnes in 1980. As a result of this increasing demand, new mines have been opened and others are under development in Queensland and New South Wales. Exploration for coal has been stimulated and further rich deposits of coking coal and steaming coal have been located. Raw coal production in 1980 was 93.4 million tonnes; saleable coal output rose to 76.3 million tonnes.

A paper entitled Coal Exploration in Australia has been published in the *Australian Mineral Industry Quarterly*, Vol. 31, No. 1.

Petroleum

At the end of 1980 there were 18 fields producing stabilised crude oil (which includes condensate marketed as part of a crude oil stream): Moonie, Alton, Conloi, Kincora, Cabawin, Bennett, Silver Springs and Trinidad in Queensland; Barrow Island, Yardarino and Dongara in Western Australia; and Barracouta, Halibut, Mackeral, Cobia, Tuna, Kingfish and Marlin offshore from Victoria in Bass Strait. The production of stabilised crude oil in 1980 amounted to 22.2 million kilolitres. This was a reduction of 12 per cent from the 1979 production level of 25.4 million kilolitres. The reduction was due mainly to industrial action involving production, shipping and refining difficulties. Production in 1978 was 25.2 million barrels which had increased by 1 per cent from the 1977 level of 25.0 million barrels.

Natural gas production in 1980 was 9,567 million cubic metres. About 12 per cent of this was used in the field and processing plants, the balance being sold mainly as fuel to markets in New South Wales, Queensland, Victoria, South Australia and Western Australia. The production level of 8,381 million cubic metres in 1979 was an increase of 14 per cent over the 1978 level of 7,324 million cubic metres. In 1977 natural gas production was 6,766 million cubic metres.

Seventeen offshore exploration wells were drilled in 1980, four fewer than in 1979; metres drilled decreased from 76,954 in 1979 to 62,012 in 1980. The year saw the winding down of exploration drilling in the deep waters of the Exmouth Plateau off northwest Western Australia; by the end of 1980 only one unit, the Sedco 471 remained in Australian waters.

Offshore development drilling continued in the Gippsland Basin on the Mackeral platform (4 wells) and Tuna platform (3 wells). Drilling on the Mackeral platform was completed in September 1980 and the drilling rig moved to the recently installed 27-well Snapper platform.

Onshore exploration drilling activity rose from 31 wells in 1979 to 77 in 1980; metres drilled increased from 61,845 to 138,813. The drilling was mainly centred in the Bowen-Surat Basin in Queensland, the Cooper Basin in South Australia, and the Perth Basin in Western Australia. Twenty-two onshore development wells were drilled, 25 less than in 1979 (Queensland 9, South Australia 6, Western Australia 7). Metres drilled for onshore development drilling fell from 40,961 to 37,484.

During 1980 significant onshore gas discoveries were made at Glen Fosslyn No. 1, in the Bown-Surat Basin, Queensland, and in Wareena No. 1, in the Cooper Basin in Queensland, at Woodada No. 1, in the Perth Basin, W.A. and in Beanbush No. 1 and Cuttapirrie No. 1 in the Cooper Basin in South Australia. Oil was encountered in Kincora No. 8 and oil indications were found in Barcoo Junction No. 1 in the Eromanga Basin, in Queensland. Both oil occurrences are to be further evaluated.

The Northwest Shelf natural gas project was officially launched during 1980 with the signing of contracts on 30 September between the Joint Venture partners and the Western Australia State Energy Commission for the supply of 10.9 million cubic metres of gas per day to the State for the next two years. A platform for the North Rankin field development has been ordered from overseas and the initial development of onshore facilities at Withnel Bay has started near Dampier. A major natural gas pipeline is to be contructed from Withnel Bay to Perth. Export contracts for the supply of LNG to Japan were being finalised at the end of 1980.

Nickel

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

Mine production of nickel in ore and concentrates was 74,323 tonnes in 1980. Australia was the fourth largest world producer. Production from Agnew, W.A., mine is being increased to reach 15,000 tonnes per year 'contained nickel' by 1984. Development of Mount Windarra continued in 1980 and a decision was made for the mine to re-open in 1981. The concentrates are toll-smelted at the Kalgoorlie smelter, together with those from Kambalda-St Ives-Nepean and the newly-opened Carnilya Hill mine, a joint venture between Western Mining Corp. Ltd and The Broken Hill Pty Co. Ltd. The Spargoville mine, which opened in 1975, closed early in 1980 with the exhaustion of economic ore reserves.

Mineral sands

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

Considerable expansion from 43,000 to 58,000 tonnes per year has been completed in the Western Australian production capacity for the benefication of ilmenite. Australia is still the world's largest producer and exporter of natural rutile, ilmenite, zircon and monazite by the amalgamation of operating companies, particularly in Western Australia.

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 has set up a pilot plant to treat kimberlite at Ellendale, W.A. Another plant was established at Argyle, W.A., to bulk-test the diamond-bearing alluvials and kimberlite in the Smoke Creek area. A detailed feasibility study is underway on the AKI kimberlite pipe in the Argyle area, with a view to commercial production, possibly by 1985. Production from the smaller but high-grade Smoke Creek alluvials is also planned to begin in the near future.

Uranium

Construction of a metallurgical pilot plant at Kalgoorlie, W.A., to test ore from Yeelirrie, W.A., was completed in 1980.

During the year 1980-81, Mary Kathleen Uranium Limited produced 731 tonnes of uranium as yellow cake and Queensland Mines Limited produced 1,314 tonnes of uranium at Nabarlek.

In September 1980, the Commonwealth Government assigned its interest in the Ranger Uranium Project in the Northern Territory to Energy Resources of Australia Limited for a premium of $125 million plus reimbursement of developmental expenses, interest and incidental charges previously incurred by the Government and the Australian Atomic Energy Commission.

Construction of the processing plant at Ranger was almost complete by June 1981 with the object of operation at designed capacity by October 1981. Preproduction mining operations commenced at the beginning of the 1981 dry season.

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, *Australian Mineral Industry Quarterly* (8403.0). The annual ABS statistical publications, *Census of Mining Establishments, Summary of Operations, Australia (Preliminary)* (8401.0); *Census of Mining Establishments, Details of Operations, by Industry Class, Australia* (8402.0); *Mineral Production, Australia* (8405.0); *Mineral Exploration, Australia* (8407.0) and the irregular publication *Census of Mining Establishments, Industry Concentration Statistics, Australia* (8411.0), contains economic statistics of the industry prepared and published as soon as possible after the data have been compiled. Other current statistics on mining or mine products are contained in the *Monthly Summary of Statistics, Australia* (1304.0), the *Digest of Current Economic Statistics, Australia* (1305.0), and the monthly publication *Production Statistics, Australia* (8302.0). For uranium industry *see* Annual Reports of the Australian Atomic Energy Commission.

BLACK COAL IN AUSTRALIA

(*Source:* Bureau of Mineral Resources, Geology and Geophysics, Australian Mineral Industry Quarterly, 34 (1981).)

M. B. Huleatt

Introduction

Coal was first discovered in Australia in 1791 by an escaped convict near the site of Newcastle. This discovery was followed in 1793 by a report of coal at South Cape, Tasmania; 32 years later, in 1825, black coal was discovered near Wonthaggi, Victoria and in 1824 outcrops were found in the Ipswich district of Queensland. Discoveries at Irwin River, Western Australia and Leigh Creek, South Australia were made in 1846 and 1888, respectively.

Exploration and development

New South Wales

Mining began in 1799 with the collection of coal from outcrops near Newcastle for sale in Sydney, and the first export of Australian coal took place in 1801 when 150 tonnes of Newcastle coal was despatched to India.

Although coal was first discovered very early in the colony's settlement, no attempt at systematic investigation of coal resources was made for 75 years.

From about 1867, government geologists showed increasing interest in coal, and many geological investigations and drilling programs were undertaken. Increasing demand for coal by a growing steel industry and for the production of town gas in the early years of the twentieth century created further interest in exploration, particularly by companies.

A sharp brake was applied to the industry with the onset of the depression in the 1930s and it was not until after World War II that renewed interest was shown in coal as an energy form.

In the late 1940s and early 1950s a vigiorous exploration program was undertaken by the Joint Coal Board with additional investigations by BMR and the Geological Survey of New South Wales. Exploration received a boost in 1957 when the Electricity Commission of New South Wales began exploration and development of coal deposits. Companies had continued active exploration during the 1950s with emphasis on supplying the steel industry's coal requirements.

The most important factor in exploration and development in recent years was the advent of a growing export market in the 1960s and 1970s. Exploration philosophies changed in this time—

attention was turned toward proving reserves in areas known to contain coal and in districts already producing coal. The Geological Survey and the Joint Coal Board concentrated efforts in areas outside allotted exploration leases and colliery holdings, while companies were responsible for exploration within lease boundaries.

Queensland

Although the initial discovery of coal was made in 1824 at Ipswich, the first true mining venture did not commence until 1846 at a location between Ipswich and Brisbane.

Following the discovery of coal at Blair Athol in 1846, interest in exploration grew steadily and government geologists in the latter part of the century concentrated activity in the Bowen Basin of Central Queensland. These investigations mainly took the form of mapping and interpretation of the geology; some drilling was done in the northern Bowen Basin in 1885, but it was only partly successful in delineating new coal reserves.

At the turn of the century attention focused on the Blackwater district where considerable drilling programs were undertaken by the Mammoth Coal Company and the Mount Morgan Gold Mining Co.

The depression years seriously restricted both exploration and mine development and although there were some small developments it was not until the early 1960s that the industry commenced a period of growth, which has continued to the present. As in New South Wales, it was assisted by the rapid growth in export markets, but Queensland coal producers with a limited domestic market and no local steel industry still are heavily dependent on export sales.

Exploration grew rapidly in the late 1950s and has continued at a high rate to the present. The early stages of this exploration resulted in the establishment of mines at Callide, Moura, Kianga, and Blackwater. Subsequent investigations led to the establishment of mines at Goonyella, Peak Downs, and Saraji; more recently, Gregory and Norwich Park mines have come into production.

Queensland coal exploration is now carried out in a pattern very similar to that in New South Wales: the Geological Survey of the Department of Mines undertakes investigations outside allotted exploration leases and colliery holdings, while companies continue exploration within lease boundaries.

Victoria

Black coal was first discovered at Cape Preston in 1825, but it was not until 1908 that drilling by the Department of Mines outlined a deposit at Wonthaggi on which a State coal mine was established.

The competition from brown coal caused a strong shift away from the use of black coal and in 1968 the State mine closed. Smaller mines established at Wonthaggi had closed years before. There are now no operating black coal mines in Victoria.

Tasmania

The first report of coal in Tasmania was in 1793 at South Cape. In the succeeding decades small occurrences were discovered in many places on the east coast and in northern districts, but the most important coalfield was discovered in 1886 at Mount Nicholas.

Mining of coal in the State began near Port Arthur in 1834 but this operation ceased when the penal colony was abandoned in 1877. Although many small operations commenced in the late 1800s and early 1900s only The Cornwall Coal Company's operation near Fingal, which was established soon after the discovery of the Mount Nicholas Field in 1886, has survived.

Scope for development and growth of coal mining in Tasmania has always been restricted because most of the State's electricity is provided by hydro-electric schemes, leaving only relatively small industrial consumers, and for some time railways, to maintain a demand for coal.

South Australia

Black coal was discovered at Leigh Creek in 1888. A shaft was sunk at the site in 1892, but the coal proved to be unsatisfactory for use in railway locomotives and the shaft was abandoned. A further attempt to mine the coal was undertaken in 1906 but it too was abandoned. It was not until 1944, after a series of detailed investigations, that mining began at the Telford open cut at Leigh Creek. The coal was once used by the railways and industry as well as for electricity generation, but now the entire production is consumed at the Port Augusta power station. In 1948 the mining operations came under the control of the Electricity Trust of South Australia.

Exploration in recent years has resulted in discoveries of large but low-quality deposits in the Arckaringa Basin to the west of Lake Eyre.

Western Australia

Black coal was discovered in Western Australia in 1846 at Irwin River southeast of Geraldton, and in 1883 the important Collie deposits were found.

Investigation of the Collie field commenced almost immediately and culminated in the establishment of a mine in 1898. After World War II a systematic survey of the Collie field was undertaken by the Geological Survey of Western Australia with assistance from BMR. This survey delineated the boundary of the deposits and allowed estimates of the reserves to be made.

Coal from Collie was originally used mainly in the State's rail system and to a lesser extent for electricity generation. The development of alumina projects in Western Australia has created a demand for coal, through increased power requirements, which has more than offset that lost as the railways converted to liquid fuel.

Exploration is continuing in various areas of the State, particular interest being shown in the prospective areas around Derby and Eneabba.

Current position

Black coal is mined today in every Australian State except Victoria and the Northern Territory, and exploration is being undertaken in all the States by companies, and in most States by government bodies. Research into the geology, exploration, mining, preparation, and use of coal is funded both by industry and government. Funding by the Federal Government is by way of grants from the National Energy Research Development & Demonstration Council.

Exploration is largely in the hands of private enterprise and almost $47 million was spent by companies in 1979-80 in the search for coal. Of this, just over half was spent in Queensland and 30 percent in New South Wales. Expenditure in 1979-80 was almost twice that of the previous year and almost four times that in 1976-77, indicating the great resurgence of interest in coal as an energy source in recent years. Of the $47 million spent on exploration in 1979-80 only $6 million was spent within the boundaries of existing production leases.

TABLE 1. AUSTRALIAN COAL MINES, 30 JUNE 1980.

	N.S.W.	*Qld*	*S.A.*	*W.A.*	*Tas.*	*Total*
Open-cut	13	19	1	2	..	35
Underground	70	26	..	1	1	98

(*Source:* Joint Coal Board.)

The Joint Coal Board (1981) reported that, at the end of June 1980, there were 133 operational coalmines in Australia distributed as shown above. Of the 133 mines, 98 were underground and 35 open-cut mines. The location of mining areas is shown in Plate 39.

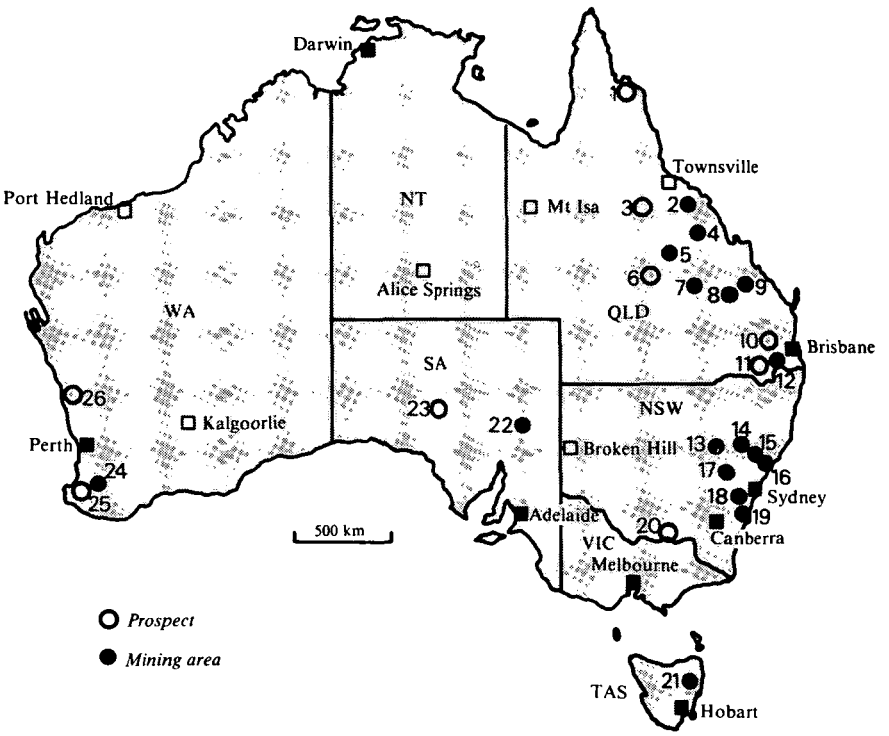
The importance of open-cut mining to the industry is well illustrated by the fact that in 1980 five open-cut mines produced 19.0 million tonnes (Mt) of saleable coal or almost 25 percent of total Australian production. The remaining 128 mines produced a total of 57.3 Mt. It is expected that this trend will be further accentuated when large open-cut mines like Gregory and Norwich Park work up to full capacity.

The five mines referred to are the Goonyella (3.6 Mt saleable coal in 1980), Peak Downs (3.7 Mt), and Saraji (3.9 Mt) operations of Central Queensland Coal Associates (CQCA), the Blackwater mine (3.8 Mt) of Utah Development Co. in Queensland, and the Ravensworth mine (4.0 Mt) operated by Costain Australia Ltd for the Electricity Commission of New South Wales.

Underground mines were the dominant producers of coal until 1974, when, for the first time, almost half the annual production of raw coal was from open-cut mines. Although the proportion of coal won by open-cut methods had been rising for many years a sharp increase occurred in 1972, as new mines in Queensland came on stream and worked up to full capacity. In that year an extra 10.5 Mt of open-cut coal was produced and the open-cut share of production rose from 30 to 40 percent. A similar but smaller increase in open-cut production and a reduction in underground production in 1974 increased the open-cut share of production to almost 50 percent. Since 1975, the relative proportions of underground and open-cut have stabilised, remaining steady at a little more than half for open-cut coal.

Over the last decade New South Wales, Queensland, and Western Australia have produced coal from both underground and open-cut mines. In New South Wales most coal has traditionally come from underground mines and that situation still prevails, although on a raw-coal basis their contribution has fallen from 92 percent in 1970 to 72 percent in 1980. In Queensland the reverse applies: open-cut production has been dominant and is becoming increasingly so. The proportion of total production won by open-cut mining in Queensland has risen from 70 percent in 1970 to 88 percent in 1980. A similar situation prevails in Western Australia where the proportion of production supplied from open-cut mines rose from 61 percent in 1970 to 80 percent in 1980.

The ability of the Australian coal industry to increase coal production in response to increasing demand was based largely on the following factors: the advent and growth of open-cut mines, the advent of mechanised mining, particularly in underground operations, and the existence of large unexploited resources.



1 Laura Basin 2 Bowen District 3 Pentland 4 Mackay District 5 Blair Athol
6 Alpha 7 Blackwater District 8 Kianga-Moura District 9 Callide 10 Tarong
11 Millmerran 12 West Moreton District 13 Ulan 14 Singleton-North West District
15 South Maitland District 16 Newcastle District 17 Western District
18 Burragorang Valley District 19 South Coast District 20 Oaklands 21 Fingal
22 Leigh Creek 23 Lake Phillipson 24 Collie 25 South Perth Basin 26 Eneabba

PLATE 39

Mining methods

Coal mining in Australia was essentially a manual operation until the mid-1930s. Most early mines were dug into coal seams from surface exposures, the coal being recovered by pick and shovel. The coal won was carried or pushed in trolleys to the surface, or to the bottom of a vertical shaft or inclined shaft and then hoisted to the surface. Some burden on the miners was removed with the introduction of pit ponies to haul coal.

Historically most of Australia's coal production has come from underground mines. From pick and shovel operations of limited production, these mines have been transformed by mechanisation to highly sophisticated operations capable of high rates of production. The most important development in underground mining has been the advent of machines for continuous and longwall mining.

Most underground coalmines in Australia use variations of the bord-and-pillar system of mining which, although theoretically capable of recovering all the coal, in practice usually recovers only about 60 percent. Continuous-mining machines are used in the bord-and-pillar system to break and extract coal from the working face, which is about 10 m wide, and load it into shuttle cars for transport.

Longwall mining is not widely used in Australia but its use is expected to increase. While it may be possible to achieve 100 percent coal recovery by longwall techniques it is generally considered that, with good mining conditions, a maximum recovery rate is about 90 percent. The longwall miner shears coal onto a conveyor from a working face 100-200 m wide.

One of the main advantages of the longwall system therefore is that it allows greater recovery than the bord-and-pillar system. To achieve maximum benefit from a longwall unit the coal seam should be of uniform thickness and not have any geological discontinuities, e.g. faults, or intrusions. Continuous miners, on the other hand, are able to mine coal more efficiently from seams affected by such discontinuities.

The introduction of high-capacity mechanised mining has meant that all material in the coal seam at the working face is mined. Consequently any stonebands or other impurities are mined along with the coal. Because it is usually not possible to separate such impurities at the working face, they must be removed later if the coal is to meet specifications.

Coal as mined is referred to as 'raw coal'. Raw coal is crushed and usually washed to remove the impurities. The largest coal preparation plants currently in use are able to process up to 2000 tonnes/hour. The Joint Coal Board reported that at the end of June 1980, coal producers in New South Wales were operating 35 washeries and that two additional plants were in operation at Port Kembla and Newcastle steelworks. In 1979 in Queensland 9 washeries serviced underground mines and 9 open cuts. The only other washery in Australia is a small plant servicing the Duncan mine in Tasmania. Once the coal has been crushed and washed the upgraded product is referred to as 'saleable coal'.

Employment

The black coal industry has always been a large employer, but the level of employment compared to production reflects the impact mechanisation has had on the industry.

In 1930 there was an average of 27,528 people employed in the black coal industry and production was slightly more than 9.5 Mt. By the end of 1980 employment was 27,591, yet production of raw coal for 1980 had risen to 93.4 Mt.

Employment levels in the industry have undergone several long-term fluctuations over the last fifty years, in response to a variety of social, economic, and technological pressures. From the high level in 1930 the Great Depression resulted in numbers falling to slightly less than 21,000 in 1931 and to 17,687 by 1935. From just before to just after World War II the increased demand for coal raised employment to a stable level of about 22,300.

In the late 1940s and the first half of the 1950s the demand for coal continued to rise in response to the post-war reconstruction and development boom. Employment in the industry grew strongly as a consequence, peaking at 27,135 at the end of December 1952 and 27,028 in June 1954.

By 1956 the first impact of oil as a substitute for coal was being felt. Production of coal stagnated in the late 1950s and grew only slowly in the first half of the 1960s. The effect of this slackening in demand and the progress made in mechanisation of mines was dramatic. Employment fell below 20,000 and for most of the 1960s was around 15,000 to 16,000.

The first three years of the 1970s saw some increase, with employment rates of about 18,500. The remainder of the 1970s saw a steady growth in employment. Perhaps the most important factor in bringing on this changed position was the increasing demand for coking coal by the Japanese steel industry. Although the demand for coking coal slackened, the impact of oil crisis of 1973 and the subsequent uncertainty of supplies resulted in renewed demand for thermal coal, which has ensured steady growth in employment.

Production, exports, and consumption

A statistical summary of Australian black coal production and trade since 1951 is given in the following Table 2 and Plate 40.

From 1799, when mining first began, to the end of 1980, over 1,963 Mt of coal was won. Despite some short-term setbacks, as occurred during the depression years of the 1930s, production has increased steadily.

Black coal production statistics are presented as tonnes of raw coal and tonnes of saleable coal. Until 1949 raw and saleable coal were virtually the same, but social, economic, and technical factors since then have resulted in a lowering of the proportion of saleable coal produced from raw coal.

Three distinct phases can be delineated in the production of raw coal since 1951; a slow increase from 1951 to 1959 (average increase 0.34 Mt/year), a faster increase from 1960 to 1967 (1.67 Mt/year), and a still faster increase from 1968 to 1980 (3.91 Mt/year). The second and third phases both reflect increased demand from the international market. The corresponding growth figures for saleable coal are lower, reflecting the increased tonnage of mined coal being discarded as washery reject material. The average growth was 0.22, 1.36, and 2.95 Mt/year for each phase. Strikes in 1980 adversely affected production; otherwise the third-phase averages would have been higher.

Accelerated growth of production in 1960–67 can be attributed to increased demand for coking coal from the Japanese steel industry, but for 1968–80 the situation is more complex. Until the early 1970s, increased demand for coking coal for steel production, particularly in Japan, continued to be the main factor. The effect of a faltering in the rate of growth of world steel production in the mid-1970s was offset by increasing demands for thermal coal and diversification of markets for coking coal. Demand for thermal coal was the direct result of the 1973 quadrupling of oil prices, causing many countries and energy-intensive industries to turn from oil to coal.

Exports of black coal have increased consistently from 1960 to the present. From 100,000 tonnes exported in 1951, exports grew slowly to 795,000 tonnes in 1959. For 1960 the figure was 1.6 Mt, valued at $13 million, and for 1980 it was over 42 Mt, valued at $1,684 million. Although the relative importance of Japan as a market for Australian coal has declined in recent years, in 1980 that country still took over 69 percent (29.3 Mt) of the coal exported from Australia. The Republic of Korea and Taiwan Province were the next most important customers, taking 5.7 percent (2.5 Mt) and 4.4 percent (1.9 Mt) respectively.

Though the growth in Australia's consumption since 1962 has been consistent, it has not matched the growth in exports. Exports have increased to over 420 times their 1951 level, but domestic consumption has only doubled in the same period, rising from 17.6 Mt in 1951 to 36.4 Mt in 1980. It was not until 1973 that the tonnage exported surpassed the tonnage consumed in Australia.

The electricity-generating industry is by far the largest consumer of coal in Australia. In 1980 it accounted for 67 percent of all coal used whereas the iron and steel industry accounted for only 22 percent. The equivalent figures for 1970 are: electricity generation 51 percent, and iron and steel industry 32 per cent. New South Wales, the major consuming State, used over 23 Mt (64 percent) of all coal consumed in Australia in 1980, most of it for electricity generation.

It is expected that domestic consumption will continue to increase, but the growth rate will be dependent to a large extent on developments in the aluminium-smelting and cokemaking industries.

TABLE 2. BLACK COAL IN AUSTRALIA: PRINCIPAL STATISTICS
('000 tonnes)

Year	*Production*		*Saleable Raw (per cent)*	*Saleable domestic consumption*	*Exports*	*Imports*	*Stocks at year end*
	Raw	*Saleable*					
1951	17,900	17,859	99.8	17,611	100	350	2,020
1952	19,720	19,665	99.7	17,896	205	283	3,869
1953	18,718	18,591	99.3	18,484	367	17	3,624
1954	20,069	19,835	98.8	19,240	364	3	3,859
1955	19,605	19,362	98.8	18,940	216	4	4,061
1956	19,578	19,322	98.7	18,773	282	5	4,346
1957	20,197	19,804	98.1	18,955	768	9	4,461
1958	20,852	20,140	96.6	18,807	822	6	4,971
1959	20,943	19,820	94.6	19,962	795	8	4,034
1960	23,350	21,917	93.9	20,107	1,602	5	4,233
1961	24,924	23,179	93.0	19,929	2,896	8	4,633
1962	25,374	23,501	92.6	20,210	2,956	7	4,922
1963	25,908	23,835	92.0	20,488	3,226	10	5,028
1964	28,718	26,276	91.5	21,880	4,883	11	4,612
1965	32,944	30,086	91.3	22,811	7,271	11	4,803
1966	35,111	31,657	90.2	22,504	8,373	13	5,307
1967	36,676	32,822	89.5	23,667	9,550	8	5,087
1968	42,568	37,917	89.1	24,429	12,291	9	5,995
1969	48,154	42,572	88.4	25,265	16,039	12	6,977
1970	52,350	45,407	86.7	25,141	18,296	10	8,847
1971	52,423	44,077	84.1	25,327	20,178	18	6,661
1972	65,537	54,647	83.4	26,608	23,511	9	10,834
1973	67,858	55,598	81.9	27,292	28,434	11	10,875
1974	70,435	57,943	82.3	29,019	29,440	15	10,454
1975	74,784	60,944	81.5	29,591	30,428	6	11,697
1976	84,224	68,198	81.0	31,327	32,917	11	14,037
1977	87,321	70,809	81.1	32,087	36,427	3	16,544
1978	89,345	71,831	80.4	32,967	38,095	23	16,830
1979	93,043	74,993	80.6	34,875	41,050	16	16,317
1980	93,406	76,304	81.7	36,381	42,284	2	13,623

Source: Joint Coal Board, Bureau of Mineral Resources.

Resources

Australia's demonstrated economic resources of black coal are 50.4 x 10^9 tonnes in situ. Of this total only 28.7 x 10^9 tonnes is regarded as being recoverable with currently available technology and prevailing economic and social constraints. Queensland and New South Wales together have over 98 percent of the country's in situ demonstrated economic resources. An outline of Australia's demonstrated economic resources is given in Table 3.

As a result of renewed interest in coal as an energy source in recent years and the consequent increase in exploration, the level of demonstrated economic resources has increased substantially. From 34.7 x 10^9 tonnes in 1975 it rose to 50.4 x 10^9 in 1980. It is relevant to note that this increase (15.7 x 10^9 tonnes) is 30 times larger than the total amount of coal mined in that period (0.522 x 10^9 tonnes).

PRODUCTION, CONSUMPTION, EXPORTS AND STOCKS OF BLACK COAL IN AUSTRALIA, 1951 TO 1980

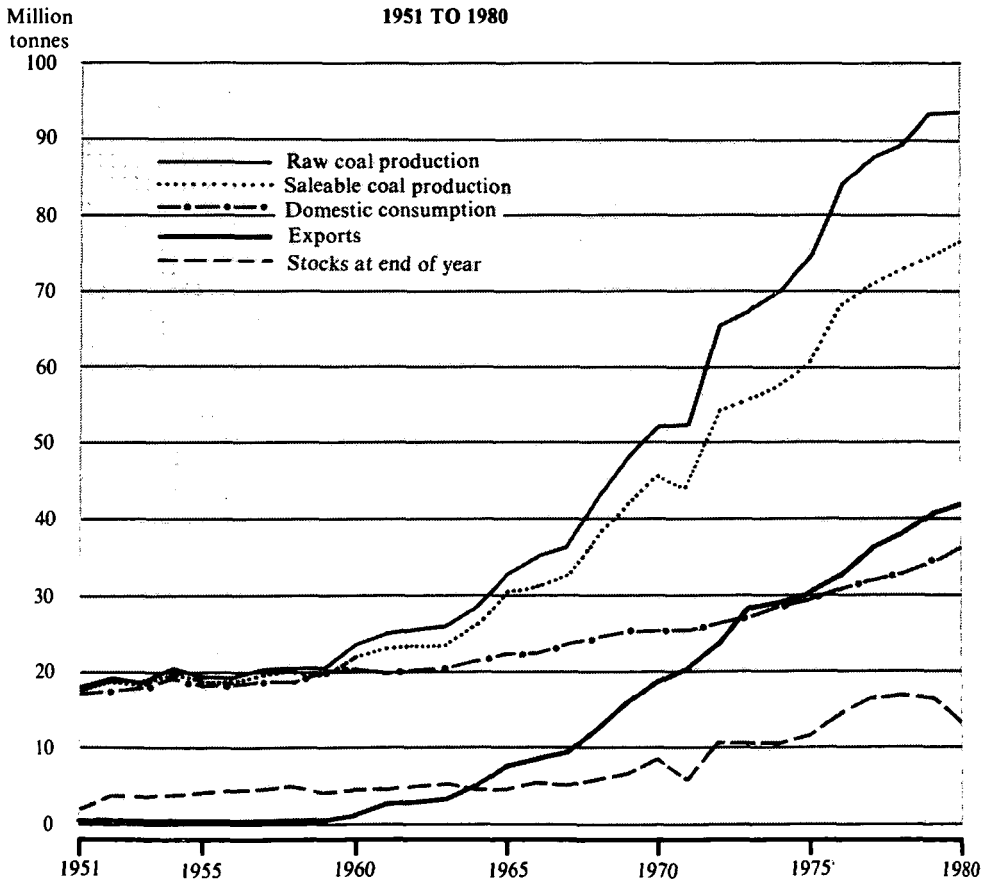


PLATE 40

TABLE 3. AUSTRALIAN DEMONSTRATED RESOURCES OF BLACK COAL
(million tonnes)

	In situ	*Recoverable*
New South Wales		
Sydney Basin	21,234	11,001
Gunnedah Basin	972	637
Gloucester Basin	36	33
Oaklands Basin	500	450
Ashford	1	1
	22,743	*12,122*
Queensland		
Bowen Basin	22,678	12,854
Galilee Basin	800	450
Ipswich Basin	490	245
Tarong Basin	280	241
Callide Basin	205	142
Mulgildie Basin	15	7
Surat-Moreton Basin	2,428	2,118
Styx Basin	4	2
	26,900	*16,059*
Western Australia		
Collie	496	362
Tasmania	139	69
South Australia	120	120
Grand total	**50,398**	**28,732**

Source: Joint Coal Board, Queensland Department of Mines.

Resources currently less well known geologically ('inferred resources') total 477 x 10^9 tonnes, of which 273 x 10^9 tonnes is considered to be recoverable. Any coal deposit included in this category requires further testing by drilling, etc., before it can be classified as a demonstrated resource.

Thus Australia's total demonstrated-plus-inferred resources are 527 x 10^9 tonnes, of which just over 9 percent is demonstrated. The fact that there is detailed information available on such a small proportion of Australia's resources suggests that it is most important that exploration continue at a rate at least equivalent to that achieved in recent years. This point becomes all the more significant when the projected growth in both exports and domestic consumption is considered.

Over half the currently known inferred resources are in the Sydney Basin; however, very little work has been done on the estimation of inferred resources outside New South Wales. Although no concerted attempt has been made to estimate Queensland's inferred resources it is most probable that they would at least equal those of New South Wales.

The Bowen and Sydney Basins are the main regions which inferred resources will be upgraded to demonstrated resources. There are, however, other regions in most States that have the potential to contain considerable tonnages of demonstrated resources. In Queensland, outside the basins from which coal is currently being mined, the most prospective area is the Galilee Basin. The Queensland Department of Mines (1981) reports the quantity of demonstrated resources in the Galilee Basin as 800 Mt, located near the township of Alpha. Substantial but unquantified resources occur in the basin several hundred kilometres further north near Hughenden. Despite the remoteness of the Galilee Basin in comparison with the Bowen Basin, future exploration will almost certainly add considerable tonnages to Australia's demonstrated economic resources.

In South Australia the most prospective area for increasing the level of demonstrated resources is the Arckaringa Basin, although it is unlikely that this coal will be economically recoverable in the near future. The Department of Mines & Energy (1980) reported demonstrated resources of 600 Mt, with considerably larger inferred resources. Continuing private exploration has suggested that substantial tonnages occur to the north of the presently known Lake Phillipson deposit.

Considerable exploration has been carried out in Western Australia, and the prospects for increasing the State's demonstrated resources are good. There is a strong possiblity that any coal discovered in these areas may not be economically recoverable in the near future. Both the northern and southern parts of the Perth Basin appear to have good prospects for the proving of deposits. Encouraging intersections of coal have been encountered in drillholes in the Canning Basin in the Derby region and further exploration could well delineate substantial deposits at these locations.

Coal occurrences are widespread in Tasmania, but in many areas of interest exploration and exploitation are hindered by the coal's being covered by hard igneous rocks. Recent exploration has indicated that the delineation of small but locally significant deposits will add considerably to Tasmania's demonstrated economic resources.

The areas discussed above are those considered most likely to have inferred resources upgraded to demonstrated economic or sub-economic resources in the next decade.

In addition to the demonstrated economic and inferred resources Australia has substantial but generally not well delineated resources of deeply buried coal. Included in this category is 130 x 10^9 tonnes in the Sydney Basin, and the South Australian Department of Mines & Energy (1980) have noted the presence of as much as 3000 x 10^9 tonnes between 1,400 and 4,000 m deep in the Cooper and Pedirka Basins. Although there is no prospect of these resources being utlilised in the foreseeable future those in New South Wales may ultimately be recovered by underground mining. The deep resources in the Cooper and Pedirka Basins, towards the centre of the continent, will probably only ever be utilised if adequate technologies are developed for *in-situ* processing such as gasification.

Australia's coal industry in the world context

Australia was the world's ninth-largest producer of black coal in 1980, with about 3 percent of total world production of saleable coal. Of the coal traded internationally in 1980 Australia provided 42.3 Mt, making it the second-largest exporter after USA (Table 4).

Most of Australia's strength in the international coal trade is derived from its ability to produce far more coal than is required for domestic consumption. In 1980 Australia was able to export 55 percent of total saleable production. The only other country able to achieve a percentage close to this level was Canada with 49 percent, but it must be remembered that Canada also imports large tonnages of coal.

On estimates currently available Australia has 4 percent of the world's in-situ demonstrated economic resources and 6 percent of the world's recoverable demonstrated economic resources. However, very large inferred resources, which ultimately are likely to be economically mineable, are known to occur in both Queensland and New South Wales.

Technology

The increasing cost and potential shortage of petroleum will, in the future, result in greater demand for coal. Interest has been growing in the re-introduction of coal-fired ships in place of oil-fuelled ones. The first step in this direction has already been taken with an order for the construction of two coal-fired bulk carriers for use in the Australian coastal alumina trade.

TABLE 4. WORLD PRODUCTION AND EXPORTS OF BLACK COAL IN 1980

	Production (Mt, Saleable coal)	*Exports (Mt)*	*Exports / Production (percentage)*
Australia	76.4	42.3	55
Canada	30.8	15.0	49
China	663.0	–	–
Germany, F.R.	94.5	12.6	13
India	107.5	–	–
Poland	193.1	30.4	16
South Africa	115.1	29.2	25
UK	128.2	–	–
USA	723.6	82.3	11
USSR	519.0	n.a.	–
Australia's ranking	9	2	1

Expanded use of coal may also be expected in the manufcture of bricks and cement and in the fuelling of boilers previously operated with oil.

Possibly the most important innovation will be the development of a commercially viable fluidised-bed combustion system. This method of combustion can not only burn normal coal fuels efficiently but can also use lower-grade coals and much of the reject material discarded from coal washeries.

A very large additional tonnage of coal, both black and brown, will be required if commercial plants for coverting coal to liquid fuels are set up in Australia. It has already been decided to establish pilot plants and undertake further feasibility studies of the production of liquid fuels from brown coal. Black coal is less certain to be used because it will face strong competition from oil shale as a source of liquid fuels.

The future

The Australian black coal industry is experiencing a period of sustained growth that appears certain to continue for many years. Stimulus for this growth is being provided by increasing demand for thermal coal from overseas buyers.

The actual level of production, consumption, and exports that will be achieved at any particular time in the future is arguable. Projections made by authoritative organisations usually differ, but they all agree that growth will be strong. A summary of some forecasts is given in the following table.

TABLE 5. FORECAST 1990 EXPORTS AND DOMESTIC CONSUMPTION OF AUSTRALIAN BLACK COAL (Mt)

	Exports			*Domestic consumption*		
	Thermal	*Coking*	*Total*	*Thermal*	*Coking*	*Total*
Department of National Development & Energy (1981)	70	60	130	–	–	–
Department of Trade & Resources (1981)	50-70	50-60	100-130	–	–	–
World Coal Study (1980)	42	68	110	64(*c*)	12(*c*)	76
Joint Coal Board (1980) (*a*)	57-100	58-80	115-180	57.3-75.3	16.7-22.7	74-98
BMR (*b*)	55	60	115	48	12	60
Actual 1980	8.9	23.3	42.2	28.1	8.2	36.3

(*a*) Joint Coal Board figures are estimates of demand rather than forecasts of actual exports or consumption. (*b*) Refer to text for discussion of Bureau of Mineral Resources estimates. (*c*) Estimates derived from World Coal Study (WOCOL) Report.

Exports

The BMR export projections have been made on the assumptions that markets will be available, that satisfactory prices will be negotiated, and that Australian infrastructure, availability of suitable personnel, and industrial relations will allow demand to be met. Although it is acknowledged that each of these factors may have a significant influence on the industry, it is not within the scope of this paper to discuss them; however, it is considered most likely that any difficulties that may arise will be resolved without serious long-term impact on the industry.

BMR's estimates of thermal and coking coal exports are based on categorisation of product by potential producers. While this does not influence the total export projection it does introduce an uncertainty into the individual product estimates. In view of the prevailing conditions in the world steel industries and the increasing demand for thermal coal, it is expected that some poorer coking coals will in fact be exported as thermal coals. Projected export for 1990 are 66 Mt of nominal coking coal and 49 Mt of nominal thermal coal. It is considered that up to 6 Mt of coking coal may in fact be used as thermal coal in 1990, and the export estimates by BMR shown in the previous table have been adjusted accordingly.

Should the current world oil supply and price situation deteriorate, the demand for thermal coal will increase. Alternatively, even if the position should improve, the difficulties and uncertainties in relation to oil created in the 1970s may act against any concerted move back to oil, although some plans to convert from oil to coal firing, particularly in older plants, may be cancelled.

Domestic consumption

Growth in domestic consumption is expected to be considerably slower than in exports. However, it too will be dominated by increased thermal coal use.

The BMR forecast presented here for thermal coal consumption is substantially less than the other estimates shown in the previous table. The reason for this is that the demand as a result of expansion in the aluminium industry is now expected to be less than was previously thought, and growth in other areas will not be sufficient to offset this loss.

The estimates for 1990 exclude any coal that may be used in the production of liquid fuels, because it is considered most unlikely that any significant tonnage will be so utilised by that year. Further, before any commitment is made to commercial coal conversion careful consideration must be given to the question whether that process is an optimum use of Australia's coal resources, particularly in view of the country's large resources of oil shale.

Adequacy of resources

All the forecasts presented in Table 5 suggest strong growth in the Australian coal industry over the next decade. The extent and level of knowledge of Australia's coal resources have been discussed above. The adequacy of those resources to meet the projected growth in the industry must also be considered.

The following discussion on the adequacy of resources must be based on projected raw coal production. For this reason the projections in the previous table, which are for saleable or disposable coal, are converted to raw coal equivalents according to the recovery rate prevailing in 1980 of 82 per cent.

Production between now and 1990 will probably be in the order of 1,300 Mt of raw coal. This demand would reduce today's recoverable demonstrated economic resources to 27,432 Mt. Converting the projections given in the previous table to raw coal, using the 1980 average recovery, one may calculate the life of the demonstrated economic resources as follows: for BMR projections, 129 years; for World Coal projections, 121 years and for Joint Coal Board, 119 years (low projection) or 81 years (high projection).

These figures are based on 1981 recoverable demonstrated economic resources an assume no growth in demand after 1990 and no technological changes that would allow increased recovery of coal. Exploration in the next decade will of course continue to elevate inferred and newly discovered resources into the 'demonstrated economic' category and demand after 1990 will most likely continue to grow. The extent to which addition to resources will outstrip increased use or vice versa is unknown, although the situation should be kept in perspective by noting that between 1975 and 1980 some 522 Mt of raw coal was mined while over 15,500 Mt was added to *in situ* demonstrated economic resources. Consequently, I would suggest that the resource life projections above are minima. However, these figures do not account for possible use of coal for synfuel production. If a decision is taken to use black coal as a feedstock for production of liquid fuels, consumption is going to increase greatly, putting additional strain on the resource.

On the basis it would appear that our present knowledge of Australia's demonstrated black coal resources may be adequate for medium-term use and planning. For longer-term planning and use, i.e. beyong 20-30 years, considerably more exploration and testing is necessary. The fact that 477,000 Mt of resources is categorised as 'inferred' means that, while such resources may well exist in the tonnages estimated at present, we do not know enough about them to determine if they can be mined economically or if the quality is acceptable to consumers.

A combination of many factors will ultimately determine the rate of growth of the Australian coal industry. Perhaps the greatest obstacle to achieving the projected growth rates might be the failure to customers to commit themselves to purchase coal in sufficient time to allow financing and all associated works at mines and ports to be completed. Within Australia obstacles to be overcome will include transport and port facilities of adequate capacity to handle the projected tonnages. Less obvious but of equal importance is the question of availability of trained manpower including miners, mining engineers, and geologists. Continued effort is required to upgrade our knowledge of the coal presently included in the 'inferred resources' category, and to quantify resources about which little is presently known. Despite these reservations, the Australian coal industry seems assured of a bright future.

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