

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 throughout Australia, their geological age ranging from Precambrian to Recent. Many of the large deposits such as those at Broken Hill (N.S.W.), Mount Isa (Qld), the Kalgoorlie and Pilbara regions of W.A. and the Alligator Rivers area of N.T. are Precambrian in age. In eastern Australia the major deposits such as the Elura, Cobar, Woodlawn and Rosebery base-metal deposits and most of the black coal deposits, are Palaeozoic in age. The black coals of the Moreton district of Queensland, northeast New South Wales and Leigh Creek, S.A. are of Mesozoic age. Deposits formed in Tertiary times include the brown coal in Victoria, the bauxites of Weipa (Qld), Gove (N.T.) and the Darling Range (W.A.) and the nickeliferous laterites at Greenvale (Qld).

Mineral resources

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

For further details of principal Australian mineral deposits, and notes on principal mineral resources, see Year Book No. 61, pages 925-932 and the Australian Mineral Industry Quarterly and Annual Reviews.

Administration

All mineral rights in Australia are vested in the Crown except those on land which was granted before the Crown began to reserve mineral rights. In practice, these private mineral rights are 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 and proclaimed on 14 February 1983, provide 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 are 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 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. The offshore constitutional settlement and the operation of Commonwealth and State offshore petroleum legislation are being reviewed by the Commonwealth Government. Decisions on the outcome of the review and details of any changes are expected to be known in 1984.

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)

	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82
New South Wales(a)	46,354	49,062	35,651	86,797	116,923	87,915
Victoria(b)(c)	32,696	48,446	60,111	90,554	118,611	108,782
Queensland(a)	50,842	53,651	53,679	73,522	73,329	81,430
South Australia	3,346	4,106	4,541	5,869	7,312	8,810
Western Australia	51,638	54,519	57,810	66,712	78,341	81,330
Tasmania	1,496	2,093	2,193	5,261	3,557	2,209
Northern Territory(d)	362	277	1,256	2,549	5,666	3,020
Commonwealth Government(c)	13,805	23,002	28,031	43,337	54,567	52,321
Total	200,539	235,156	243,272	374,601	458,306	425,817

(a) Includes royalties on sand and gravel from Crown lands. (b) Includes royalties on brown coal paid by State Electricity Commission. (c) Includes royalties received under the *Petroleum (Submerged Lands) (Royalty) Act 1967-68*. (d) Excludes the mining royalties paid into Aboriginal Benefits trust fund prior to 1978-79.

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 minerals and metals are prohibited unless permission is granted by the Minister for Trade 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, uranium, monazite and materials of nuclear significance. Controls on tin are applied in respect of Australia's obligations under the International Tin Agreement.

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.

Exporters of common salt in bulk and of ores, concentrates, matte and oxides of nickel, lead, zinc, copper, manganese, tungsten, and blister and refined copper and lead bullion are given automatic approval to export, on application, to cover expected shipments over a 12 month period. 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.

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) as well as through the National Energy Research, Development and Demonstration Program.

Income taxation concessions as at 30 June 1983. 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 exploration for and development 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 ten years, whichever is less on a straight line basis.

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

The allowable capital expenditure of a general mining enterprise, other than costs of exploration, may be deducted against income from any source over the life of the mine, or over ten years, whichever is the lesser on a straight line basis. Expenditure incurred by a 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 Commissioner of Taxation in respect of the moneys subscribed. By lodging those declarations, certifying that the capital subscriptions have been, or will be, spent on eligible outgoings within a specified period, the petroleum mining companies forgo deductions to which they might otherwise be entitled for capital expenditure.

Payments to producers and importers of phosphate fertilizers. The *Phosphate Fertilizers Subsidy Act 1963* provides for a subsidy to be paid on phosphatic substances produced in Australia or imported and sold for use in Australia as a fertilizer. Phosphatic substances used as a supplement to stock food are also regarded as being used as a fertilizer. Subsidy 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, subsidy 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 fertilizers (primary producers). The Act expires on 30 June 1985.

Payments to producers and importers of nitrogenous fertilizers. The *Nitrogenous Fertilizers Subsidy Act 1966* provides for a subsidy to be paid on inorganic nitrogenous substances produced in Australia or imported and sold for use in Australia as a fertilizer. Nitrogenous substances used as a supplement to stock food are also regarded as being used as a fertilizer. Subsidy is payable at the rate of \$20 per tonne of the nitrogen content of which the goods consist. The intention of the Act is to assist consumers of nitrogenous fertilizers (primary producers). The Act expires on 30 June 1985.

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 Resources 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 Resources and Energy with the advice of the BMR.

At 30 September 1983, 507 officers were employed at the BMR, this included 147 professional officers (geologists, geophysicists, chemists, engineers and mineral economists) and 61 research scientists.

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 Minerals and Petroleum Branches and a Uranium Resource Evaluation Unit. Other branches are Planning and Programs, Special Projects and Geoscience Services, and a Geoscience Database Branch is proposed.

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

State Government assistance

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

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

A wide range of services, information and advice is provided on many subjects including geological and geophysical investigations, scientific and chemical research, geological and metallogenic mapping, prospecting, mining legislation and administrative procedures. The Geological and Mining Museum, one of the States's foremost specialist museums, is maintained by the Department, as is the reference library of geology, mining and allied topics situated at the Department's head office and Bore Core Library situated at Londonderry, near Penrith.

The Department is engaged in the continuous assessment of the State's mineral resources; its coal exploration and assessment programme in particular has identified many coal deposits of high commercial promise.

Victoria. The Department of Minerals and Energy advises on, monitors, co-ordinates and implements energy policy. The Department conducts geological, groundwater and mineral surveys, produces geological maps, and issues scientific and technical reports thereon. Drilling operations are carried out and the results are used in sedimentary basin studies 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 are regulated and controlled. Also that 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.

Queensland. The Department of Mines regulates, encourages and assists the search for and development of mineral resources, including petroleum, working through a system of authorities, leases and licenses issued under Acts of Parliament.

The Department provides assistance to mining by way of grants for construction and maintenance of roads in mining areas, repayable advances or subsidies for mine development, hiring of equipment, assistance to prospectors and geological services. Detailed information is collated from in-house geological studies and seismic surveys and continuous scientific appraisal of results achieved and reported by commercial exploration groups. The information effort is underpinned by a Departmental drilling program focusing on coal and mineral exploration and deep stratigraphic drilling.

The Department carries out a continuous inspection on mine safety and provides an expert technical advisory service to mining organisations. Other activities include research on mine safety and health and the administration of safety regulations on gas installations and storage of explosives. Additionally, the Department maintains an Assay Office at Cloncurry, a District Geologist's Office at Charters Towers and has Inspectors of Mines, both metalliferous and coal, stationed at various major centres throughout 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. The Western Australian Department of Mines operates fifteen State Batteries throughout the goldfields, for the treatment of ore (principally gold) from prospectors and small mine owners, at a nominal charge. Through its Geological Survey Division, the Mines Department carries out geological investigations and surveys throughout the State. The results of this work are made available in both map and report format. The Government Chemical Laboratories Branch of the Mines Department provides analytical and research services to the mining and mineral exploration industry.

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 encourages the development of an efficient mining and processing industry. Through six divisions the Department administers relevant legislation and provides a wide range of services.

The N.T. Geological Survey Division elucidates the regional geology and geophysics of the Territory, researches new mapping, geological survey and mineral search techniques and provides technical information through its computer indexes at Darwin and Alice Springs.

Registration and orderly administration of mineral and petroleum tenure, and provision of essential drafting services fall within the ambit of the Policy and Administration Division.

Mines Division has primary responsibility for the development of policy and legislation relating to exploration and mining industries. The Division also has regulatory responsibility in the fields of occupational hygiene, mine safety and environment protection to ensure the efficient, orderly and safe recovery and utilisation of the Territory's mineral resources. A range of services including technical and financial are also provided to prospectors.

Energy Division has primary responsibility for policy development, and advice to Government, on all energy matters. Its regulatory function in the petroleum exploration and development area is administered from Darwin and Alice Springs.

The Industrial Safety Division provides inspectorial, training and advisory safety services in the fields of construction safety, dangerous goods and machinery safety. These services are provided from the division's offices at Darwin, Alice Springs, Tennant Creek and Katherine.

Resource Economics Division provides advice to the Government on special projects and provides a consultancy service to other Divisions.

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). Operations are based in Adelaide with branch laboratories in Perth, Melbourne and Townsville. 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, 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, below).

Subjects of current research are ore genesis investigations; Geological research is coordinated with the field research programs of the Bureau of Mineral Resources, Geology and Geophysics.

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 carries out programs in:

- Fossil Fuels: including their origin and distribution in space and time; onshore sedimentary basin analysis; geophysical investigations of the structure of onshore basins; framework studies of Australian offshore areas; and modern marine processes.
- Minerals: including the origin and distribution in space and time; metallogenic provinces; the weathered zone; and related resources; airborne geophysical mapping and interpretation; crustal geophysics; and the origin and distribution of offshore mineral deposits.
- Groundwater, basin hydrogeology; and fractured rock hydrogeology.
- Earthquake hazards.
- National and international geoscience maps.
- Overseas programs: including land geoscience in south east Asia; marine geosciences in the Southwest Pacific; geoscientific co-operation with China; and Antarctica.
- Petroleum and mineral resource assessment.
- National geoscience data base.

Commonwealth Scientific and Industrial Research Organization

Minerals Research

Minerals 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 improving methods of locating, evaluating, defining and characterising Australia's mineral resources and of planning their recovery, development and effective use consistent with the minimization of environmental stresses. Divisions of the Institute engaged in mineral research are the Division of Geomechanics at Syndal (Vic.); the Division of Fossil Fuels at North Ryde (N.S.W.); the Division of Mineral Chemistry at Port Melbourne (Vic.); the Division of Mineral Engineering at Clayton (Vic.); the Division of 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 Resources and Energy

The functions of the National Coal Research Advisory Committee which was established in 1964 have been incorporated into the National Energy Research, Development and Demonstration Council (NERDDC) which is administered by the Department of Resources and Energy. For details of NERDDC, which advises the Minister for Resources 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 covering geology, ore genesis and exploration techniques, mining and rock mechanics, mineral processing, ecology, energy, analytical methods and miscellaneous other items.

International relations

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

International Tin Agreement

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

The objectives and provisions of the present (Sixth) Agreement are broadly similar to those of 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. The Sixth Agreement provides for a larger buffer stock than in the previous Agreements of up to 50,000 tonnes of tin metal. For the first time, financing of the buffer stock is to be shared equally between producers and consumers. In the event of persistent market disequilibrium through causes beyond the control of the buffer stock mechanism, the agreement 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, Indonesia, Malaysia, Nigeria, Thailand, Zaire; *Consumers*—Belgium-Luxembourg, Canada, Denmark, Finland, France, Germany (Federal Republic of), Greece, India, Ireland (Republic of), Italy, Japan, Netherlands, Norway, Poland, Sweden, Switzerland, United Kingdom and Yugoslavia. The producing countries hold a total of 1,000 votes, distributed so that each country receives five initial votes and an additional number corresponding to its percentage as laid down by the Agreement. The consuming countries hold a total of 1,000 votes also distributed so that each country receives five initial votes and an additional number proportionate to quantities consumed. The allocation of votes in each category is periodically reviewed.

International Lead-Zinc Study Group

With the cessation of stockpile buying of lead and zinc by the United States Government in 1958, world producers were faced with the prospect of a serious imbalance between world supply and demand for these metals. To meet this problem, a series of meetings of interested governments was held at which Australia was represented. These meetings culminated in the formation of the International Lead-Zinc Study Group which was established in January 1960. The Study Group comprises the following Governments: Algeria, 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.

Association of Iron Ore Exporting Countries (APEF)

Australia is a founder member of the Association of Iron Ore Exporting Countries (APEF). The other members of the Association are 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, 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. The Association's work is mostly concerned with exchanging views and information on a range of industry matters. The commercial and technical aspects of formulating minimum export prices for bauxite and alumina have received particular attention. In November 1982 the Council adopted recommendations on minimum CIF prices for bauxite and alumina sold by member countries in 1983. Australia was not included in the majority that voted for the recommendations and is not bound by them. The Association publishes a Quarterly Review.

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 1980-81 and were published in *Enterprise Statistics: Details by Industry Class, Australia, 1980-81* (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 1979-80 and 1980-81 censuses and surveys are given in Chapter 17.

The following table shows key items of data for establishments in Australia for 1981-82 based on the 1978 edition of the *Australian Standard Industrial Classification* (ASIC).

MINING ESTABLISHMENTS: SUMMARY OF OPERATIONS BY INDUSTRY CLASS, 1981-82

Industry ASIC code	Description	Establish- ments at 30 June	Average employment over whole year(a)			Wages and salaries (b)	Stocks			Total pur- chases, transfers in and selected expenses	Fixed capital expendi- ture less Value added disposals
			Males	Females	Persons		Turnover	Opening	Closing		
		No.	No.	No.	No.	\$'000	\$'000	\$'000	\$'000	\$'000	\$'000
	Metallic minerals										
	Ferrous metal ores										
1111	Iron ores	23	7,563	1,139	8,702	211,698	1,379,249	186,750	209,283	735,268	666,514
1112	Iron ore pelletising . . .	2	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
	Non-ferrous metal ores										
1121	Bauxite	6	1,853	245	2,098	46,688	292,583	19,700	22,429	69,880	225,432
1122	Copper ores	10	4,059	300	4,359	92,951	239,967	52,249	51,416	130,190	108,944
1123	Gold ores	70	2,622	149	2,771	55,318	213,148	35,604	52,126	112,137	117,533
1124	Mineral sands	16	1,562	127	1,689	31,253	160,083	48,540	53,475	81,045	83,973
1125	Nickel ores	5	2,514	245	2,759	74,313	278,925	32,730	32,199	106,935	171,459
1126	Silver-lead-zinc ores . . .	13	6,828	389	7,217	147,459	610,496	105,781	99,718	226,424	378,009
1127	Tin ores	77	1,905	150	2,055	34,774	136,937	20,218	23,219	60,283	79,655
1128	Uranium ores	3	839	133	972	22,964	236,035	51,271	102,831	54,109	233,486
1129	Non-ferrous metal ores n.e.c.	11	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.	n.p.
11	Total metallic minerals . . .	236	31,607	3,093	34,700	754,569	3,791,533	610,550	698,601	1,712,750	2,166,833
	Coal, oil and gas										
1201	Black coal	128	30,948	830	31,778	848,620	3,445,802	309,863	468,627	1,390,676	2,213,890
1202	Brown coal	4	4,439	404	4,843	121,857	2,096,193	66,875	84,572	239,947	1,873,943
1300	Oil and gas	15									
	Construction materials										
1401	Sand and gravel	347	1,732	207	1,939	31,475	218,198	11,635	14,299	105,265	115,597
1404	Construction materials n.e.c. .	450	3,965	400	4,365	75,452	427,895	36,141	43,434	206,488	228,700
14	Total construction materials . .	797	5,697	607	6,304	106,927	646,093	47,776	57,733	311,753	344,297
	Other non-metallic minerals—										
1501	Limestone	55	767	15	782	14,984	61,491	11,667	13,546	33,306	30,065
1502	Clays	112	294	31	325	4,073	31,135	3,794	4,418	19,126	12,633
1504	Salt	20	620	89	709	14,932	56,974	12,768	13,809	18,363	39,651
1505	Non-metallic minerals n.e.c. . .	123	822	101	923	15,485	88,164	17,187	13,584	49,820	34,740
15	Total other non-metallic minerals	310	2,503	236	2,739	49,473	237,763	45,416	45,357	120,615	117,088
	Total mining (excl. services to mining) . . .	1,490	75,194	5,170	80,364	1,881,446	10,217,383	1,080,480	1,354,888	3,775,741	6,716,050

(a) Includes working proprietors.

(b) Excludes amounts drawn by working proprietors.

Mineral production

This section contains details of the output (quantity and value) of principal 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 Resources 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 principal minerals produced and contents of principal metallic minerals produced during 1981-82 and earlier years. Further data are available relative to all minerals in the annual publication *Mineral Production, Australia* (8405.0)

QUANTITY OF PRINCIPAL MINERALS PRODUCED

<i>Mineral</i>		<i>1979-80</i>	<i>1980-81</i>	<i>1981-82</i>
METALLIC MINERALS				
Bauxite	'000 tonnes	27,629	25,450	24,690
Copper concentrate	"	812	866	905
Gold bullion(a)	kg	16,805	13,806	21,008
Iron ore	'000 tonnes	96,998	93,754	86,786
Lead concentrate	"	654	622	704
Lead-copper concentrate	tonnes	24,185	22,328	31,999
Manganese ore—				
Metallurgical grade	'000 tonnes	2,173	1,485	1,198
Mineral sands—				
Ilmenite concentrate(b)	"	1,336	1,259	1,238
Rutile concentrate	"	301	273	220
Zircon concentrate	"	447	461	459
Nickel concentrate	"	347	404	423
Tantalite-columbite concentrate	tonnes	166	235	263
Tin concentrates	"	23,083	24,204	24,604
Tungsten concentrates—				
Scheelite concentrate	"	3,864	3,800	3,364
Wolfram concentrate	"	2,411	2,463	2,017
Uranium concentrate	"	837	2,523	5,086
Zinc concentrate	'000 tonnes	903	845	1,097
COAL				
Black coal—				
Bituminous	'000 tonnes	74,402	88,766	92,119
Sub-bituminous	"	6,847	7,308	7,172
Brown coal—				
For briquettes	"	3,350	2,891	2,658
Other	"	29,544	29,212	34,904
Briquettes	"	1,253	1,081	993
OIL AND GAS				
Crude oil (stabilised)	'000 m ³	23,668	23,036	22,313
Natural gas	mill. m ³	8,876	10,269	11,294
Ethane	"	147	140	152
CONSTRUCTION MATERIALS(c)				
Sand	'000 tonnes	26,241	27,285	28,712
Gravel	"	14,998	14,338	16,088
Crushed and broken stone	"	56,123	53,891	58,478
Other (decomposed rock etc.)	"	38,072	41,162	33,965
OTHER NON-METALLIC MINERALS				
Asbestos (chrysotile)	tonnes	90,524	73,416	34,293
Brick, clay and shale	'000 tonnes	9,005	8,146	7,882
Limestone (including shell and coral)	"	11,521	11,894	12,790
Salt	"	5,335	6,799	4,985
Silica	"	1,884	1,828	1,847

(a) Includes alluvial gold. (b) Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. (c) Excludes dimension stone.

CONTENTS OF PRINCIPAL METALLIC MINERALS PRODUCED

<i>Contents of metallic minerals produced</i>		<i>1979-80</i>	<i>1980-81</i>	<i>1981-82</i>
Alumina (Al_2O_3)	'000 tonnes	n.p.	n.p.	n.p.
Antimony	tonnes	1,435	1,207	1,295
Bismuth	kg	n.p.	n.p.	n.p.
Cadmium	tonnes	1,757	1,676	2,080
Cobalt	"	3,133	3,513	3,075
Copper	"	235,122	246,441	259,633
Gold	kg	18,273	15,991	22,328
Iron (b)	'000 tonnes	61,319	59,064	54,886
Lead	tonnes	n.p.	381,377	454,776
Manganese	"	1,039,141	717,209	587,919
Monazite	"	14,033	12,676	10,636
Nickel	"	64,393	73,367	81,424
Palladium	kg	202	464	360
Platinum	"	83	69	65
Selenium	tonnes	—	63	—
Silver	kg	791,760	759,290	887,569
Sulphur	tonnes	369,358	338,734	414,551
Tantalite-columbite ($Ta_2O_5 + Nb_2O_5$)	kg	69,113	91,930	129,635
Tin	tonnes	12,379	12,690	12,750
Titanium dioxide (TiO_2)	"	1,028,859	1,008,386	940,946
Tungstic oxide (WO_3)	mtu(a)	449,372	451,245	384,294
Yttrium oxide (Y_2O_3)	kg	7,273	9,187	17,152
Zinc	tonnes	518,040	581,887	623,904
Zirconium dioxide (ZrO_2)	"	297,961	306,079	299,201

(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 principal minerals produced during 1981-82 and earlier years. Further data are available in the annual publication *Mineral Production, Australia* (8405.0).

VALUE OF PRINCIPAL MINERALS PRODUCED
(\$'000)

<i>Mineral</i>	<i>1979-80</i>	<i>1980-81</i>	<i>1981-82</i>
METALLIC MINERALS			
Bauxite	n.p.	n.p.	n.p.
Copper concentrate	327,471	288,768	231,952
Gold bullion(a)	203,337	184,434	200,408
Iron ore	1,004,308	1,007,307	1,131,186
Lead concentrate	623,973	375,018	252,136
Lead-copper concentrate	41,193	23,904	21,474
Manganese ore—			
Metallurgical grade	95,737	59,207	46,136
Mineral sands—			
Ilmenite concentrate(b)	27,252	33,200	36,610
Rutile concentrate	76,481	82,301	61,758
Zircon concentrate	28,175	30,180	37,526
Nickel concentrate	n.p.	n.p.	n.p.
Tantalite-columbite concentrate	12,339	17,594	11,091
Tin concentrate	166,674	143,343	141,716
Tungsten concentrate—			
Scheelite concentrate	34,923	33,739	27,612
Wolfram concentrate	19,768	19,606	15,607
Uranium concentrate	62,342	192,755	356,219
Zinc concentrate	174,065	188,075	n.p.

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

<i>Mineral</i>	<i>1979-80</i>	<i>1980-81</i>	<i>1981-82</i>
COAL			
Black coal—			
Bituminous	1,665,489	2,276,080	2,777,212
Sub-bituminous	94,607	116,380	143,903
Brown coal—			
For briquettes	91,821	107,052	137,138
Other	24,938	22,230	27,045
Briquettes			
OIL AND GAS			
<i>Oil and Gas</i>	<i>1,190,260</i>	<i>1,665,786</i>	<i>1,779,989</i>
CONSTRUCTION MATERIALS(c)			
Sand	76,738	95,958	110,239
Gravel	52,612	61,030	80,566
Crushed and broken stone	252,376	263,159	325,406
Other (Decomposed rock etc.)	54,141	80,768	90,535
OTHER NON-METALLIC MINERALS			
Asbestos (chrysotile)	27,240	25,735	14,464
Brick clay and shale	23,054	23,706	27,029
Gems			
Opal(d)	64,135	49,490	45,374
Sapphire	24,672	19,783	22,675
Limestone (incl. shell and coral)	42,585	44,153	58,785
Salt	40,871	66,485	52,177
Silica	14,362	15,858	18,494

(a) Includes alluvial gold. (b) Includes ilmenite from which titanium dioxide is not commercially extractable and beneficiated ilmenite. (c) Excludes dimension stone. (d) Partly estimated.

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 and Selected Mineral Processing Industries, Australia 1981-82* (5317.0) and *Foreign Control in Mineral Exploration, Australia 1975-76* (5323.0).

Mineral exploration (other than for petroleum and oil shale)

Definition

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

Sources of statistics

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

Classification

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

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

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

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

Expenditure, metres drilled

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

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

	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82
Expenditure (\$'000)—						
On drilling	36,139	50,019	50,729	72,408	126,088	141,872
Other	97,835	108,378	131,780	213,722	344,401	433,700
Australia	133,974	158,397	182,509	286,130	470,489	575,572
Metres drilled ('000)—						
Drilled-core	469	410	639	617	743	648
Drilled-non-core	1,364	1,919	1,689	2,299	3,222	3,377
Australia	1,834	2,329	2,328	2,917	3,965	4,025

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 1981-82 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 of expenditure on petroleum exploration have been obtained by the addition of values collected in a quarterly survey conducted by the Australian Bureau of Statistics. Other data shown were collected by the Bureau of Mineral Resources, Geology and Geophysics. Further information relating to petroleum exploration is published by the Australian Bureau of Statistics in its annual publication *Mineral Exploration, Australia* (8407.0) and by the Bureau of Mineral Resources in *The Petroleum Newsletter* (issued quarterly) and *The Australian Mineral Industry Annual Review*.

Scope

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

Operations

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

PETROLEUM EXPLORATION

		1979-80	1980-81	1981-82
Expenditure—				
Private sources	\$'000	294,709	368,330	803,983
Government sources	\$'000	5,020	5,351	6,797
Total	\$'000	299,729	373,683	810,781
Wells (a) —				
Drilled (i.e. those which reached final depth) —				
As oil producers	No.	1	14	21
As gas producers	No.	8	24	38
Plugged and abandoned	No.	43	56	99
Total	No.	52	94	158
Average final depth of wells drilled	m	2,460	1,747	1,999
Drilling still in progress at 31 December (uncompleted holes)	No.	4	11	17
Wells drilled or drilling over 3,000 metres	No.	14	24	18
Metres drilled (a) —				
Completed wells	m	127,403	180,157	296,818
Uncompleted holes	m	10,205	19,151	25,566
Total	m	137,608	199,308	322,384

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

Mineral processing and treatment

The extraction of minerals from ore deposits, as in mining and quarrying, is only a part of mineral technology, as few minerals can be directly used in the form in which they are mined. In most cases minerals must undergo considerable processing and treatment before utilisation. 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 (a) OF PRINCIPAL MANUFACTURED PRODUCTS OF MINERAL ORIGIN

Commodity		1979-80	1980-81	1981-82
METALS(b)				
Non-ferrous—				
Alumina	'000 tonnes	7,290	7,235	6,651
Refined aluminium	tonnes	283,006	344,753	380,457
Blister copper(c)	"	163,608	167,778	177,344
Refined copper	"	137,000	159,437	163,052
Lead bullion (for export) (c)	"	167,744	149,027	180,675
Refined lead	"	204,287	206,127	207,242
Refined zinc	"	299,606	297,871	301,266
Refined tin	"	5,249	4,669	3,617
Ferrous—				
Pig iron	'000 tonnes	7,481	7,335	6,606
Steel ingots	"	7,374	7,012	6,198
Precious—				
Refined gold(d)	kg	15,038	12,494	17,773
Refined silver	"	293,966	315,584	325,105

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

Commodity		1979-80	1980-81	1981-82
FUELS				
Coal products—				
Metallurgical coke	'000 tonnes	4,302	4,676	4,198
Brown coal briquettes	"	1,230	1,081	993
Petroleum products—				
Diesel-Automotive oil	'000 tonnes	5,958	6,137	6,445
Industrial fuel and marine fuel	"	991	985	775
Fuel oil for burning	"	4,674	3,854	3,285
Automotive petrol	mil. litres	14,370	14,002	14,375
BUILDING MATERIALS				
Clay bricks	millions	2,172	2,287	2,234
Portland cement	'000 tonnes	5,201	5,656	6,136
Plaster of paris	"	419	443	480
Plaster sheets	'000 sq m	54,770	63,617	63,768
CHEMICALS				
Sulphuric acid	'000 tonnes	2,153	1,976	2,039
Caustic soda	tonnes	n.p.	n.p.	n.p.
Superphosphate(e)	'000 tonnes	4,202	3,557	3,464

(a) Some products exclude production of single establishment manufacturing establishments employing less than four persons and production of establishments predominantly engaged in non-manufacturing activities but which may carry on in a minor way, some manufacturing. (b) Excludes secondary metal with the exception of pig iron and steel ingots. Source: Bureau of Mineral Resources, Geology and Geophysics (non-ferrous and precious metals only). (c) Metallic content. (d) Newly-won gold of Australian origin. (e) Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22% P₂O₅ equivalent.

Overseas trade**Exports and imports**

For 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. See Chapter 24. Overseas Transactions.

Considerable quantities of metallic ores, concentrates, slags, and residues are exported from Australia for refining overseas. The following table shows selected items exported during 1981 and their principal metallic content as estimated by assay.

**PRINCIPAL METALLIC CONTENTS OF SELECTED ORES AND CONCENTRATES ETC. EXPORTED
FROM AUSTRALIA, 1982**

<i>Metallic contents—estimated from assay</i>								
<i>Ores and concentrates, etc.</i>	<i>Copper</i>	<i>Lead</i>	<i>Zinc</i>	<i>Tin</i>	<i>Iron</i>	<i>Tungstic Oxides</i>	<i>Gold</i>	<i>Silver</i>
	tonnes	tonnes	tonnes	tonnes	tonnes	tonnes	kg	kg
Copper concentrate	47,944	2,297	1,884	—	—	—	395	30,538
Blister copper	7,147	—	—	—	—	—	796	1,536
Copper matte, slags, etc. (a)	9,366	7,054	—	—	—	—	436	9,745
Lead concentrate	5,027	36,391	6,273	—	—	—	1,342	91,144
Lead bullion	—	165,433	—	—	—	—	27	432,711
Lead slags and residues	—	1,941	—	39	—	—	—	26
Zinc concentrate	944	4,755	289,370	—	—	—	288	38,079
Zinc slags and residues	—	—	4,506	—	—	—	—	—
Tin concentrate	—	—	—	7,075	—	—	—	—
Iron ore—								
Pellets	—	—	—	—	1,615	—	—	—
Fines	—	—	—	—	25,501	—	—	—
Lump	—	—	—	—	18,539	—	—	—
Scheelite concentrate	—	—	—	—	—	2,226	—	—
Wolfram concentrate	—	—	—	—	—	1,188	—	—
Total metallic content	70,429	217,872	302,034	7,114	45,655	3,414	3,283	603,780

(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)										
Period	Tin			Nickel U.S.A. (\$US—lb)	Aluminium		Gold		Silver	
	Aust. (\$A— tonne)	L.M.E. (£Stg— metric ton)	Straits (\$Mal— picul)		Aust. (\$A—tonne)	U.S.A. (USC—lb)	Premium markets (\$A—f. oz) Australia and Overseas	U.K. (\$US—f. oz)	Aust. (\$A—kg)	U.K. (Stg new pence— f. oz)
1981	13,363.32	7,071.44	(b)32.34	3.45	1,501.25	61.05	407.22	459.99	298.82	515.07
1982	10,483.49	7,320.35	(b)30.17	3.25	1,370.00	47.58	373.51	375.95	244.71	455.78
1982										
Highest	15,639.00	9,000.00	(b)35.50	3.29	1,370.00	52.25	511.00	488.50	342.48	685.15
Lowest	13,002.00	5,460.00	(b)29.00	3.20	1,370.00	43.57	291.85	297.00	182.58	285.10
Period	Copper		Lead			Zinc				
	Aust. (\$A— tonne)	L.M.E. (£Stg— metric ton)	Aust. (\$A— tonne)	L.M.E. (£Stg— metric ton)	U.S.A. (USC—lb)	Aust. (\$A— tonne)	L.M.E. (£Stg— metric ton)	Prod. (Stg— ton)	U.S.A. (USC—lb)	
1981	1,535.83	863.82	662.53	362.69	37.30	798.54	424.01	914.04	45.44	
1982	1,474.50	846.73	622.61	310.98	27.14	848.96	425.42	847.83	39.05	
1982										
Highest	1,620.00	933.50	650.00	372.50	38.00	877.00	461.50	950.00	47.00	
Lowest	1,240.00	684.50	600.00	263.50	19.50	796.00	369.00	800.00	36.00	
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)	
1981		112.55		140.54–144.63		24.00–25.00		288.33–299.17		82.08–87.08
1982		114.34		102.17–106.50		26.50–28.92		253.33–265.00		110.42–115.42
1982										
Highest		118.85		130.00		30.00		290.00		120.00
Lowest		104.30		76.00		24.00		250.00		100.00

(a) Where a daily price does not actually exist for a commodity, daily prices have been imputed from price data which are available.
(b) Shown in \$ kg.

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 during 1982 are reviewed briefly in subsequent parts of this section. Additional information on developments in the industry is available in *Australian Mineral Industry Annual Review 1982* 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 35, Number 4, details Australia's identified mineral resources, 1982.

General Review of 1982

The gross domestic product (GDP) of Australia in 1981–82 was \$147,576 million, of which an estimated \$9,100 million was generated by the mineral industry, excluding smelting and refining. If smelting and refining were included, an estimated \$2,200 million could be added to this figure, thus making the mineral industry the largest primary sector contributor to the GDP. Australia's export trade again increased in total value, although in real terms a decline was evident. Japan, USA and EEC were the main markets for mineral commodities.

Increased output and higher prices for some major commodities were sufficient to bring about yet another record ex-mine value of minerals produced in Australia in 1982 of about \$9,870 million. The greater part of this increase was accounted for by the energy minerals, coal, crude oil and natural gas. Most other major commodities recorded downturns in quantities and values of production reflecting a continuation of gloomy conditions on world markets. Lead, copper, gold, and silver output was higher than in 1981, but output of nickel, was lower. Production of uranium oxide (yellowcake) increased by more than 50% because of output from the newly operational mine and concentrator at Ranger, N.T. The downturn in the world steel industry resulted in reduced demand for Australian iron ore and manganese, although there was a slight increase in demand for Australian steel products. Because of reduced demand for rutile, and increased supplies, Australian mineral-sands operators cut back production, particularly on the east coast.

Imports—1982

The value of imports of mineral products rose by 30 per cent to \$3,099 million. Crude oil and other refinery feedstock was the largest single mineral import, rising by 38 per cent to \$2,778 million. Other significant mineral imports were gem diamonds and fertiliser materials (phosphate rock, elemental sulphur, and potassium salts). Imports of mineral primary products accounted for 13.1 per cent of the total value of merchandise imports compared with 9.8 per cent in 1981. Although the value of imports rose, the surplus in the balance of mineral trade rose slightly, increasing from \$4,700 million in 1981 to \$4,892 million in 1982.

Exports—1982

Australia's mineral exports rose in current dollars by 33 per cent to \$9,870 million, a new record. Those mineral commodities which lost ground in current dollars as a result of depressed world industrial and trading conditions included rutile, tin and copper. Black coal exports increased in both quantity and current dollar terms and remained the largest single export earner, accounting for \$2,551 million or 32 per cent of the total value of mineral primary products.

Iron ore was the second largest export earner with a value of \$1,427 million (an increase of 27 per cent) followed by alumina which increased in value by 2 per cent to \$1,100 million. In total, black coal, iron ore and alumina accounted for nearly 64 per cent of the total value of exports of mineral primary products. A significant contribution was also made by gold, silver, uranium and zinc.

Pattern of mineral trade—1982. Australia exported metals and minerals to more than 100 countries. Japan accounted for 43.5 per cent of Australian exports 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 the EEC was 18.8 per cent (including 6.8 per cent to the UK), and to the USA 10.9 per cent. To the EEC countries, exports were mainly iron ore, black coal, lead and copper, and to the USA alumina, nickel, bauxite, manganese ore, mineral sands, iron ore, lead, and zinc.

Bauxite, Alumina and Aluminium

In 1982, production of bauxite decreased by 6.6 per cent to 23.93 million tonnes, while aluminium production increased slightly to 380,796 tonnes. Australia was again the world's largest producer of bauxite and alumina.

The commissioning of the new alumina refinery at Wagerup, W.A., has been delayed until at least 1984. Initial rated capacity is to be 500,000 tonnes per year.

The first stage of the alumina refinery at Worsley, W.A., was completed in late 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.

Enlargement of the Kurri Kurri, N.S.W. aluminium smelter has been deferred due to the depressed world aluminium market. The planned expansion will increase total capacity from 90,000 to 135,000 tonnes per year. Comalco's aluminium smelter at Boyne Island, near Gladstone, Qld, is supplied with alumina from the nearby Queensland Alumina Ltd (QAL) refinery. The smelter has a first-stage design capacity of 103,000 tonnes per year and it is planned to expand capacity to 412,000 tonnes by the end of the decade. The rated capacities of the other two Australian aluminium smelters, at Point Henry, Vic., and Bell Bay, Tas., are 165,000 and 117,000 tonnes per year respectively. Point Henry uses Western Australian alumina while Bell Bay obtains its alumina from Queensland.

Construction of the Portland, Vic., smelter, which was to be commissioned in 1983, has been delayed. Initial capacity is to be 132,000 tonnes per year. The Tomago, N.S.W. smelter was commissioned in mid-1983; it will have an initial capacity of 110,000 tonnes per year. The proposed Lochinvar, N.S.W., smelter has been abandoned.

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 1982 mine production of copper increased to 245,322 tonnes. Western Mining Corporation Ltd and BP Australia Ltd entered into an Indenture Agreement with the South Australian Government on the development of the Olympic Dam copper project at Roxby Downs, S.A. The proposed agreement commits the two companies to spend at least a further \$50 million on the feasibility stage by the end of 1984, with a decision to proceed required within three years of that date. In July 1982, WMC stated that widely spaced drilling has shown the Olympic Dam mineralisation to extend over an area of 7 km by 4 km and the estimated amount of mineralisation so far drilled to be about 2,000 million tonnes at an average grade of 1.6 per cent copper, 0.6 kg/tonne uranium oxide (U_3O_8), and 0.6 g/tonne gold.

The Mount Chalmers mine near Mount Morgan, the Mammoth mine in northwest Queensland, and the Dianne in north Queensland ceased production in 1982.

Broken Hill Associated Smelters Pty Ltd announced the proposed construction of a plant at Port Pirie, S.A., to produce copper metal from by-product materials. Capacity will be 4,000 tonnes of refined copper a year; the plant will cost about \$12.3 million.

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 1982 was 87.7 million tonnes, 4.5 per cent higher than in 1981. Export of iron ore and iron ore pellets was 72.6 million tonnes valued at \$1,427 million. Australia remained the second largest exporter of iron ore and the third largest producer.

Cliffs Robe River Iron Associates in 1982 completed the transfer of all mining operations to East Deepdale, 24 km west of the deposits mined initially.

Production at the Mount Goldsworthy deposits ceased at the end of 1982, the reserves exhausted. Agreement was reached with Japanese steel mills for a two year extension of sales contracts from April 1983 to enable production to continue at Shay Gap and Sunrise Hill at a rate of 4.4 million tonnes per year.

Production at Koolyanobbing fell substantially early in 1982 following the closure of the Kwinana blast furnace which it mainly supplied.

Silver, lead and zinc

Mine production of lead and zinc metal increased in 1982 to 455,338 tonnes and 664,800 tonnes respectively, with lead being 16 per cent more and zinc metal 32 per cent more than in 1981.

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.

Mining capacity for silver-lead-zinc ore at Mount Isa, Queensland, was increased by 20 per cent to 180,000 tonnes of contained lead and proportional increases in zinc and silver production.

Production at the Elura lead-zinc-silver deposit, near Cobar, N.S.W., began in early 1983.

Black coal

Raw black coal production in 1982 was a record 119.0 million tonnes, 8 per cent higher than in 1981. The output of saleable coal rose by 6.5 per cent to the record level of 98.2 million tonnes. Domestic consumption increased slightly from 37.4 million tonnes in 1981 to 37.5 million tonnes in 1982, despite a drop in use for electricity generation of almost 0.8 million tonnes. Exports fell by almost 1 million tonnes to 49.8 million tonnes in 1982 but the value of exports rose to \$2,544 million. Of total exports 32.3 million tonnes were shipped to Japan.

Demand for steaming coal on the international market remained high. As a result Australian exports of steaming coal rose by 21 per cent to 12.7 million tonnes. At the same time, the continuing world recession resulted in a 7 per cent fall in exports of coking coal to 37.1 million tonnes. Several new mines had commenced operation or were at an advanced stage of construction by the end of 1982.

Papers dealing with the Australian coal industry have been published in the *Australian Mineral Industry Quarterly* Vol. 31, No. 1 and Vol. 34, No. 2.

Petroleum

1982 was a record year for petroleum exploration in Australia. At the end of 1982 there were 24 fields producing stabilised crude oil (which includes condensate marketed as part of a crude oil stream): Moonie, Alton, Conloi, Kincora, Cabawin, Bennett, Riverslea, Thomby Creek, Yapunya, Yellowbank Creek, Silver Springs and Trinidad in Queensland; Barrow Island, Blina, Yardarino and Dongara in Western Australia; and Barracouta, Halibut, Mackerel, Cobia, Tuna, Kingfish, Snapper and Marlin offshore from Victoria in Bass Strait. The production of stabilised crude oil in 1982 amounted to 21,700 megalitres, a decrease of 5.1 per cent over the 1981 production level.

Natural gas production in 1982 was 11.6 million cubic metres, an increase of about 3 per cent over the 1981 production level. About 17 per cent of natural gas production 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.

Forty-four offshore exploration wells were drilled in 1982, 28 more than in 1981. Metres drilled increased from 44,946 in 1981 to 126,288 in 1982. At 30 June 1983 there were nine offshore drilling vessels operating in Australian waters.

Offshore development drilling continued in 1982 in the Gippsland Basin and continued on the Snapper platform (6 wells). On the West Kingfish platform development drilling started, and the Cobia and Fortescue platforms were installed in October 1982. The fabrication of the Flounder platform was well in hand. Major development work commenced on the North West Shelf project during 1982 and by the end of the year the jacket for the first offshore platform was in position and work was in progress on the platform. Site preparation and fabrication for onshore treatment facilities was well in hand and laying of the underwater gas pipeline to shore was completed.

Onshore exploration drilling activity rose from 142 in 1981 to 182 in 1982. Metres drilled increased slightly from 325,651 in 1981 to 325,795 in 1982. Drilling in 1982 was mainly centred in the Bowen-Surat Basin in Queensland, the Cooper Basin in South Australia and the Perth, Carnarvon and Canning Basins in Western Australia.

Eighty-nine onshore development wells were drilled in 1982, 48 more than in 1981. Metres drilled almost doubled from 85,232 in 1981 to 152,780 in 1982. New developments included construction of the Cooper Basin liquids scheme whereby petroleum liquids will be piped 659 kilometres from the Cooper Basin to a fractionation plant at Port Bonython near Whyalla.

Production leases were granted for the Mereenie oil field in November 1981 following agreement with the Aboriginal land owners on royalties. A 20 well, two year appraisal program is under way and further assessment of the resource is expected as more wells are drilled. Present oil reserves are estimated at 64 million barrels and recoverable gas reserves are put at 0.9 TCF. A contract was signed in November 1981 for the use of Palm Valley gas in power generation at Alice Springs. Tenders for construction of a pipeline between Palm Valley and Alice Springs were called in late 1982.

In 1982 there were 15 significant oil discoveries and 27 significant gas discoveries.

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 87,552 tonnes in 1982. Australia was the second largest world producer after USSR. Concentrates from Kambalda, Agnew and Mount Windarra are smelted at the Kalgoorlie nickel smelter. Some of the matte produced is railed to the Kwinana nickel refinery to be refined to nickel metal and the remainder is exported. Nickel-laterite ore mined at Greenvale, Queensland, is treated at the Yabulu nickel treatment plant to produce nickel oxide sinter for export.

Mineral sands

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

Australia is still the world's largest producer and exporter of natural rutile, ilmenite, zircon and monazite. Output of rutile, ilmenite and monazite concentrates was reduced but the production of zircon concentrates increased.

Diamonds

Evaluation of the diamond deposit at Argyle, W.A., continued. The deposit consists of the AK-1 kimberlite pipe, overlying scree, and the Upper Smoke Creek and Limestone Creek alluvials. Total diamond output during pilot testing until the end of 1982 amounted to 829,377 carats. Commercial production from the AK-1 pipe is planned to start in January 1985; commercial production from the Upper Smoke Creek alluvials began in January 1983.

Uranium

Production of uranium in Australia in 1982 was 5,215 tonnes of yellowcake (4,422 tonnes contained u), 56 per cent greater than in 1981. The increase was mainly due to the production from the Ranger mine, N.T., which was in full production for the whole year. Nabarlek mine, N.T., continued to treat ore stockpiled before the deposit was mined out in 1979. Mining operations ceased at Mary Kathleen, Qld, and the treatment plant closed down later in the year. No other mine is in production. 1982 exports were 5,460 tonnes of yellowcake.

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