

COMMONWEALTH OF AUSTRALIA

Australian Mineral Industry

VOLUME 23 No. 2 DECEMBER 1970

Part 1—Quarterly Review

Issued by the Bureau of Mineral Resources under the authority of the Hon. the Minister for National Development.

Part 2—Quarterly Statistics. Quarter ended 30 June 1970

Prepared under instructions from the Honourable the Treasurer, by J. P. O'Neill, Acting Commonwealth Statistician.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS
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Review**

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COMMONWEALTH OF AUSTRALIA

DEPARTMENT OF NATIONAL DEVELOPMENT

MINISTER: THE HON. R. W. C. SWARTZ, M.B.E., E.D., M.P.

SECRETARY: L. F. BOTT, D.S.C.

BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS

DIRECTOR: N. H. FISHER

THIS REVIEW WAS PREPARED IN THE MINERAL RESOURCES BRANCH
ASSISTANT DIRECTOR: L. C. NOAKES

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Information of interest to the mineral industry, corrections to published data, and suggestions will be welcomed.

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Commodity Review

Z. KALIX, J. WARD, W. G. B. PHILLIPS, A. J. GOURLAY, R. PRATT,
R. Z. de FERRANTI

FUEL

Coal. Preliminary figures for the September quarter indicate that exports of coal were maintained at a high level despite an industrial dispute which made loading facilities at Newcastle, Sydney, and Port Kembla idle for three weeks between mid-August and early September. The reduction in exports from New South Wales during September was offset by substantially increased shipments from Queensland where exports for the nine months to the end of September exceeded total exports in 1969. As a result of the shipping strike in New South Wales there has been an unusually large build up in stocks held by mines producing for the export market. The Joint Coal Board reported that by 5 September, colliery stocks in New South Wales amounted to 2,374,900 tons as compared with 2,075,100 tons on 8 August and 987,700 tons a year earlier. In the light of recent press reports that there would be a cut in Japanese steel production, there was some concern that reduction of New South Wales coal production could become necessary if Japanese importers decide to reduce coal purchases.

Statistics released by the Joint Coal Board and the Queensland Coal Board show that production in the 36 weeks ended 5 September was well ahead of production in each State during the same period of 1969. Queensland production was 18.1 percent higher and New South Wales production 7.2 percent higher, while domestic consumption had increased only 5.4 percent in Queensland and 1.5 percent in New South Wales.

The New South Wales Government announced on 5 November that agreement had been reached with Clutha Development Pty Ltd over a project involving a 40-mile railway, conveyors, and an offshore coal loader on the southern coalfields of New South Wales. Legislation for the agreement was to be introduced into State Parliament in mid-November so that work on the project could proceed. Feasibility studies are expected to be completed within a year and the facilities could be in operation in about three years' time. The proposed railway will link mines owned by Clutha Development in the Burragorang Valley with a conveyor commencing on the escarpment above Coalcliff, leading to stockpiles and an offshore loading berth. The standard gauge railway will be built and operated as a private enterprise from which the Government expects to receive at least \$100 million in franchise over 20 years. Clutha Development has based its feasibility study on a minimum export of 7 million tons per annum, but is optimistic about the possibility of greater exports as well as using the loading facilities for exports by other companies.

Currently, coal from the Burragorang Valley is loaded at Balmain, in Sydney, and coal from Clutha's South Clifton colliery (near Coalcliff) is exported through Port Kembla. Coal loading facilities at both ports have recently been operating close to capacity and more facilities are urgently needed if expansion of exports

from the southern and western coalfields is to proceed. Clutha Development has proposed a similar railway and port project on the northern coalfields where new coal loading facilities are also needed. However, the State Government has stated that it is unlikely to grant an exclusive franchise to any single company in that area. On 17 September, the Premier of New South Wales announced that existing facilities at Newcastle and Port Kembla would be improved, while new facilities for Newcastle and Wollongong are being considered.

On 22 September, Utah Development Company announced that its coal mining operations in central Queensland would be expanded beyond the levels previously planned. The mines involved are at Blackwater, where an increase of 1 million tons will bring rated annual capacity to 4 million tons of washed coal by late 1972 and the Peak Downs Mine now under construction and scheduled to commence coal shipments in mid-1972, where rated capacity will be increased by an additional 1.3 million tons to 5 million tons of washed coal annually by mid-1973. These expansions, together with the 4 million tons per annum Goonyella Mine (also under construction) will raise the combined output of the three mines to approximately 13 million tons of washed coal annually by mid-1973. Both expansions await finalization of railway agreements with the Government of Queensland, and in connection with the Blackwater Mine an agreement with the Gladstone Harbour Board for the installation of necessary port facilities.

R. Z. de F.

METALS

Aluminium. Production of primary metal in the first nine months of 1970 was 148,988 tons, according to preliminary statistics, indicating that output for the year will be at a record level of around 200,000 tons. Production will continue to increase until the smelter of Alcan Australia Ltd at Kurri Kurri, N.S.W., reaches full capacity production of 50,000 tons annually expected by the end of 1970, and when the Bell Bay smelter of Comalco Ltd is expanded to 94,000 tons per annum by mid-1971.

Alumina production continued at a high level in the first half of 1970. That production would be marginally ahead of 1969 was indicated by production statistics for the September quarter, and is attributed to the bringing in of expanded capacity at Kwinana and a steadily rising output from Gladstone. With the completion of a further 210,000 metric ton unit, the Kwinana refinery of Alcoa of Australia (W.A.) N.L. operated at a capacity of 1,040,000 tons per annum during the third quarter of 1970, and is scheduled to reach a production capacity of 1,250,000 tons of alumina annually by the end of this year. Queensland Alumina Limited is currently expanding production capacity at Gladstone to 1,275,000 tons annually by early 1971 and to 2,000,000 tons by mid-1972.

In November, Nabalco Pty Ltd announced that the target date for the 1,000,000 tons per year alumina production had been brought forward to mid-1973, instead of mid-1974 as formerly planned. The date of commissioning of the refinery at its initial capacity of 500,000 tons annually by mid-1972 remains unaltered. Mining of bauxite has already commenced in preparation for the commencement of exports in July 1971 at an annual rate of 2,000,000 tons.

The Queensland Minister for Mines announced on 30 September that the Pechiney Group of France had been granted an option to acquire a 20% interest in the bauxite/alumina project headed by Tipperary Land and Exploration Corporation Pty Ltd (U.S.A.) and Holland Aluminium N.V. Indicated reserves of bauxite outlined to date within the consortium's leases south of Weipa are reported to be in excess of 300 million tons. The consortium is studying the feasibility of bauxite mining and the construction and operation of an alumina refinery of about one million tons annual capacity, with necessary infrastructure.

An agreement was signed in Perth on 18 November between the State Government and the partnership, Broken Hill Proprietary Co. Ltd and Alwest Pty Ltd (a subsidiary of News Ltd) for the establishment of bauxite mining in the Darling

Range and an alumina refinery and port facilities at Bunbury. Under the agreement, the companies have two years to present their final proposal to the Government and a further three years to commence alumina production at a minimum rate of 200,000 tons annually. The actual production rate is thought more likely to be of the order of 500-600,000 tons per year initially, with expansion to 1 million tons, and possibly further to 2 million tons yearly.

A. J. G.

Copper. Preliminary statistics show that mine production of copper during the first six months of 1970 was 68,661 tons, compared with 61,650 tons during the corresponding period of 1969, and 67,614 tons in the half year ended 31 December 1969. The output of 136,275 tons in the fiscal year 1969/70 is the highest recorded for any year to date, and the figures also indicate that production for calendar year 1970 will be of the same order. It may reasonably be expected, however, that domestic supplies in the second half of 1970 will be augmented by new production from projects initiated towards mid-year, such as that at Mount Gunson, S.A., Mount Oxide and Gunpowder Creek, Qld, as well as by steadily increasing output from Mount Isa, Mount Lyell, and Tennant Creek.

Following their relatively high level of 16,691 tons in the January-March quarter, exports of refined copper fell sharply in the second quarter of the year, and for the period January-June 1970 totalled 20,880 tons, valued at \$30.97 million. Preliminary data for the September quarter show that exports of refined metal continued to decline. On the other hand, production of primary refined metal remained at a fairly constant level throughout the first six months and an appreciable increase was indicated in the third quarter. A relatively high apparent consumption for the period is therefore indicated, which is consistent with inevitable building up of stocks with falling prices in recent months. Production of refined copper from purchased scrap for the period January-June was 8,122 tons. A downward trend evident in the months April to June was reversed in the July-September period, no doubt a reflection of the abovementioned conditions. A possible apparent consumption for the year 1970 of the order of 120,000 tons is suggested by the above preliminary data on production and exports, which is a record for any year to date. The situation merely reflects the extent to which consumers were forced to deplete stocks during the period of abnormally high prices which had prevailed without any appreciable relief from the beginning of 1969 until September 1970.

The Australian producers' price for wire bar was 52 cents per pound (\$1,164.80 per ton) throughout September to 9 October. It fell relatively rapidly to 46 cents (\$1,030.4) on 31 October, its lowest since 3 December 1968, and remained at that level at 30 November. The London Metal Exchange daily cash price remained relatively stable during September, and with minor fluctuations continued in the range £510-£530 through the month, to fall below £500 on 6 October again for the first time since December 1968. The overall downward trend continued to the end of October and the price continued at somewhat above £450 to mid-November and was at £446½ per ton on 19 November. A contango of the order of £10-£13 per ton prevailed throughout the period, and reflected a continuation of the situation of high stocks levels and weakening in demand for prompt metal referred to previously. In the United States, the producers' price for domestically produced wire bar was reduced from the range 60-60½ cents to 56-60½ cents from 22 October. The Phelps Dodge company announced a 4 cent reduction to 56 cents, which was followed by Anaconda on 23 October. This was the first producer price-cut since January 1961, apart from the rescinding of temporary increases in November 1965 induced by Government stockpile releases.

Substantial increases in copper reserves were announced in November by Mount Isa Mines Ltd. Primary copper ore reserves are now stated at 120 million tons with an average grade of 3% copper, an increase of 45 million tons on previously announced reserves.

Production of copper ore is scheduled to begin at Kanmantoo, S.A., in the second half of 1971 according to an announcement by the chairman of Broken Hill South Ltd, which has a 51 percent interest in Kanmantoo Mines Ltd. Ore reserves are stated to be sufficient to support an operation with a throughput of 750,000 tons per year for eight years, that is about 6,000,000 tons. The grade of the ore is 1% copper and recovery is expected to be about 7,000 tons of copper from concentrates annually.

Installed treatment capacity at the CSA Mine, Cobar, would be increased by 50 percent to 90,000 tons per month by 1972, according to an announcement by the company chairman in November. Mining operations at the CSA Mine would be increased to provide the additional throughput required until the Chesney Mine was brought into production in 1974. Initial production from the latter mine would be at the rate of 235,000 tons of ore annually; ore reserves at the Chesney Mine have been estimated as 4 million tons of 2% copper. Exploratory drilling in the CSA Mine area had also indicated appreciable additional mineralization.

Pacific Copper Explorations has upgraded copper reserves on its leases near Cadia, N.S.W. The company announced in late October that an additional 5 million tons of ore with an average content of 0.53% copper had been outlined by diamond drilling. Previously estimated reserves were reported as 15 million tons, with an average content of 0.8% copper. Directors stated that the full commercial significance of the prospect could not be assessed until further drilling and other studies had been carried out.

A. J. G.

Iron and Steel. Reflecting the continuing expansion of operations by iron ore producers in the Pilbara, W.A., exports of iron ore and iron ore pellets increased to an annual rate of 38 million tons during July to September. Exports for the 9-month period January to September 1970 were recorded at 28.3 million tons valued at \$230 million.

Steel ingot production by The Broken Hill Proprietary Co. Ltd during January to September 1970 at 4.9 million tons, was slightly below the output of 5.1 million tons in the same period of 1969.

The feasibility of establishing a steel plant at Port Latta, Tasmania, based on the use of iron ore from Savage River is being investigated by Tower Research and Development Corp. The investigation is expected to take 12 months. A plant capable of producing 200,000-300,000 tons of high quality ingot steel per year mainly for export is envisaged.

Sentinel Mining Inc. and Goldsworthy Mining Ltd have reportedly reached agreement over the purchase by Goldsworthy of Sentinel's iron ore reserves in the Nimingarra area, W.A.

Ashburton Sands Pty Ltd which is investigating titaniferous iron sand deposits at the mouth of the Ashburton River, W.A., stated that reserves of 6 million tons of heavy mineral concentrates have been proved and 15 million tons of heavy mineral concentrate have been inferred over 20 miles of beach front. Other recent reports indicate that beach deposits of titaniferous iron sands are under investigation in Papua also, by Australian Oil and Gas Corp. Ltd and by Kathleen Investments (Aust.) Ltd.

Marcona Corporation was investigating magnetic iron deposits at Warrambo, S.A. during the period under review. Reserves were stated to be 1,500 million tons averaging 23-30 percent iron.

Kratos Uranium N.L. is investigating iron deposits 100 miles south of Darwin near the junction of the Daly River Road and the Stuart Highway. Reserves were considered to be between 15-20 million tons with an iron content exceeding 40 percent. Northern Mining Corporation N.L. has submitted to the W.A. Government a programme for the development of its iron ore deposit at Weld Range, W.A. Reserves are stated to be 100 million tons averaging 60 percent iron.

In November it was stated that capacity to produce iron ore fines and iron ore pellets of the project under development by the Robe River Consortium was planned to be 20 million tons per year by 1974.

R. P.

Lead and Zinc. The International Lead and Zinc Study Group concluded its 14th Session in Geneva on Friday, 20 November 1970. The total membership of the Study Group is 30 countries and includes nearly all the major producers and consumers of lead and zinc.

The supply and demand situation for lead and zinc was reviewed, and it was found that after the exceptional expansion of consumption, which was a feature of the market for lead and zinc in 1968 and 1969, there had been a pause in the growth of consumption in both metals in 1970, particularly in the United States and other countries where measures had been taken to curb inflation.

Lead consumption in 1970 was expected to amount to about 3.2 million tons, one half of one percent more than in 1969 following the exceptionally high increase of 8 percent in 1969.

Zinc consumption, which traditionally has risen faster than lead, had fallen back in 1970 and was now expected to amount to almost 4 million tons, 4 percent less than the record level reached in 1969 when it was 8½ percent above 1968.

The supply of both metals was expected to exceed demand in 1970. Because of the lower demand resulting from the general economic situation metal production in some countries had been reduced from the levels forecast at the last meeting of the Study Group a year ago. Nevertheless, latest available reports showed producers' stocks of both metals at the end of August 1970 at high levels.

Lead prices, which had risen to their highest level for many years by the end of 1969, had declined somewhat since the beginning of 1970. However, zinc prices had been more stable and there had been little change during the last 18 months.

Most member countries expected lead and zinc consumption to resume more normal growth rates in 1971. Mine and metal production was also forecast to expand. However, it was noted that some producers had earlier announced a curtailment of production. The statistical estimates suggest that in the absence of continued restraint stocks might rise further.

The Study Group took note of the urgency of the problems confronting Governments and the lead industry as a result of action under consideration in the number of countries for restricting the use of lead in gasoline. It was decided to set up immediately a small group to establish the relevant facts of the situation and to report back to the Study Group as early as possible. The World Health Organization will be invited to send a representative to participate in the work of the group. Among the matters discussed by the Study Group were consumption trends, disposals of surplus government-held stocks, trade liberalization in lead and zinc, promotion of consumption, trends in production rates, and the growth of lead and zinc industries in developing countries. The Study Group will continue to collate and examine information on tariff and non-tariff barriers affecting world trade in lead and zinc.

It was agreed to publish, in the course of 1971, a special issue of the Group's monthly statistical bulletin to contain statistics covering the decade since the Study Group was established in 1960.

Reports were received from the Special Working Group, the Standing Committee, from the Statistical Committee, a Sub-Committee on New Mine and Smelter Projects and from a Sub-Committee on Consumption Trends.

The Study Group elected as its chairman for 1971 the leader of the Australian Delegation. The representatives of Spain and the U.S.S.R. were elected as joint vice-chairman. At the invitation of the Spanish Government it was agreed that the 15th session of the Study Group would be held in Madrid.

W. G. B. P.

Manganese. Exports of manganese ore during January to September 1970 were 334,364 tons valued at \$6,230,693 compared with 455,691 tons valued at \$8,283,805 in the same period of 1969. Reduced shipments to Japan and Europe probably reflect the general world surplus of manganese ore as well as reduced demand from the steel industry following heavy purchases and a high level of steel output during 1969.

Manganese ore production at Groote Eylandt, N.T., by Groote Eylandt Mining Co. Pty Ltd during January to September 1970 was 487,000 tons. An expansion programme is under way at Groote Eylandt which, excluding other grades, will raise production capacity for metallurgical grade lump ore to 800,000 tons per year by mid-1971. The current expansion programme will bring total expenditure at Groote Eylandt since 1965 to around \$40 million.

Longreach Manganese Pty Ltd was negotiating with Nippon Steel Corporation, Japan, during the period under review over the sale of ferruginous manganese ore from manganiferous deposits at Ripon Hills, W.A. The deposits at Ripon Hills have been reported to exceed 60 million tons averaging 17 percent manganese and 25 percent iron.

R. P.

Nickel. An important step in the growth of Australia's nickel industry was taken when an agreement with the Western Australian Government regarding the erection of a nickel smelter by Western Mining Corporation Ltd was signed on 4 November 1970. The smelter will be built near Kalgoorlie and production of matte could commence about two years after the agreement has been ratified by the Western Australian Parliament. Initial design output of the smelter will be 20,000 tons of nickel in matte per annum when treating 10 percent nickel concentrates, and by providing additional handling equipment and an oxygen plant capacity could be increased to approximately 40,000 tons of nickel per annum. The smelter will use the flash smelting process developed and used by the Finnish company, Outokumpu Oy, whereby the concentrate is made to roast and smelt itself in a single autogenous operation. At the Outokumpu operations in Finland, nickel concentrates and quartz sand are mixed with preheated air and blown into the smelter where ignition takes place instantaneously and the exothermic reaction of iron and sulphur in the concentrate with oxygen in the air provides substantially all the heat required for smelting. Matte from the smelter, containing about 35 percent nickel is then charged to a converter in which the grade is increased to about 63 percent nickel. Hot exhaust gases from the flash smelter are used for steam generation, preheating of combustion air for the smelter charge and finally, sulphur dioxide contained in the gases is employed in the manufacture of sulphuric acid.

The agreement also included an undertaking by Western Mining to contribute to the cost of linking Kalgoorlie and Esperance by means of a standard gauge railway. In return, W.M.C. will be allowed special freight rates on ore, concentrates, matte, and certain other goods as well as the right, under certain circumstances, to construct a private standard gauge railway to serve areas north of Kalgoorlie. Under another section of the agreement, the Government will supply water needed for the expansion of activities centred on Kambalda, in return for further capital contributions by W.M.C. towards the cost of constructing facilities.

The agreement also provides for the retention by W.M.C. under certain limitations, of certain areas in which the company is prospecting, including the areas of laterite near Ora Banda, Kunnanulling and Broad Arrow. Western Mining has announced that initial drilling of the laterite areas has yielded a preliminary estimate of a potential of about 120 million tons averaging approximately 1 percent nickel of which a portion could be mined at somewhat higher grade. It was stated by the company that the right to build a private railway north of Kalgoorlie, the availability of water and the ability to produce by-product sulphuric acid (from the smelter) may provide some of the conditions necessary to bring this source of nickel into production.

An equally important agreement was reached between the Queensland Government and the Metals Exploration N.L.-Freeport of Australia Inc. partnership on 5 November. Negotiations between the Government and the two partners had previously been deadlocked over details of royalty payments and rail freights which would apply to the proposed Greenvale nickel project. The new agreement, which will be submitted to Cabinet for final approval, will yield a return to the Queensland Government of approximately \$45 million over twenty years. The Greenvale project involves mining and transporting to the coast approximately 2.5 million tons of low grade ore per annum. The partners plan to construct a refinery based on an ammonia leaching process at Townsville, to produce nickel oxide sinter and mixed nickel-cobalt sulphide. A pilot plant in the United States has been completed and will be operated on 5 tons of ore per day until all process details have been confirmed.

In its quarterly report for the period ended 30 September 1970, Metals Exploration announced further details of exploration at Mount Keith in Western Australia. Allowing for 250 feet of oxidised overburden and assuming the mineralized zone extends 1,000 feet probable reserves amount to 120 million tons of open-cut material averaging 0.55 to 0.60 percent nickel. Studies are continuing to investigate nickel recovery, mining and treatment costs, capital requirements and overall feasibility for the establishment of a large open pit operation.

On 15 October, the International Nickel Co. of Canada Ltd announced a 4 percent increase in its nickel price in all markets outside Canada, to compensate for the effect of changes in the exchange rate of the Canadian dollar. As a result, the United States price increased from \$1.28 per pound to \$1.33 per pound f.o.b. Port Colborne (Canada) and in the United Kingdom the price increased from £1,200/10/- per metric ton to £1,246/10/- per metric ton. In Australia, the price of nickel sold by Western Mining Corporation is now \$1.20 per pound, f.o.b. Kwinana (equivalent to \$1.33 per pound). During the period under review, free market prices continued the downward trend established since settlement of the Canadian strikes in November 1969. The London Metal Bulletin quotation fell from £1,550-£1,750 per long ton on 4 August to £1,300-£1,400 per long ton at 3 November.

R. Z. de F.

Tantalum and Columbium. Output of tantalite by Greenbushes Tin N.L. at Greenbushes, W.A., continues to increase and the company reported that production in the year to June 1970 was 21 tons of contained Ta_2O_5 in concentrates compared with 17 tons of contained Ta_2O_5 in 33.67 tons of concentrates in the year to June 1969.

In the 1969 year sales of tantalite-columbite concentrates amounted to 72.48 tons containing about 36% Ta_2O_5 ; of this total Greenbushes Tin N.L. sold 26 tons of tantalite concentrates averaging 51.8% Ta_2O_5 and Vultan Minerals Ltd, also at Greenbushes, sold 45 tons of concentrates averaging 10.5% Ta_2O_5 . The remainder was sold from the Pilbara, W.A., area.

Vultan Minerals Ltd stated in September that tin and tantalite ore reserves at its Greenbushes leases were estimated at 44 million tons. Production at Greenbushes averages 2 pounds of tin-tantalite per ton of material treated and Vultan Minerals expects to recover values of 1 pound of tin-tantalite per ton after construction of a new treatment plant is completed. This plant will be capable of treating 500,000 tons of ore per year.

In April 1970 Goldrim Mining Australia Ltd stated that work done on its Pilbara, W.A. tin-tantalite leases at Strelley, Wodgina, and Tabba Tabba was considered to warrant a sustained exploration programme and that this programme would commence in May. In October the company stated that a tantalite zone within a pegmatite, considered large by world standards, had been delineated at Strelley over a drilled length of 1,800 feet averaging 200 feet by 80 feet thick.

World production of columbium and tantalum concentrates in 1969 was about 15,200 tons compared with 8,900 tons in 1968. In 1969 output of columbium concentrates accounted for 96 percent of the production of columbium and tantalum concentrates. The principal producers during 1969 (with comparable 1968 figures) were: Brazil, 10,442 tons (5,250), principally pyrochlore concentrates; Canada, 2,768 tons (1,891) of pyrochlore concentrates (tantalite production not available); and Nigeria, 1,341 tons (1,265), principally columbite concentrates, mainly as a by-product of tin mining.

Non-Communist world consumption for tantalum metal or equivalent was about 540 tons in 1969, of which the United States accounted for 75 percent. The steep growth of its use in the United States has largely resulted from an increasing use of tantalum in electrolytic capacitors used in the electronics industry.

Demand for columbium has doubled during the last decade and estimates of projected demand suggest that it may expand a further 60 percent by 1975.

R. P.

Tin. On the basis of preliminary statistics available for the first three quarters of 1970 domestic mine production of tin will probably increase to about 8,600 tons for the year as compared with 8,100 tons in 1969. Domestic reserves of tin, particularly those contained in hard-rock deposits, continue to be expanded and expansion plans announced by the major hard-rock producers indicate that Australian mine output of tin will be well in excess of 10,000 tons per annum within a few years. In particular, Renison Ltd has completed a study to test the feasibility of more than doubling the throughput of ore at its Renison-Bell operation. A more immediate increase in production will result from the commissioning of a 10,000 ton-per-month flotation plant designed to recover fine tin from gravity-concentrator tailings. During 1969/70, the company's pilot-scale flotation plant achieved a recovery rate of almost 62 percent in the production of tin concentrates assaying about 22% Sn. In the same general locality, Cleveland Tin N.L. will increase output of tin-in-concentrates from its Luina plant by about 30 percent to some 2,000 tons per annum. As in the case of Renison, Cleveland is installing flotation facilities for the recovery of fine tin. In New South Wales, Ardlethan Tin N.L. is increasing capacity at its Ardlethan plant from 1,000 t.p.d. of ore to 1,500 t.p.d. to cope with increased mine production from the Ardlethan West deposit. Stripping of overburden has commenced from the deposit which will be developed as a joint project of Ardlethan Tin N.L. and Storeys Creek Tin Mining Co. N.L.

In addition to continued increase in mine production, the results of recent expansion in tin smelter capacity are also becoming evident. Although domestic smelter production of primary, refined tin will probably be confined to about 5,500 tons in 1970 (4,156 tons in 1969) smelter capacity of about 7,000 tons of refined tin per annum was achieved towards the end of the September quarter, 1970.

Overseas, the eighteenth meeting of the International Tin Council under the Third International Tin Agreement was held in London on 19-21 October 1970. The Council agreed to raise the floor price in the Tin Agreement from £1,260 per metric ton to £1,350 per metric ton, and the ceiling price of £1,605 to £1,650. The lower sector was revised to the range £1,350-1,460, the middle sector to £1,460-£1,540, and the upper sector to the range £1,540-£1,650.

Since July 1970, the world market for tin has remained relatively stable with the London Metal Exchange quotation for spot tin fluctuating within the current middle sector of the Tin Agreement, i.e. the sector within which the Buffer Stock manager does not normally operate. In recent months, prices have tended to firm with supply and demand in reasonable balance, the continued absence of stockpile releases by the United States General Services Administration, and the virtual exhaustion of buffer stock holdings—as at 30 June 1970 the buffer stock of the International Tin Council held only 955 tons of tin metal. In early Sep-

tember, the L.M.E. cash price for tin moved into the upper half of the current middle sector, i.e. above £1,500 per metric ton, and remained above this level throughout October and most of November, before easing to £1,480 in late November.

J. W.

Tungsten. In 1969 domestic production of wolfram concentrates increased by more than 50 percent over 1968, and overall output of 2,645 tons (65% WO_3 basis) of tungsten concentrates was the highest level ever recorded in Australia. Domestic mine production of tungsten was well maintained during the first half of 1970, and, although wolfram output has continued at a high level, scheelite production decreased significantly in the September quarter due principally to a shortfall of development ahead of ore in the No. 1 orebody of King Island Scheelite (1947) Ltd which resulted in inflexibility of selection of ore-grade. The ratio of stripping of overburden has been increased from 3:1 to 10:1 to overcome this difficulty. Nevertheless, it appears likely that losses in production up to date will be such as to reduce total domestic production of tungsten concentrates in 1970 to a level marginally below that of 1969.

In the longer term, significant increases in domestic production of both wolfram and scheelite may be expected. Overall resources of the Aberfoyle-Storeys Creek tin-wolfram operation are being concentrated at the Storeys Creek wolfram mine where daily ore production is being expanded from 275 tons to 400 tons to take advantage of the continuing high prices of tungsten ore. Expansion plans by King Island Scheelite (1947) Ltd include the erection of a new concentrator with supporting facilities and the development of No. 2 and No. 3 orebodies to increase ore throughput from 300,000 t.p.a. to 450,000 t.p.a. by 1973.

Overseas, the London price of wolfram concentrates which had climbed to over 700 shillings per long ton unit WO_3 in May and June 1970 began to decline in the latter half of the year in line with the easing in overall world demand and the uncertainty in world markets pending an official announcement concerning future tungsten releases from the United States Government stockpile. By mid-October, the London *Metal Bulletin* quotation for standard grade wolfram had been reduced to the range 520-500 shillings per l.t.u. WO_3 . On 22 October 1970 the United States General Services Administration announced details of its future disposals programme. In summary, the programme will consist of domestic off-the-shelf sales and sales for export on a competitive bid basis. The domestic offering will consist of 20-25 million pounds of tungsten at an initial base price of \$55 per short ton unit WO_3 . Of this amount the G.S.A. will offer up to 7 million pounds (W content) through to 30 June 1971. Disposals offerings for export are seen as about 4 million pounds (W) up to mid-1971 consisting of 0.75 million pounds in the initial offering, and subsequently monthly offerings of up to 0.5 million pounds, with an overall limit of 6 million pounds (W) for export up to mid-1971. No sales for export will be made at price levels lower than the shelf price for domestic consumption.

Open market quotations began to firm following the G.S.A. announcement, and, supported by the establishment of a virtual floor price of 530 shillings per l.t.u. WO_3 c.i.f. Europe (the equivalent of \$855 per s.t.u. WO_3), European prices had recovered to the range 560-600 shillings by late November 1970.

J. W.

NON-METALLIC MINERALS

Barite. Mine production of barite during 1969 was 39,562 tons, which was only slightly higher than in 1968. The bulk of production was again from South Australia, which increased by about 10 percent to 36,061 tons. This increase was partly offset by reduced output from New South Wales, although there was a slight upturn in Western Australian production. Domestic consumption continued at a relatively high level, following the recent boost provided by off-shore drilling operations, and is estimated to have been in the range 14-15,000 tons.

Exports of barite increased further in 1969 to 23,995 tons, valued at \$811,827. Increased sales to Brunei (12,910 tons) and New Zealand (3,767 tons) accounted for the increase, despite a fall in shipments to Papua, to 7,009 tons, from 12,983 tons in 1968. There is a growing demand for barite in the Southeast Asian area for use as a weighting agent in oil drilling muds. A consequence of this is that Australian producers are developing mining and treatment facilities in the northern part of the continent which is closer to this potential market.

South Australian Barytes Ltd (SABAR) reported that considerable work had been carried out at Inverway, N.T., in preparation for the delivery of barite ore to Wyndham by road trains, which were expected to commence operating in the latter part of 1970. The company proposes to transfer its larger mill from Quorn, S.A., possibly by early 1971.

Mineral Deposits Ltd is conducting an exploration programme for barite in Australia, on behalf of Baroid Australia Pty Ltd. Samples of high grade barite from the company's prospect at Dorisvale, N.T., have been tested by the Bureau of Mineral Resources.

A. J. G.

Fluorspar. Probably the most significant development in the domestic fluorspar industry in recent months has been the commencement of commercial production near Walwa, Vic., in April 1970. Nevertheless, the bulk of local requirements of metallurgical grade and the total requirement of acid grade are still imported, and consumption in the iron and steel and fluorochemicals industries is continuing to increase. As a result of the growing pressure on reportedly limited world supplies of fluorspar, several companies are currently engaged in exploration activity in Australia.

There was no recorded production of fluorspar in Australia during 1969; however, Frank Hambridge Pty Ltd, of Sydney, commenced production in April 1970 at the Pine Mountain mine, near Walwa. The company plans to increase output to 60-80 tons weekly by the end of 1970; the ore is reported to be of metallurgical grade, with an average assay of 88% CaF_2 . The mine has been worked intermittently in the past, for a total recorded production of 4,155 tons up to 1960.

Imports of fluorspar increased by 34 percent in 1969 to 20,022 tons, valued at \$667,449, which was still below the record of 22,431 tons imported in 1967. The value of imports in 1969 was much higher than in any previous year as a result of the high proportion of acid grade material imported from the United Kingdom. Mexico was a major source of metallurgical grade in 1969 (8,500 tons) and imports from South Africa were lower at 2,291 tons (4,512 tons in 1968). In the first half of 1970, imports continued at a high level and were 13,534 tons, valued at \$446,804; the bulk of these (10,633 tons, valued at \$331,776) was from South Africa.

Apparent consumption of fluorspar in 1969, based on imports, was about 20,000 tons, which is probably close to actual consumption according to company statements on usage. The steel industry is estimated to have consumed around 12,000 tons. Consumption by The Broken Hill Proprietary Co. Ltd is expected to increase by 66 percent with the commissioning of a new basic oxygen furnace at Port Kembla by the end 1971.

A. J. G.

Sulphur. Due to the depressed demand for sulphuric acid for superphosphate, domestic output decreased further during the first seven months of 1970. Production was 940,000 mono-tonnes, which represented a 10 percent increase compared with that of the equivalent period in 1969.

Total imports of elemental sulphur (in bulk) in the first half of 1970 were 202,657 tons which is about 27 percent greater than that of the corresponding period of 1969.

Production of elemental sulphur in the non-Communist world is expected to reach 18.2 million tons during 1970, an increase of about 6 percent on output of the previous year. Actually, this expansion of output would seem to be attributable to the further growth of production in Canada and to increased supplies from the Near East, in particular from Iran and Kuwait.

In Canada, significant expansion of gas processing and sulphur recovery capacity scheduled for introduction in 1970 is expected to add 1.0 million tons to the 1969 level of output, making a total of 4.7 million tons of recovered sulphur.

However, output by Frasch producers is likely to be dependent on the volume of sales, and any downward trend will be partially offset by expanded production of recovered sulphur in the United States and in France.

Z. K.

Talc. Production of talc increased by 30 percent in 1969, with continued expansion in production for the export market. Total production of talc (including steatite) was 49,267 tons, valued at \$791,697, compared with 38,280 tons, valued at \$657,000 in 1968. There was a sharp increase in pyrophyllite production in New South Wales from 501 tons in 1968 to 2,766 tons in 1969.

Most of the increased activity was at Three Springs, W.A., where output increased by about 47 percent to 36,293 tons. Production from South Australia continued to expand, and was 12,262 tons.

There was a 34 percent increase in the quantity exported in 1969, in part the result of steadily rising shipments from Western Australia to the Netherlands, which were 21,885 tons, compared with 18,725 tons in 1968. The increase was mainly attributed, however, to the commencement of exports to Japan at a relatively high level in the third quarter of the year; shipments to Japan totalled 9,818 tons, valued at \$241,945, for the half year. Exports during the first half of 1970 totalled 15,981 tons, valued at \$409,166, of which 7,860 tons went to the Netherlands and 7,169 tons went to Japan.

A. J. G.

MINERAL RESOURCES OFFSHORE WITH SPECIAL REFERENCE TO AUSTRALIA

by L. C. NOAKES

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Mineral Resources offshore with Special Reference to Australia

L. C. NOAKES

INTRODUCTION

Important amongst man's recent achievements in science and exploration is his growing knowledge of environments offshore and of associated mineral resources. Although tin deposits were first mined offshore in the early years of this century, systematic investigation of mineral resources had to await new methods and equipment which have been developed in the last 20 years.

Production from the first offshore oil wells in the late 1940's indicated the new potential for shelf resources which petroleum production in more recent years has now firmly established. Minerals other than petroleum offshore have shown much less spectacular potential than has petroleum although the tendency still exists in some quarters to view all offshore prospects in the same encouraging light.

This article attempts to review present knowledge of mineral resources offshore with special reference to the Australian region; it can provide no more than a progress report because knowledge of offshore environments is very incomplete and is continually broadening. More emphasis is placed on minerals other than petroleum offshore because these have not enjoyed the same publicity as petroleum and thus tend to be less well understood. Petroleum is certainly likely to continue as the most important resource of continental shelves where current investigations are centred, but on the other hand in the future metals are likely to be the dominant resources in the deep oceans beyond the continental shelves.

Although this progress report deals primarily with potential in Australian waters, the subject matter appears so new as to require some general background information on mineral resources offshore to which progress in Australia can be related. In consequence, the article briefly refers to the types of mineral deposits currently known offshore and discusses potential and current constraint to exploitation before dealing with progress in Australian waters.

ENVIRONMENTS OFFSHORE AND ASSOCIATED MINERAL DEPOSITS

The seabed can be divided into two broad environments on both morphological and geological grounds—the continental shelf and slope, and the deep ocean basins; each has its own set of geological characteristics which in turn give rise to potential for different mineral deposits. General morphology offshore is shown diagrammatically in Figure 1 and types of mineral deposits in Figures 2 and 3.

Turning first to morphology, the continental shelf extends seawards from the land mass and gives way to the continental slope which leads down to the deep ocean floor. The width of the shelf can range from about nothing to 1,400 kilometres, and shelf seas are comparatively shallow in most places the shelf is bounded sea-

ward by a shelf edge where a marked change in inclination signals the upper end of the continental slope. The edge of the shelf has been defined for international purposes as water depth of 200 metres although in fact shelf edge throughout the world is normally somewhat shallower and between 110 and 146 metres.

The continental slope has an average inclination of about 4 degrees and leads down to the deep ocean floor at depths of 2-4,000 metres. In some, but not all places the continental slope towards its lower end flattens out forming a feature known as the continental rise; this normally represents a fan of largely detrital material accumulated along the bottom of the continental slope.

The deep ocean floors show considerable variation in morphology; they include abyssal plains commonly 3,000-6,000 metres in depth, but also deep ocean basins, submarine mountain ranges and sea mounts as well as deep trenches which provide the greatest depths known in the ocean.

This broad division of the sea floor into continental shelves and deep ocean basins reflects fundamental differences in geology between the two regions. The continental shelf and slope represent the prolongation of the land mass beneath the sea and are part of the thick continental crust, called "sial", which is typically composed of acid igneous rock and derived sediments; the continental shelves were, in fact, dry land at periods during the Pleistocene Ice Age within the last million years when the shoreline, itself not a static feature, retreated to near shelf edge.

In contrast, the deep ocean bed is typically underlain by oceanic crust (sima) which mainly consists of basic igneous rocks; the oceanic crust averages about 9 kilometres in thickness and is considerably thinner than the continental crust which averages about 35 kilometres in thickness. Both types of crust rest on an inner zone of the crust called the mantle, the upper boundary of which is known as the Mohorovicic Discontinuity (Moho).

Current concepts of ocean spreading suggest that continents have drifted apart, particularly in the last 200 million years, as sea floors have been extended and floored by submarine volcanic material erupted from the prominent ridges which are characteristic of all the major oceans. The oceanic crust is commonly overlain by Mesozoic and younger sediments which consist of fine grained ooze and clays away from the continents, but include considerable thicknesses of coarser grained sediments adjacent to shedding continental masses.

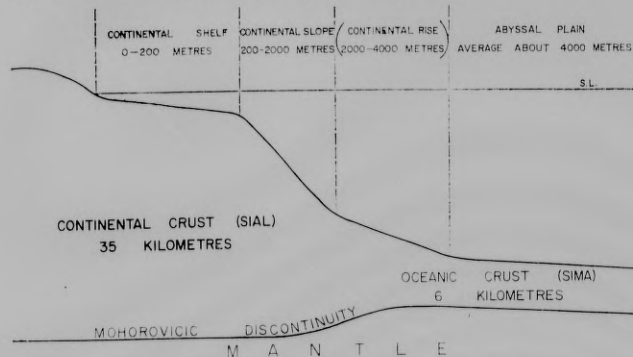


FIG 1 GENERALISED MORPHOLOGY AND STRUCTURE

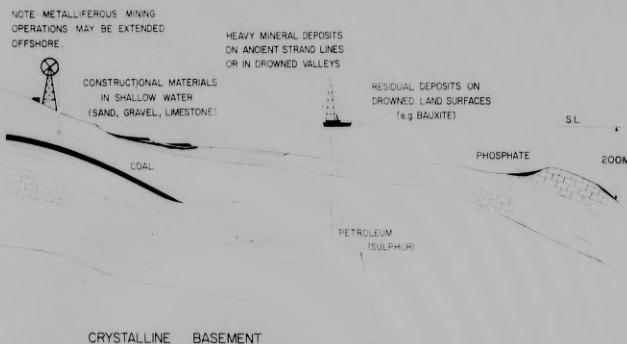


FIG 2 MINERAL RESOURCES OF THE CONTINENTAL SHELF

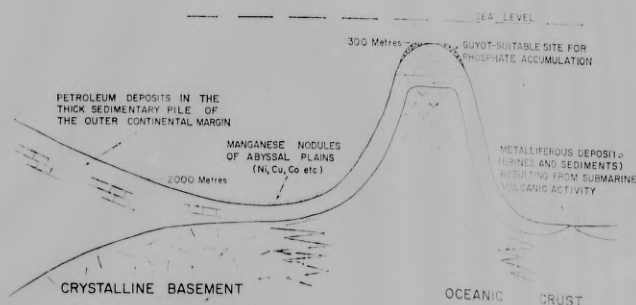


FIG 3 MINERAL RESOURCES OF THE OCEANS

The contrast between these two fundamentally different environments offshore is inevitably reflected in the character of associated mineral deposits; as a prolongation of the continent, the continental shelf may be expected to exhibit the range of mineral deposits well known on land, whereas the few types of mineral deposits already recognised in the deep sea basins represent a different group of which study is just beginning.

Before listing in turn the types of mineral deposits known in these two environments offshore, the mineral resources of sea water itself deserve mention. Sea water contains on average, 3.5 percent of salts in solution; some 60 of the 102 elements known to man have been measured in sea water, although nearly all of them are in very minor concentrations (Mero, 1961). Since the oceans of the

world hold some 330 million cubic miles of water, even low concentrations of metals such as the 0.01 parts per million for zinc, iron, and aluminium and 0.003 parts per million for tin, copper, and uranium represent a prodigious source of minerals for which future generations may well of necessity find processes for economic recovery.

At present, some of the world's salt is obtained by the controlled evaporation of sea water; bromine and much of the magnesium and magnesium compounds consumed come from the same source. Many attempts to extract gold commercially from sea water have failed (concentration 0.000004 parts per million), but recent experiments in the United Kingdom in the extraction of uranium from sea water by ion exchange, although far from commercial, provide some promise that the mineral potential of sea water will be further tapped at some future time.

Returning to the seabed and first to the continental shelf, potential mineral deposits may be conveniently related to two sub-environments, the consolidated, lithified or crystallized rocks beneath the seabed and the veneer of more recent unconsolidated sediments which commonly blanket the consolidated rocks and form the sea floor itself (see Figure 2). The consolidated rocks of the continental shelf can include the same range of sedimentary, metamorphic, and igneous rock types as are found on the continent, although as a result of preponderance of marine conditions in shelf areas, continental shelves probably have a higher proportion of unaltered sediments than is common beneath the continents themselves.

Beneath the continental shelves and slopes therefore, one might expect to find the deposits of petroleum, coal, water, etc. associated with sedimentary basins on land and, in metamorphic and igneous rocks, the type of metalliferous deposits which continue to provide us with metals on land. In fact, the continental shelf and slope are parts of the continent equally prospective as dry land, but where cover of water has until very recent times prevented man from exploring and mining. Indeed, offshore prospects for petroleum may well be better than those on land because relatively young sediments of Mesozoic and Tertiary age are the favoured host rocks for petroleum accumulation throughout the world and these younger sediments are more extensively preserved on continental slopes and shelves than on the continents themselves. According to figures given by Kossinna (1921), the area of continental shelves to a water depth of 200 metres extends the prospecting areas of the continent by 5 to 6 percent; the addition of the continental slopes to a water depth of 2,000 metres considerably extends this area to a total of 23 percent of the area of the continents themselves.

Sedimentary basins offshore, commonly the continuation of those known onshore, are potential sources of petroleum, coal, water, sulphur, potash and other minerals such as clays and uranium which can occur in this environment. Petroleum continues to make the major contribution from consolidated rocks offshore but the reasons for this are discussed later.

The igneous and metamorphic rocks beneath the continental shelf and slope doubtless include lodes or orebodies similar to those known on or below the land surface although the effects of surface weathering in terms of leached outcrops or induced secondary enrichments, well known on land, are likely to be rare developments offshore.

The more recent unconsolidated sediments which commonly blanket the basement rocks of the continental shelf make their own contribution to potential mineral deposits. This includes construction materials such as sand, gravel, shells and coral and detrital heavy minerals such as gold, tin and the beach sand minerals magnetite, ilmenite, rutile, zircon and monazite, concentrated in ancestral stream beds or beaches. Phosphorite and manganese nodules are also found in places on continental shelves but these are more commonly found in deeper waters.

Environments of the deep ocean are still being explored and no doubt our knowledge of potential mineral deposits in this environment is presently very incomplete. Currently three types of mineral deposits are recognised. Deposits of phosphorite are known in comparatively shallow waters from about 60 to 3,000 metres, commonly encrusting the top or sides of banks on or separated from the continental shelf, on steep submarine escarpments, or on the tops or sides of seamounts rising up from the deep ocean floor. The occurrence of phosphorite in these places apparently stems from supplies of cold, phosphorus-rich ocean water, commonly from the upwelling of deep ocean currents, to parts of the sea floor where little or no clastic sediments can dilute the chemical or organic accumulations of calcium phosphate.

Nodules of manganese, rounded or of irregular shapes and ranging in size from a few millimetres to large slabs, are widely distributed on the sea floor from continental shelves to abyssal plains of the deep ocean floor. The nodules commonly lie on the sea floor itself with little or no cover of sediments and in places form almost a continuous layer; although their distribution is likely to be patchy, large quantities can be recovered by dredging. Economic interest lies not so much in the oxides of manganese and iron, of which the nodules are principally composed, as in the many associated trace elements, notably nickel, copper, and cobalt. In general, nodules found in shallower water show relatively low concentrations of these valuable metals whereas nodules occurring on parts of the deep ocean floor in all oceans, commonly at depths of 3,500 to 4,000 metres, are more attractive commercially.

TABLE 1: AVERAGE METAL CONTENT OF SURFACE MANGANESE OXIDE NODULES FROM DIFFERENT REGIONS (after Cronan, 1967, in the Pacific and Indian Oceans, and Manheim, 1965, in the Atlantic)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Mn	34.0	14.9	22.4	18.4	15.9	16.4	16.1	14.0	12.6	13.7	15.8	15.1	13.5
Fe	1.6	12.7	8.9	10.9	9.6	14.1	13.5	13.1	12.1	15.9	11.3	17.7	15.5
Ni	.1	.4	1.1	.9	.9	.4	.5	.4	.5	.3	.5	.3	.3
Co	.1	.5	.2	.2	.2	.6	.4	1.1	.2	.3	.1	.5	.2
Cu	.1	.1	.7	.3	.6	.2	.4	.1	.3	.1	.3	.1	.2
Depth (m.)	3,535	1,131	4,553	4,141	5,025	3,551	5,024	1,756	5,142	3,722	5,046	3,240	

- (1) Southern California borderland (3 samples).
 (2) Baja California borderland-seamount (6 samples).
 (3) Northeast Pacific (10 samples).
 (4) Southeast Pacific (11 samples).
 (5) Central Pacific (12 samples).
 (6) South Central Pacific (12 samples).
 (7) West Pacific (30 samples).
 (8) Mid-Pacific Mountains (5 samples).
 (9) North Pacific (5 samples).
 (10) West Indian Ocean (13 samples).
 (11) East Indian Ocean (14 samples).
 (12) Carlsberg Ridge (10 samples).
 (13) Atlantic Ocean (excluding Antarctic sector).

McKelvey and Wang, 1969.

Mero (1965) has suggested that the metal content of nodules in the deep oceans varies fairly systematically so that regions can be delineated in which nodules have different characteristics—high manganese, high nickel and copper, or high cobalt. However, current data are insufficient to provide any reliable average metal contents of nodules throughout the deep oceans. Table 1, taken from McKelvey and Wang (1969), shows the average analysis of samples taken from a number of localities in three major oceans and emphasises the Northeast, Southeast, and Central Pacific Ocean as attractive for the mining and recovery of nickel and copper.

The third type of deposit presently known from the deep oceans concerns the occurrence of heavy metal deposits in fine sediments of which the Red Sea muds remain the first discovered and best example. These sediments, discovered and explored in the last decade, occur in at least three small basins or depressions

towards the centre of the Red Sea; the largest of the three basins, called the Atlantis II Deep, measures about 56 square kilometres at a water depth of about 2,000 metres, with a bottom layer of sediment at least 10 metres thick overlain by metal-bearing brines with temperatures up to 56° C. The sediments appear to be layered and include a sulphide bed of about 1 metre in thickness containing particularly zinc, copper, and lead. The average assay of the top 10 metres of sediments in Atlantis II Deep shows Cu 1.3%, Zn 3.4%, Pb 0.1%, Fe 29.0%, Ag .0054%, Au .00005% (Emery, Hunt and Hays, 1969).

Fine grained metal bearing sediments discovered recently off the east coast of U.S.A. in water depths of about 3,000 metres, probably belong to the same class of deposit; one sedimentary layer contained significant quantities of sphalerite (zinc sulphide) and another some native copper although both layers were found at depth below the sea floor and not in surface layers amenable to dredging.* The Red Sea muds appear to be associated with graben tectonics and igneous intrusives from which the metals may well have been derived by exhalations or hydro-thermal fluids. Little is presently known about the origin of the metal-liferous sediments off the coast of U.S.A. but the environment appears to be different from that of the Red Sea occurrences and suggests that additional occurrences of metal bearing sediments may well be discovered on or beneath the ocean floor.

CURRENT POTENTIAL OFFSHORE

We should now turn from this background of types of mineral deposits to be found offshore to a realistic analysis of present potential beyond the shoreline based on the capacity of present technology to discover, mine and treat.

The course of events offshore in recent decades has of course been controlled by man's capacity not only to discover but also to exploit. Although in fact tin has been mined offshore, as a continuation of deposits known on land, off and on since early this century, systematic prospecting for inferred mineral deposits offshore had to await the advanced technology developed since World War II.

Although development directly associated with marine investigations such as improved diving equipment, submarines, underwater photography including closed-circuit television, and sophisticated positioning and navigational equipment have all played their roles, the major contribution has undoubtedly come from the extension of geophysical surveys from the continents to offshore areas. Aero-magnetic surveys, first developed on land to measure major changes in the earth's magnetic field and thus provide some indication of the thickness of sediments in sedimentary basins and the configuration of basement rocks, were readily extended to provide the same information offshore; moreover, more detailed magnetic data became available through the development of magnetometers towed behind oceanographic research vessels. Gravity surveys developed on land to measure the force of gravity at successive stations, and thus provide data on the density of rocks beneath the surface were also extended offshore, initially by lowering a marine gravity meter to the sea floor but subsequently by designing shipboard instruments to provide a continuous record.

However, the major geophysical contribution to geological knowledge offshore must be credited to the seismic method by which the structural pattern, particularly of sedimentary basins, could be determined. The process developed on land of initiating and recording the travel times of shock waves using explosives was first adapted for marine investigations by using one vessel to produce submarine explosions and another to record the resultant shock waves; however, advancing technology produced methods using sound waves from an electrical or compressed air source which obviated the use of explosives in marine prospecting geophysics and could be carried out from a single vessel. Furthermore, by varying frequency, it was possible to seek maximum resolution in the seismic records either in surface layers or at depths of thousands of metres below the seabed.

* Dr. C. C. von der Borch (personal communication).

The combination of these geophysical tools offshore was well designed to investigate thickness and structure of both consolidated and unconsolidated sediments below the sea floor; but in assessing the practical results of this the capacity to exploit mineral deposits becomes an important factor. In terms of the consolidated rocks of the continental shelf, petroleum, sulphur, and evaporite minerals became practical targets because these minerals could be recovered through a borehole in contrast to other deposits of sedimentary basins such as coal and clays which cannot as yet be exploited by remote control from the surface of the sea. Admittedly, gas and oil wells needed to be completed for production by men working on the seabed but technology was equal to this task; to date, wells have now been completed in 310 metres of water and manual completion can probably extend to depths of at least 400 metres, below which new systems of remote control may be necessary.

As a result of these advances about a sixth of the world's petroleum is now produced offshore and sulphur is being won offshore in the Gulf of Mexico. However, stratified deposits of sedimentary basins like coal, clays and uranium remain resources for the future except where they can be mined, like coal, in extensions of mines developed on land; such deposits offshore could be found and assessed by current drilling technology offshore but neither present need nor technology supports their development.

Turning to possible mineral deposits contained in metamorphic and igneous rocks beneath the continental shelf, constraints imposed by current technology become more obvious in regard to both discovery and exploitation. Geophysical tools now available offshore can indicate the broad distribution of these rocks and magnetic surveys could assist in delineating some types of orebodies, but the geophysical methods of most use in delineating orebodies on land, the electrical methods, have yet to be adapted for work offshore where the presence of conductive seawater presents difficulties. Moreover, the exploitation of orebodies at depth offshore poses obvious difficulties although solution mining through boreholes or mining through caissons extending above sea level are possibilities for the future.

The major contribution to mineral production made by the unconsolidated sediments on the continental shelf continue to be the provision of construction materials in developed countries of Europe and North America where in some places deposits of sand and gravel are becoming scarce onshore. These offshore deposits can be readily dredged in shallow water and up to depths of 40 to 50 metres and can be delineated by shallow seismic survey with some drilling; doubtless both developed and developing countries will make more use of these deposits in the future where economics or availability favours operations offshore. Second to construction materials in annual value of mineral production from the seabed are deposits of offshore tin from Thailand, Malaysia and Indonesia; tin deposits offshore were delineated in the past by following economic deposits along river channels on land into the sea and confirming values by using land drills mounted on floating platforms. There appears to be no record of alluvial gold mining offshore although prospecting was active off Alaska, California and Nova Scotia in 1966-68. Most areas were subsequently relinquished but an encouraging near-shore prospect was reported in Alaska and one in Nova Scotia. Use of shallow seismic surveys and marine offshore drills greatly assists the search for deposits of detrital heavy minerals although present knowledge suggests some significant constraints to economic deposits of these minerals offshore.

Emery and Noakes (1968) have suggested a practical division of valuable detrital minerals into heavy heavy minerals (gold, tin, platinum, chromite), light heavy minerals (rutile, zircon, ilmenite, magnetite, monazite etc.), and gems (diamonds, sapphires etc.); this division recognises that economic deposits of the heavy heavy minerals with specific gravities above 6.8, occur principally in stream beds and less than 15 kilometres from source whereas minerals of the light heavy group, with specific gravities between 4.2 and 5.3, normally travel long distances,

and economic deposits principally depend on the high energy concentration of waves building beach deposits. Concentrations of light heavy minerals also occur in streams but very rarely are these economic unless they contain in addition minerals of the heavy heavy group like gold or tin to make stream deposits viable; in such deposits light heavy minerals may be recovered as by-products as in fact ilmenite and zircon are recovered from tin dredges in Malaysia. On the other hand, heavy heavy minerals like gold, tin, or chromite can occur in significant concentrations in beaches in close proximity to source, but such occurrences are rare.

Gems form a third group whose survival in stream deposits depends on toughness and extreme hardness rather than on a combination of resistance to erosion and specific gravity. Diamonds in particular can travel long distances and are known to occur in stream channels offshore and in some places in beach concentrations in South-West Africa.

From these considerations, Emery and Noakes have suggested a number of guidelines for the occurrences of economic deposits of detrital minerals on the continental shelf. In the first place, the most reliable guide to potential for heavy mineral deposits on the shelf is the occurrence of economic deposits either in stream channels or in beaches on land to establish provenance for minerals offshore. Occurrence of economic deposits of detrital heavy minerals seawards from a barren land could happen, but only under special conditions; prospecting in such areas would only be warranted if marine geological investigations had indicated the likely existence of both source and concentration on the shelf.

In the second place, since economic deposits of heavy heavy minerals occur close to source, known sources of minerals on land, even extending to the shoreline, are not likely to give rise to economic deposits along the seaward continuation of stream beds for more than 8 kilometres in the case of tin or for more than 15 kilometres in the case of gold. Economic deposits of these minerals farther removed from known sources would require areas of bedrock on the shelf which were sufficiently exposed during recent low stands of sea level to provide mineral concentrations. Such conditions may have existed in places but again prospecting would need to be based on detailed geological investigations because the exposure of bedrock through the veneer of recent sediments on the continental shelf is proving rather rare.

In the third place fossil strand lines, formed seaward from land areas shedding light heavy minerals and providing economic concentrations along the present shoreline, are likely to include concentrations of beach sand minerals; but these fossil beaches have been submerged beneath an encroaching sea which probably made some changes to original mineral concentrations. Likely processes and changes under these conditions are still obscure, but at least some reworking and changes in distribution of mineral concentration would be expected with perhaps remnants of original beach concentrations existing beneath cover of reworked or younger sands.

If, as seems likely, the entire sand body would need to be worked offshore, where selective mining as practised on land would at least be difficult, the grades offshore are likely to be significantly lower than those found along the present beaches, requiring very careful investigation and perhaps new techniques to exploit. Mining along fossil strand lines will need to contend with the active seas on which such concentrations have depended and is likely to face more problems than does current tin dredging offshore which operates in comparatively sheltered waters in Southeast Asia.

Occurrences of phosphorite are widespread although few localities are known where nodules are sufficiently abundant to constitute mineable deposits; occurrences off Baja, California, and on the Chatham Rise east of New Zealand appear to be in this category and doubtless other promising areas will be found.

However, it should be kept in mind that phosphate rock has a relatively low unit value—normally about \$6 to \$8 per ton of beneficiated product at the mine—and that there is at present an abundance of mineable supplies on land, chiefly in the U.S.A., North Africa, the Middle East, and in Australia. On that account the significance of submarine phosphorite may well relate more to resources for the future than for immediate supplies, although the economics of offshore mining are enhanced where deposits of submarine phosphorite exist in proximity to markets less readily served by known deposits on land.

The grade of phosphorite nodules varies considerably up to about 30 percent P_2O_5 and, in general, is stated by Mero (1965) to range between 20 and 30 percent P_2O_5 ; however, it is not clear whether this is the range of individual samples or the result of bulk sampling of potential deposits. As in the case of phosphate rock deposits on land, marine phosphorite would need beneficiation to provide a product better than 31 percent P_2O_5 ; the average grade offshore and the character and cost of beneficiation will therefore be important factors to be considered with the cost of dredging and of transport to shorebased treatment plants. As no marine deposits have yet been exploited the pioneering and costing of recovery methods has yet to be done.

Like marine phosphorite, there is little doubt that manganese nodules represent significant resources for the future, particularly in terms of nickel, copper and cobalt, although it is not clear when such deposits may become viable. Again, there is no shortage of manganese, nickel, copper, or cobalt on land although of course manganese nodules might provide the closest source of these metals to markets in some parts of the world. It follows that viability in the immediate future will require an order of costs of mining, treatment, and delivery at least no greater than those pertaining to deposits on land.

Referring to Table 1 and considering the most promising average assay of ten samples from the North-West Pacific, the average content of 1.1 percent nickel, 7 percent copper, and 0.2 percent cobalt, allowing an overall 85 percent recovery, would presently return at marketing point about \$38 per long ton of nodules; it seems doubtful whether the manganese content could be marketed, but if so this would add another \$6 to \$7. The market value of the combined nickel, copper and cobalt content, at \$38 (\$24.4 nickel, \$6.3 copper and \$7.3 cobalt) looks attractive as the equivalent of over 4 percent copper on land, but other difficulties are likely to arise. Harvesting in bulk by some type of suction dredge, even from great depths, is possible, although no reliable order of costs is available; however, treatment on commercial scale to recover both nickel and copper or all three metals certainly presents difficulties. Recovery by a number of promising processes such as differential leaching or solvent extraction have been investigated in the laboratory, but one gathers from recent workers like Brooke and Prosser (1969) that despite encouraging progress much has still to be done.

A further difficulty may well lie in the marketing of cobalt for which world demand is of the order of 20,000 tons per year. Since the mining of manganese nodules would probably require economies of scale and throughput of at least 1,000,000 tons of nodules per year, each separate plant would recover nearly 2,000 tons of cobalt or about one-tenth of the world's demand so that extensive mining would be likely to result in depressed prices for cobalt or other difficulties in marketing the material. The same 1,000,000 ton plant would produce about 10,000 tons of nickel and 6,000 tons of copper per year, but production of this order, representing about 2 percent and 0.1 percent of present annual world demand respectively should present few market difficulties unless many plants were in operation.

However, despite these difficulties a number of organizations are pioneering the recovery of manganese nodules, amongst them the International Nickel Corporation of Canada and Kenneco of the United States which has already successfully

harvested nodules from a depth of about 2,000 metres by a specially designed dredge off the east coast of the U.S.A. Moreover, a Japanese consortium is experimenting with nodule mining in the North Pacific.

The significance of the metal-bearing muds of the deep ocean also stems from promise of future resources rather than of immediate supplies. Preliminary values are available only for occurrences in the Red Sea where Bischoff and Manheim (1969) suggested that the upper ten metres of mud in the Atlantis II Deep contained 2.9 million tons of zinc and 1.1 million tons of copper. Estimates of gross value of metals per short ton of brine-free material, on late 1967 prices, was given as approximately \$us28 (or approximately \$us5 per short ton of mud in situ) at a depth of 2,000 metres.

At least two consortia continue investigations of these occurrences, although investigation and exploitation of this unique type of deposit will require new metallurgical and mining techniques. However, the problems of exploiting such deposits should not be allowed to detract from the importance of thorough investigation of known occurrences and of continued search for additional ones; these are some of the resources for the future which we will surely need to exploit.

This discussion of potential and problems in offshore resources might well conclude with brief reference to matters of tenure offshore. Limits of national and international jurisdiction offshore, and particularly in relation to the deep ocean, are present subjects for discussion within the United Nations and principally by the Committee for Peaceful Uses of the Seabed; these discussions are far from concluded but, on present showing, the deep oceans may come under some scheme of international control with national sovereignty extending at least to the 200 metre depth line on the shelf, as already ratified by a number of nations following the Geneva Convention on the Continental Shelf of 1958.

Present lack of agreement in these deliberations is apparently having little effect on exploration on continental shelves, particularly within the 200 metre line where national sovereignty is currently accepted by many nations, but some concern is apparent beyond the 200 metre depth line and particularly in the deep ocean basins beyond the continental margin.

Current investigation of manganese nodule deposits mentioned above indicates that prospecting and investigation has not been greatly affected to date, but matters of control of tenure in deep ocean basins need to be clarified as soon as possible in the interests of continued exploration for and eventually exploitation of resources which the world will certainly need.

In summary, and before turning to the Australian scene offshore, we should note that levels of current technology both in exploration and mining have inevitably induced the discovery and exploitation of petroleum as the first major economic fruits of exploration beneath comparatively shallow seas offshore; petroleum and kindred deposits of sulphur and evaporite minerals are likely to continue to provide the most valuable contribution to man from those parts of the continent covered by sea. Other possible resources of the consolidated rocks and the continental shelf and slope, like coal in sedimentary sequences or ore deposits in metamorphic and igneous rocks, are best regarded as resources for the future, requiring both improved technology and more urgent need to perfect discovery, assessment and mining. Unconsolidated sediments will make an increasing contribution as construction materials in the future and, in places, will provide some resources of detrital heavy minerals as man improves techniques for discovery and economic mining, although prospecting in this field is likely to be wasteful if not scientifically based.

Deposits of phosphorite in special localities on shelves or on highs in the deep oceans and those of manganese nodules at depth appear certain resources for the future where exploitation will depend on technology in both mining and treatment and the ability of these deposits to compete with those providing similar minerals on land.

Metal bearing muds in the deep ocean are further removed from current exploitation, but serve as a potent inducement to continue exploration beyond the continents in search of scientific understanding of sources of minerals which the world will need in the future.

PROGRESS IN AUSTRALIAN WATERS

Introduction

In the last decade Australia has followed a world trend in the commencement of systematic exploration of both continental shelves and ocean basins with initial emphasis on continental shelves where improved technology is gradually making available sub-sea resources.

Offshore prospecting, directed at petroleum, really commenced in Australia with aeromagnetic surveys off the coast of Gippsland in Bass Strait by the Bureau of Mineral Resources in 1956 and over Tasmanian waters in 1960; these led to more detailed investigations by companies in the early 1960's and since that time shelf investigations for petroleum have continued and increase in tempo. Details of petroleum tenements offshore are shown in petroleum tenement maps compiled by the Bureau of Mineral Resources at six-monthly intervals.

The early 1960's were also marked by a growing interest in minerals other than petroleum offshore, induced by the potential of new technology for exploration beyond the shore line. In Australia, this came at a time when exploration for heavy minerals onshore was nearing saturation and when the search for phosphate was under way and resulted in significant offshore prospecting in the middle 1960's which subsequently declined under the sobering influence of scientific assessments.

Exploration permits for minerals other than petroleum offshore covered 16 percent of the Australian continental shelf in 1967 when offshore prospecting was carried out off all coasts except those of Victoria and the Northern Territory. At present, there are a few cases of land tenements extending marginally offshore, and additional areas are held by Planet Metals Limited along the central east coast and by Ocean Resources Ltd off Weipa in the Gulf of Carpentaria. However, a map showing current offshore tenements would be misleading in that it could not indicate the present level of interest offshore, because applications have been made for many additional areas, particularly in eastern Australia. The tenement situation for minerals other than petroleum offshore remains complicated because matters concerning mining legislation offshore have still to be resolved between the Commonwealth and the States.

Uniform legislation between Commonwealth and States in regard to petroleum offshore (Petroleum (Submerged Lands) Act 1967) was passed by both Commonwealth and State Parliaments in 1967. This was followed by increased exploration and development offshore. In the case of minerals other than petroleum offshore the Commonwealth has proposed a Federal Act to uniformly control offshore exploration and development which States may administer off their own coasts. Pending the passage of this Act, the Commonwealth has agreed that it will honour titles granted by the States where the proposed grant is referred to, and concurred in by, the Commonwealth. A number of applications submitted by the States have been cleared by the Commonwealth on this basis.

The notes that follow on mineral exploration offshore are intended only as a progress report for the interest of those following Australian mineral development. The writer acknowledges with thanks the interest and guidance of many friends in the industry, in State Mines Departments, and of his colleagues in the Bureau.

Petroleum

Success in the search for petroleum offshore in Bass Strait has been well documented and needs only summary treatment in this article; the petroleum geology of the area has recently been discussed by Richard and Hopkins (1969).

Possible petroleum potential was first indicated by an aeromagnetic survey carried out by the Bureau of Mineral Resources in 1956. The sequences of comparatively younger sediments were further investigated by aeromagnetic and marine seismic surveys carried out by companies in 1962-64 which established promising structures, the first of which to be drilled in 1965, Barracoota, proved to be a commercial gas field. Subsequent drilling of other structures between 1966 and 1968 discovered two more large gas fields, Marlin and Snapper, and three oil fields, Kingfish and Halibut and Tuna. Relatively small oil reserves were also found in deeper sands of the Barracoota and Marlin gas fields. Initial reserves amounting to 1,580 million barrels of oil and about 10 trillion cubic feet of gas have been established in the basin, and the current production is providing some 200,000 barrels of oil and 73 million cubic feet of gas per day. Production of oil from Bass Strait in 1971-72 should reach 135 million barrels per annum or about 70 percent of Australian demand for crude oil at that time to meet local consumption. The recent successes offshore relate to the Gippsland Basin; investigations of other basins in Bass Strait, the Bass and Otway, have not as yet been successful although more investigations are planned in all three basins.

On present knowledge, prospects for petroleum appear more promising offshore than on the continent itself and, apart from Bass Strait, the continental shelf west and northwest of the continent appears most promising; both thick sedimentary sequences and promising structures have been identified in these areas although 19 offshore wells have now been drilled without establishing commercial fields. However, these wells have included Legendre No. 1, 220 kilometres west-northwest of Port Hedland which flowed crude oil at the rate of 1,014 barrels per day, which might have represented a small commercial oil field on land, Gage Roads No. 1, 42 kilometres west of Perth which test-flowed oil at a rate of 300 barrels per day, and Petrel No. 1, 160 kilometres west of Darwin, which struck high pressure gas in what might well be commercial quantities.

Prospects in other areas offshore, such as the Gulf of Carpentaria and the Barrier Reef area of Queensland, have still to be investigated and two wells in the Gulf of Papua (Pascas and Uramu) produced good flows of gas and considerable amounts of condensate in the case of Pascas.

The petroleum potential of the Australian continental shelf has been established and continues to support prospecting although it should be recognised that offshore prospecting for petroleum is much more costly than that on land and that the search offshore vitally needs a successful strike within the next year or so to maintain present interest offshore. It should be noted here that supplies of artesian water from sedimentary basins off dry coasts in Australia may well provide useful supplies for future development.

Heavy Minerals

Mineral Sands. There can be little doubt that Australia provides an outstanding environment in which to study mineral sand deposits offshore and that such a study should commence on the rich rutile and zircon deposits of the central east coast.

Investigation of possible offshore deposits was first commenced by the Australian-owned Planet Metals Limited which has worked consistently since 1965 off the central coast in areas between Newcastle and Brisbane. A number of companies followed Planet's lead and obtained prospecting permits offshore along the coast of N.S.W. and southern Queensland but most if not all of these were subsequently surrendered.

Revived interest in the last year or so has resulted in new applications for offshore owned Planet Metals Limited, which has worked consistently since 1965 off the permits in both States but, as mentioned earlier, the matter of tenure offshore has yet to be clarified.

* Termed "Authority to Prospect" in Queensland and "Exploration Licence" in N.S.W.

In investigating occurrences of heavy minerals offshore over the years Planet has developed new equipment and techniques for use in many aspects of offshore prospecting for mineral sands including drilling, seismic profiling, sample analysis and precision positioning at sea by the use of laser beams; research and development are being followed by detailed investigations of mineral deposits.

Brown and MacCulloch (1970) have provided some interesting information on mineral occurrences found to date. Heavy mineral concentrates can occur in a blanket or layer of sand 1.5-5 metres below the sea bed, overlying barren material or more commonly in seams in fossil beaches beneath 3-5 metres of generally barren sediments. The company has identified and concentrated on a near-shore fossil strandline in about 30-36 metres of water; there is evidence of a second strandline in 70-80 metres of water and beyond this two more strandlines are postulated in depths of less than 140 metres. Although much detailed assessment is still to be done Brown and MacCulloch give some indication of overall grade of a strandline along some 30 kilometres of coast commencing about 70 kilometres north of Newcastle where total heavy mineral content of the sediments (presumably to a thickness of 10-13 metres) averaged 0.8 percent with rutile plus zircon content in excess of 50 percent of the heavies. Assuming approximately equal quantities of rutile and zircon the overall grade of these sediments, in terms of rutile, would be in the range 0.20-0.25 percent. The most recent report by Planet refers to 375 million tons of mineral sand with an estimated grade of 0.20-0.22 percent rutile and to an indication of a further 500 million tons. Although the average grade mined on land is considerably higher than 0.22 percent rutile, cut off grades have fallen in places to at least 0.15 percent rutile and, given economies of scale, sand averaging 0.20-0.22 percent rutile and equivalent zircon content, would be profitably mined onshore.

As mentioned earlier, grades of deposits necessarily mined in bulk offshore are expected to be lower than those available onshore, particularly if compared to those which were provided by virgin beaches in the past. The principal challenge offshore may well be to mine and treat as cheaply as on land.

Although resources of rutile, zircon, and ilmenite exist offshore it is, of course, too early to talk in terms of reserves which will depend on grade and mineability. It might be noted that if, as expected, fossil strandlines continue to prove low grade, the resources of valuable mineral contained per unit volume will bear little comparison with those contained in beaches already mined. From the results of initial drilling carried out by the Bureau of Mineral Resources in the early 1950's and applying to a sample of some 70 million tons of virgin beach sand straddling the N.S.W.-Queensland border (Gardner, 1955), the writer has estimated that the overall grade of this material, if mined in toto, would have approximated 4-5 percent heavy mineral with rutile and zircon contents of about 30 percent each.

However, future needs for rutile and ilmenite (including the high-chrome ilmenite of the N.S.W. coast, discarded in the past) emphasise the importance of present studies offshore. Little is known of fossil strandlines in deeper water but they too are worthy of investigation to collect data bearing on shelf processes and on the distribution of heavy minerals as well as to seek additional mineral deposits which future technology may be able to exploit.

Results off the central coast are likely to control interest in other areas offshore from the known coastal deposits shown in Figure 4. Offshore investigations extended northward towards Gladstone, on the central Queensland coast, would enter a dominantly ilmenite province in which much of the mineral is relatively low in chrome. Rutile and zircon were identified by Ocean Mining A.G. off Naracoopa, King Island, where these minerals are currently mined on land.

The main ilmenite province along the Bunbury coast in Western Australia, where ilmenite is accompanied by by-product zircon, monazite, and rutile, is known to include some offshore concentrations although little work has yet been done.

Ilmenite has a much lower unit value than rutile or zircon but this is compensated for by much higher concentrations of heavies in the Western Australian deposits compared to those of the east coast; there seems no cogent reason why mineable strandlines off a rich ilmenite coast should not be viable if operating costs could in fact approximate those now current on land.

However, strandlines inland from the Bunbury coast have suffered leaching and secondary cementation (coffee rock) which hinder mining and appear to be the result of sub-aerial weathering. Such alteration, which would present particular problems at sea, would not normally be expected in fossil strandlines offshore; however, a reported occurrence of cemented strandline material offshore in Western Australia calls for careful investigation.

Occurrences of relatively low grade concentrates onshore, like those reported north of Perth and at Point Blaze (Ward, 1957) and on Melville Island in the Northern Territory (McKay, 1956), provide no present encouragement for offshore prospecting on the premise that only under very unusual conditions would fossil strandlines be higher in grade than those on land. Beach sand deposits containing ilmenite, rutile and some chrome near Strahan, Tasmania, may be in this class but no grades are available for this deposit nor for newly discovered deposits of ilmenite near the western end of the Great Australian Bight.

On the other hand, although guide lines suggested for offshore prospecting seem logical on present knowledge, our understanding of the processes involved in heavy mineral concentration offshore is imperfect and leaves room for research and new ideas which could pay dividends in terms of unsuspected deposits. Although not an example of possible new processes, the coast line north of Gladstone and behind the Barrier Reef could conceivably contain better prospects for detrital heavy minerals than are at present apparent. Present beaches have low concentrates of heavies presumably as the result of low wave energy inside the reef; but on the assumption that the reefs have grown with gradual rise of sea level since the last glacial epoch, any beach remnants older than this event might contain high energy wave concentrations where a supply of valuable heavy minerals was available. Although any such fossil strandlines are likely to be well covered offshore, they might exist as raised beaches behind the present shore line or beneath the present strand.

Tin and Gold. Following the guidelines of tin prospecting offshore suggested earlier in this article, the shelf off north-eastern Tasmania, including that adjacent to the Furneaux Islands, and that off the north Queensland coast obviously show some possibilities. In both areas erosion of tin-bearing granites has given rise to economic deposits of alluvial tin along the valleys of coastal streams. North-eastern Tasmania would seem the more prospective area with tin granites and alluvial deposits close to the coast and with current tin dredging along the valley of the Ringarooma River close to the sea.

Tasmanian prospects were early recognised by Ocean Mining A.G., experienced offshore prospectors, who became the operative company of a consortium which included E.Z. Industries, Anglo-American Corporation and Bethlehem Steel.

Preliminary reconnaissance offshore commenced early in 1966 and included shallow seismic profiling and reconnaissance drilling; this indicated prospects for offshore tin off the central east coast of Tasmania (Oyster Bay), in Ringarooma Bay near the north-eastern corner of the island facing Bass Strait, and east of King Island where some tin, rutile, and zircon were found. More detailed investigation indicated that the best prospects were in Ringarooma Bay where a programme including 138 drill holes in water depths ranging from 10-40 metres was completed by early 1967.

Company reports lodged with the Mines Department, Hobart, were released on open file when the company surrendered their prospecting licence in 1969. A summary of results in Ringarooma Bay (Young, 1969) indicates that tin concentrations were patchy but generally followed the continuation of the Ringarooma River offshore; holes 1 to 1.5 kilometres apart gave some preliminary indication of reserves and suggested some 30 million cubic yards grading about four ounces of tin metal per cubic yard plus some zircon and high-chrome ilmenite to a maximum water depth of 40 metres; the sediments containing the tin were rarely more than 13 metres in thickness. The report mentions, however, that closer drilling might upgrade reserves by delineating additional rich patches and that tin bearing sediments are clearly likely to continue northwards, although into deeper water.

Neither quantity or grade as presently indicated offers much encouragement offshore in the active seas of Bass Strait. Indeed, a grade of four ounces tin metal per cubic yard onshore, worth about 28 cents per yard, sold as concentrates at late 1970 prices and assuming 90 percent recovery would presently be regarded as a low grade for an economic deposit. However, the possibility of upgrading the prospect has already attracted other company interests and prospecting licences have been sought.

The shelf around the Furneaux Islands also attracted some attention in 1967 as both Flinders and Cape Baron Islands include tin-bearing granites and have provided small alluvial deposits in the past. Broken Hill Proprietary Limited and Utah Development Limited combined in this area to carry out seismic profiling and reconnaissance drilling but found no prospects to warrant continued investigations.

Prospectors in these areas were aware of the possible occurrence offshore of the productive "deep leads" known onshore—tin-bearing stream gravels covered by valley fill of younger sediments. However, "leads" onshore lie as much as 33 metres below present sea level and under as much as 33 metres of overburden and such conditions offshore would not favour economic mining. The massive geology of this area, with notes on tin prospects, have recently been covered by Slater (1969).

Prospects off north Queensland do not appear as attractive as those off Tasmania although no intensive investigation seems to have been done. The main tin province of the Herberton area, inland from Cairns, is situated on a plateau and has contributed little tin to the sea. However, between Cairns and Cape York a number of coastal streams, like the Annan River, contain some tin and would have some possibility of generating tin deposits offshore. Some offshore prospecting permits were held in this area in 1966-67 and subsequently surrendered, but no prospecting results were released.

Elsewhere in Australia known tin fields seem too distant from the coast to provide offshore prospects (see Figure 4). The small tin field of the Finnis River, shedding in part into Bynoe Harbour south of Darwin, is an exception, but offshore prospects seem unattractive; tin and tantalite shed from pegmatite and greisen dykes appear to have moved very little distance from source in this subdued terrain and deposits presently known provide no suggestion of offshore continuation.

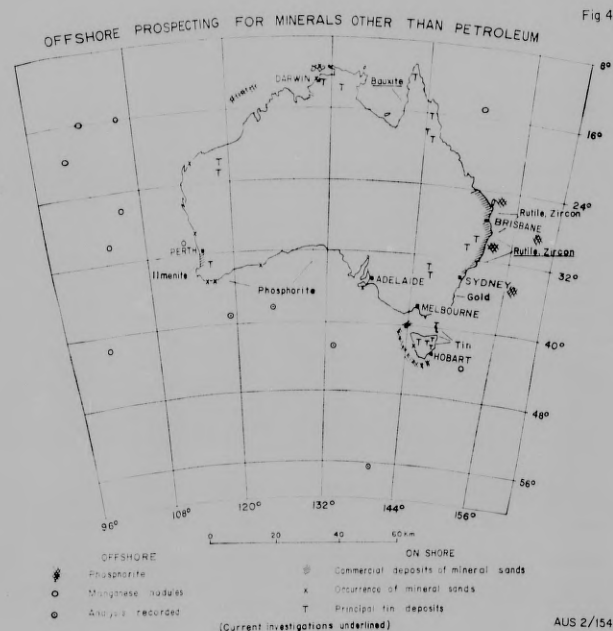
The only alluvial gold prospect known to have been investigated offshore in Australia was off Bermagui on the south coast of New South Wales, where records of mining last century reported rich gold values in beach sands. Planet Gold Ltd carried out a reconnaissance offshore in this area in 1967 but no results were released.

Phosphorite

In the first flush of shelf reconnaissance for minerals other than petroleum which occurred between 1965 and 1967, a number of companies prospected for phosphorite under permits granted by State Governments; these including shelf areas off the east coast of Australia and off Tasmania, in the Great Australian Bight, and off the west and northwestern coasts of Australia. These reconnaissances provided no encouragement, except on the west Tasmanian shelf, and this lack of success offshore, combined with the discovery on land of major deposits of phosphate rock in northwestern Queensland in August 1966, served to discourage the search for phosphorite on the shelf.

The Marine Geological Group of the Bureau of Mineral Resources took as its first project in 1967 a reconnaissance survey of the northwest shelf so as to commence geological shelf mapping in an area in which some upwelling was suspected and in which phosphorite could well occur. The results of this survey carried out in 1967 and 1969 (Jones, 1968, 1970) indicate uniformly low phosphate content in the sediments of the region with a maximum recording of 3.3 percent P_2O_5 ; sediments with higher than average phosphate content generally occur near the outer edge of the shelf in water depths of 200 to 300 metres.

However, marine reconnaissance carried out by Ocean Mining A.G., in Tasmanian waters with the same partners as mentioned earlier, located phosphate nodules on highs on the southern and western Tasmanian shelf in 1966; phosphate deposition presumably occurs as a result of upwelling principally along the western coast. Reports from the company available at the Tasmanian Mines Department



in Hobart indicate that the most encouraging concentrations and grades are likely to be found west of Tasmania and south and southwest of King Island (see Figure 4). Nodules were found in depths ranging from 65 to 165 metres, which is unusually shallow for phosphorite occurrences, and although the grade of most samples was less than 13 percent P_2O_5 , there were at least four localities on the western shelf where samples graded 13 to 26 percent P_2O_5 . However, these indications of possibly higher grade patches of phosphorite were not further investigated by the group.

Turning to eastern Australian waters, phosphatic nodules were dredged from the continental slope off northern New South Wales by Global Marine Inc. in 1966 and about the same time an oceanographic research vessel from Scripps Institution of Oceanography (U.S.A.) recovered phosphatic material from a sea mount rising from the Tasman basin some 500 kilometres east of Brisbane. Selected nodules from off Coffs Harbour assayed as high as 21 percent P_2O_5 (von der Borch, 1970) but most of the material was of very low grade and the survey was not continued beyond the reconnaissance stage.

These reports induced some company activity, but there was no way in which Australian Governments could support interest by providing some type of legal tenure over portions of the deep ocean beyond the shelf. The Bureau of Mineral Resources reconnoitred the area in 1969, but dredging of both the tops and sides of sea mounts in the Tasman Sea produced no evidence of phosphorite, suggesting that occurrence was patchy. However, company reconnaissance discovered smaller occurrences on sea mounts off the central and southern coasts of New South Wales although little detail of these has been released. Further work by the Bureau of Mineral Resources in 1970 has discovered phosphatic rock cropping out on the upper continental slope off Fraser Island, on the central east coast, in water depths of about 300 metres. More detailed results were not available at the time of writing, but is certainly of low grade. It is probably genetically related to the phosphatic nodules dredged from the continental slope farther south in 1966 by Global Marine Inc. and to the onshore Miocene phosphorites of southern Victoria.

Interest in marine phosphorite has recently been revived by Mr. G. Alcorn and colleagues who have formed a company, Ocean Resources N.L., to re-investigate phosphorite occurrences on the western Tasmanian shelf previously reported by Ocean Mining A.G. The company has applied for a prospecting licence along the shelf south and southwest of King Island where the occurrence of phosphorite is to be investigated in more detail, using bottom television to better determine density and distribution of nodules. The results of this investigation will be awaited with interest; commercial dredging and treatment of marine phosphorite from deposits providing good concentrations of nodules but beneath active seas, has yet to be pioneered against competition from land resources, but any encouraging concentrations in this area would have the advantage of proximity to markets in Tasmania and in southeastern Australia.

Bauxite

The search for bauxite offshore is presently unique to Australia and is being pioneered by Mr. Alcorn and colleagues through Ocean Resources N.L. with which the Canadian Superior Oil Company is associated in the search for bauxite in the Gulf of Carpentaria. Ocean Resources currently holds a prospecting authority of some 25,000 square kilometres in the Gulf off Weipa and commenced offshore drilling and investigations in November 1970; this project has aroused the interest of other companies in the search for possible bauxite deposits in the Gulf.

The bauxite occurring at both Weipa and Gove on both sides of the Gulf represents fossil weathering products of an ancient land surface which probably dates from the Lower Tertiary. Remnants of apparently the same land surface are found in the Daru area in south-western Papua and it is a fair assumption that this ancient land surface extended from the Northern Territory and Queensland, including the area of the present Gulf, northward into eastern Papua in Lower Tertiary times and that subsequent warping and faulting have been responsible for the flooding of the Gulf and for the present configuration of coastlines. The possibility of at least remnants of this ancient land surface with its crust of laterite or bauxite existing beneath the waters of the Gulf is thus a real one and as only a thin veneer of recent sediments has been found in many parts of the Gulf, the recovery of bauxite, if present, seems feasible.

The prospect of commercial bauxite mining beneath the Gulf is, however, subject to three main provisos, apart from the cost, which call for offshore investigations. First it has to be demonstrated that remnants of the ancient land surface or of its near-surface weathering products have in fact survived both continental and marine erosion during development of the Gulf. Secondly, ancient weathering products preserved beneath the waters of the Gulf may or may not be bauxite or high grade bauxite of export grade. The development of bauxite in a weathering profile presumably depends on both the character of the parent material and on pedological processes; if either of these factors changed west of Weipa, the weathering product may be laterite rather than bauxite. Thirdly, bauxite preserved beneath the Gulf would need to be sufficiently close to the seabed and to be sufficiently friable to be amenable to economic dredging.

These and other questions can only be answered by offshore prospecting, mainly by shallow seismic survey and drilling; these pioneering efforts in the Gulf of Carpentaria are to be commended as following the tradition of bold prospecting evident in Australia's mineral development.

Construction Materials

The only construction material presently mined offshore in Australia is dead coral from Moreton Bay, Queensland, which has been used in the production of cement at Darra for many years. Although an application to mine coral from Ellison Reef has been recently refused, there appears no substantive reason why dead coral should not be mined from portions of the Great Barrier Reef in the future to satisfy local demands provided reef areas are adequately investigated and mining controlled to avoid any permanent damage to the reef environment.

Apart from the reclamation of some littoral areas, resources of sand and gravel offshore in Australia have been little exploited in the past, partly because of the new approach and equipment required offshore, but mainly because deposits on land are fairly readily available. This situation is likely to continue in many coastal areas although in some, of which the city of Hobart is an example, shortage of readily available supplies of sand and gravel onshore is likely to promote the use of offshore resources in the near future.

Moreover, once equipment and techniques for offshore mining of construction materials become better established, the economics of offshore mining will become more precisely known with the likely result that more interest will be shown in offshore resources adjacent to centres of population along the Australian coast.

Manganese Nodules

Little is known as yet of the mineralogy of manganese nodules in the Australian region and little significance can be attached to the few random analyses available, mainly off the southern and western coasts. The Bureau of Mineral Resources

has commenced the collection of samples as opportunity offers, principally by visiting oceanographic vessels, with the purpose of providing preliminary data on metal content and a suite of samples for future investigation. Present emphasis is on the Southern Ocean where current tracks of M.V. *Ellunin*, National Science Foundation, U.S.A., promise additional samples.

A previously reported sample of nodules from a depth of 5,578 metres at Lat. 37° 50'S, Long. 124° 30'E (about 500 kilometres south of Esperance) analysed 18.4 percent Mn, 0.90 percent Ni, 0.45 percent Cu, and 0.15 percent Co; another sample taken from the depth of 4,760 metres at Lat. 42° 42'S, Long. 134° 10'E, showed 21 percent Mn, 1.15 percent Ni, 1.81 percent Cu, and 0.09 percent Co (Mero, 1965).

However, the average of 14 samples from the east Indian Ocean (Table 1) show relatively low metal contents and a sample taken by *Ellunin* in 1969 from a depth of 3,750 metres at Lat. 56° 25'S, Long. 140° 01'E (about 2,600 kilometres south of Adelaide) showed only 12.6 percent manganese, 0.45 percent nickel, 0.21 percent copper, and 0.08 percent cobalt. This sample was investigated in detail by Broken Hill Proprietary Ltd and a paper covering this work will be published shortly (Frazer and Ostwald, 1970). Although the material shows no current economic attraction, the investigation provides the first data of its kind in the Australian region; current investigations overseas to mine and treat manganese nodules underline the necessity for us to collect data on the distribution and character of nodules in the Australian region as probable resources of nickel, copper, and cobalt in future years.

CONCLUSIONS

Mineral deposits offshore can presently be discerned in three major environments—in the consolidated rocks of the continental shelf and slope, in unconsolidated sediments on the shelf and in the deep ocean basins. Given the appropriate technology, our experience in exploration on land can be directly applied to the search for petroleum and other minerals in the consolidated rocks of the shelf and the slope which are in fact part of the continents themselves; the other two environments offshore are new to us and require both new scientific knowledge and new technology.

Exploration offshore around Australia has already provided rich returns in terms of oil and gas on the continental shelf where currently the best prospects for additional petroleum reserves appear to lie. However, as in other parts of the world, petroleum and associated minerals in sedimentary rocks have been the first fruits of offshore exploration at present levels of technology; the exploration of other mineral deposits in consolidated rocks of the shelf and slope await advances in the technology of discovery and development.

The unconsolidated sediments of the shelf contain in places supplies of construction material and deposits of detrital heavy minerals and phosphorite; construction materials, given fuller investigation, will doubtless fulfil eventual need to augment or replace supplies onshore, but our knowledge of detrital heavy minerals and phosphorite on the shelf is insufficient to indicate the order of the resources or to be confident as to when such deposits can be economically mined. Additional resources of detrital heavy minerals, particularly of the beach sand minerals, rutile, zircon and ilmenite, are very important to Australia in the longer term and continued pioneering in this field off the east coast is to be commended. The commencement of prospecting for bauxite in the Gulf of Carpentaria and planned revival of phosphorite search off Tasmania extend this pioneering offshore and should considerably add to our knowledge of mineral occurrence.

Little is known as yet of possible mineral deposits of the deep ocean basins in the Australian region, and these remain fields to be explored for resources for the future.

It is therefore important that we recognise that although technology has enabled us to begin a new era of investigation and development of mineral resources offshore, these resources, apart from those associated with the consolidated rocks of the shelf and slope, occur in environments of which we have little real knowledge.

With the exception of construction materials, other resources offshore are not likely to be discovered or developed as readily as was petroleum; indeed success in the future in all fields offshore is likely to depend on how effectively we tackle the tasks of investigating new environments and improving technology to cope with the problems of exploitation.

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Metal and Mineral Prices

Compiled by J. A. MORRISSEY

MONTHLY AVERAGE BASE METAL PRICES

	Copper	Lead	Zinc	Tin
Australia (per long ton)—				
September	\$1,164.80	\$270	\$295.00	\$3,419.600
October	\$1,120.90	\$270	\$295.00	\$3,430.520
November	\$1,030.40	\$270	\$295.00	\$3,415.523
U.K. (L.M.E., per metric ton)—				
September	£519.5.7	£118.9.1	£124.17.7	£1,518.17.4
October	£475.15.0	£118.13.2	£123.8.6	£1,528.16.10
November	£451.18.0	£116.10.9	£121.13.8	£1,506.17.3
U.S.A. (U.S. cents per lb)—				
September	60.125	14.75	15.0	173.834
October	59.030	14.75	15.0	171.783
November	56.125	14.75	15.0	171.610

MAXIMUM AND MINIMUM BASE METAL PRICES, 1 SEPTEMBER 1970 to 30 NOVEMBER 1970

	Copper	Lead	Zinc	Tin
Australia (per long ton)—				
Maximum	\$1,164.80	\$270	\$295	\$3,479
Minimum	\$1,030.40	\$270	\$295	\$3,366
U.K. (std. L.M.E., per metric ton)—				
Maximum	£530.15.0	£121.5.0	£126.11.3	£1,542.10.0
Minimum	£442.15.0	£115.12.6	£120.7.6	£1,471.0.0
U.S.A. (cents per lb)—				
Maximum	60.25	15.00	15.0	175.87
Minimum	56.00	14.50	15.0	165.50

METAL PRICES AS AT 1 DECEMBER 1970

	Australia \$ per long ton (a)	United Kingdom £ per metric ton (a)	United States of America US cents per lb (a)
Metal			
Aluminium	(b) \$578	£257.20 delivered	(c) 29.00
Antimony	(d) \$3,500	(w) £875 per long ton	\$0.96
Bismuth	\$10.70 lb	110.3 Kg	\$6.00 delivered
Cadmium	(e) \$2.45	23.4 lb. (U.K. & Cwld)	\$2.75
Cobalt	(f) \$17.7 lb (oxide)	16.6-18.6 lb.	(g) \$2.20
Copper	(h) \$1,030.4	(i) £436-£436.10.0	53.53.25 ex-refinery
		(j) £436.10.0	
Gold	(k) \$33.66 fine oz	\$37.35 troy oz (U.S.)	\$37.75 troy oz
Lead	(l) \$270	(i) £116.5.0-£116.10.0	14.50-15.00
Mercury	Nominal	(m) £212 per flask	\$360-\$375 (20 plus flasks)
Nickel	(n) \$1.20 per lb	£1,246.10.0	(o) \$1.33
Pig Iron	(p) \$53.25	(x) £29.8.0 per long ton	(q) \$74.50
Platinum	—	(r) £541-£561 troy oz (del'd)	\$130-\$135 troy oz
Silver	148.8 troy oz f.o.b.	161.500 troy oz	162.00 troy oz
Tin	\$3,366	(i) £1,466-£1,467	(s) 169.00
Tin		(i) £121-£121.5.0	(n) 15
Zinc	(t) \$295	(v) £127.19.0	

(a) Unless otherwise stated. (b) Domestic 1-20K ingots, 99.5% c.i.f. (c) U.S. domestic price and Canadian export price delivered U.S. Buyer U.S. currency. (d) 1 ton lots, delivered capital cities. (e) Lots 1 ton and over delivered Melbourne. (f) delivered Melbourne. (g) Shot, 99% 250 kg. drums, f.o.b. N.Y., Chicago. (h) Price electrolytic ex-smelter, Port Kembla. (i) L.M.E. Quotation spot: £ per metric ton. (j) Producers price c.i.f. Europe: £ per metric ton. (k) Australian Gold Producers' Association Price: minimum 400 oz. bars. (l) Price Loh. Port Pirie. (m) Ex-Warehouse. (n) f.o.b. Kwinana. (o) Ex-refinery, Port Colborne, Cathode. (p) Price Loh. Port Pirie. (q) No. 2 Foundry f.o.b. mid-west centres. (r) U.K. and Empire refined. (s) Straits New York. (t) g.o.b. Delivered Melbourne, Sydney, Port Kembla and Adelaide. (u) Prime Western East St. Louis. (v) g.o.b. Producers Basis price, £ per metric ton. (w) Producers price regulus, English 99.6% 5 tons d'd U.K. (x) merchant pig iron, phosphorus 0.7%-1.2% delivered Gt. Britain.

ORE AND CONCENTRATE PRICES AS AT 1 DECEMBER, 1970

Note: Some ore and concentrate prices are nominal, the prices quoted being subject to negotiation between the producer and purchaser. The ore and concentrate prices quoted below will also vary according to grade and possible impurities, and in many cases with size of the ore parcel.

Ore or Concentrate	Australia S.A.	United Kingdom £ stg.	United States of America \$ U.S.
Antimony	Nominal	\$14 to \$19 L.t.u. Sb for cons 60% Sb, c.i.f.	\$14.29 to \$16.96 s.t.u. Sb for cons min. 60% Sb, c.i.f.
Beryllium	Nominal	\$37 to \$39 (U.S.) s.t.u. BeO for ore, 10% BeO, f.o.b.	Nominal
Bismuth	Nominal	Nominal	Nominal
Chromite	Nominal	\$43 to \$45 Russian, lumpy min. 48% Cr ₂ O ₃ 3.5:1 c.i.f.	\$31 to \$35 long ton 48.50% Cr ₂ O ₃ Rhodesian 31:1 ratio, lump f.o.b. Atlantic ports
Columbium	—	185s to 195s L.t.u. (Nb ₂ O ₅ + Ta ₂ O ₅) 65% combined oxides, 10:1 ratio, c.i.f.	\$115 to \$120 per lb. of 65% combined oxides, 10:1 ratio, c.i.f.
Manganese	Nominal	\$1d to \$6d L.t.u. Mn for 48 50% Mn cons max. 0.1% P, c.i.f. (nominal)	59c to 62c (nominal) per L.t.u. of contained metal min. 48% Mn c.i.f. U.S. ports
Molybdenum	Nominal	14s 4d per lb. of contained metal, cons 85% MoS ₂ f.o.b. Climax, Colorado	\$172 per lb. of contained metal, cons. 95% MoS ₂ f.o.b. Climax, Colorado
Monazite	Nominal	\$80 to \$90 per ton, 60% min. REO + Thoria, c.i.f. (Aus- tralian)	Sand, \$180 to \$200 per long ton, 55-60% REO excl. Thoria (nominal)
Tantalum	Nominal	\$7.50 to \$8.00 per lb. Ta ₂ O ₅ in ore, min. 60% Ta ₂ O ₅ c.i.f.	\$6.75 to \$7.50 about 60% combined columbium and tantalum pentoxide; 1 lb. Ta ₂ O ₅ c.i.f. U.S. ports
Tin (cassiterite)	\$28.83 per L.t.u. Sn for 70% Sn cons delivered, Sydney on 30.11.70	—	—
Titanium cons. Ilmenite	\$11 ton f.o.b. Bunbury (nominal)	29.100 to £11.10.0 per ton 52.44% TiO ₂ (Malayan) c.i.f.	\$20 to \$21 long ton 54% TiO ₂ f.o.b. Atlantic ports, shiploads
Rutile	\$145 to \$150 per ton bagged f.o.b. (nominal)	£78 to £81 per ton 95.97% TiO ₂ (Australian) c.i.f.	\$185 short tons f.o.b. cars, Atlantic ports 96% TiO ₂ delivered within 12 months
Tungsten cons. Wolfram	\$59.89 to \$64.75 per unit WO ₃ (nominal)	560s to 605s per L.t.u. WO ₃ cons. c.i.f. Europe. Standard quality (spec. com- position)	555 per s.t.u. WO ₃ cons. 65% WO ₃ c.i.f. import duty \$7.14 per s.t.u. WO ₃
Scheelite	Nominal	Nominal	As above
Zircon	\$39 per ton, 66% ZrO ₂ \$45 to \$47 per ton (nominal)	£27.50 to £28.10.0 per ton 66.67% ZrO ₂ c.i.f. £31 to £32.10.0 per ton premium quality max. 0.1% TiO ₂	\$70 per long ton 65% ZrO ₂ c.i.f. Atlantic ports

Copper Ore

Australia: The price paid for ores is related to the market price of copper, less charges listed below.
The basis of price determination is variable; details are obtainable from individual smelters.

Company	Drainage deduction on copper content deduction	Receiving sampling assaying and assaying charge per ton of ore	Conveying refining charge per ton of copper paid for	Gold refining charge per oz. of gold paid for	Silver refining charge per oz. of silver paid for
ERS(a)	1.3 unit of copper per ton of ore	10.00	1.00	1.50	0.44
Mount Isa(b)	1.3 unit of copper per ton of ore	10.50	1.50	No payment for gold	0.45
Mount Morgan(c)(d)	1% of weight of ore plus 1.3 units of copper per ton of ore	12.00	2.00	1.70	0.50

(a) The Electrolytic Refining and Smelting Company of Australia Pty. Ltd., Port Kembla, New South Wales.
(b) Mount Isa Mines Ltd., Mount Isa, Queensland.
(c) Mount Morgan Ltd., Mount Morgan, Queensland.
(d) Mount Morgan gold and silver deductions—Gold, deductions range from 1 dwt. ton for 10 dwt. ton and
lower grade ore to 1 dwt. ton plus 5 percent of the balance for 12 dwt. ton and over ore; silver, 1 oz. ton
plus 10 percent of the balance.

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P.O. Box 378
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**Part 2—
Quarterly
Statistics**

Australian Mineral Industry

VOLUME 23 No. 2 QUARTER ENDED 30 JUNE 1970

*Prepared under instructions from the Honourable the Treasurer
by J. P. O'Neill, Acting Commonwealth Statistician*

Preface

Statistics included in this Part relate to Australian production of and overseas trade in minerals and mineral products. In the main, the data relating to mineral production consist of official statistics of Mines Departments of the several States and the Northern Territory Mines Branch. These statistics have been supplemented as necessary by data obtained from the Fuel Branch of the Department of National Development and the Bureau of Mineral Resources, including information collected by that Bureau from mines and treatment plants.

The presentation of data in this Part is arranged to assemble under the one heading all statistics in respect of each particular mineral. Summary tables showing production of selected major minerals and metals are shown on page 23, and include details where available for the September quarter 1970.

The fundamental concept of Australian mineral production statistics is that quantities and values of individual minerals are reported in terms of the products in the form in which they are dispatched from the locality of each mine. This involves the inclusion in the mining industry of ore-dressing and certain elementary smelting of metallic minerals (e.g., in the case of gold) and miscellaneous treatment of non-metallic minerals where these operations are carried out in an associated plant at or near the mine. For example, in the case of a metal mine, the output is recorded as ore when no treatment is undertaken at the mine or as a concentrate where ore-dressing operations are carried out in an associated plant in the locality of the mine.

The particulars of quantities of minerals produced shown have been compiled on this basis as far as practicable. This has involved some re-arrangement of official statistics published by Mines Departments for certain States. Actual output of the mineral product (as defined in the preceding paragraph) has generally been reported, but in some cases it has been necessary to include dispatches from the mine (or reported sales) as distinct from production in deriving the total for Australia. In addition to the basic quantity data, particulars of contents of metallic minerals are shown and in general represent total contents (as determined by assay) for each metal which is a 'pay metal' or 'refiners' prize' when present in the particular mineral.

The data exclude construction materials (sand, gravel, building stone, etc.) and some particulars for non-metallic minerals which are not at present available.

Quarterly value of output statistics are not available because of delays in realization of values of several important minerals. Calendar year statistics of the value of output of the mining and quarrying industries and values of individual minerals are published in the annual statistical bulletins *Minerals and Mineral Products* and *Minerals and Mineral Products (Preliminary)*.

All tables in this publication omit particulars relating to uranium bearing minerals.

I extend my thanks to State Departments of Mines, Statisticians of the several States, and the Department of National Development who have supplied information used in the preparation of this Bulletin.

J. P. O'NEILL
Acting Commonwealth Statistician

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The following terms and symbols, where shown in tables, mean:

ton: long ton of 2,240 lb.	(—): nil
short ton: ton of 2,000 lb.	(.): less than half the unit shown
unit: 22.4 lb.	(n.a.): not available
f oz: fine content, troy ounce	(n.e.i.): not elsewhere included.
* : subject to revision	

Statistics of smelter and refinery production exclude secondary metal (i.e. metal recovered from scrap) unless otherwise specified.

All import and export values are expressed in Australian currency and are generally f.o.b. port of shipment. A more detailed description of the method of valuation is quoted in the *Overseas Trade Bulletin*.

Any discrepancies between totals and sums of components in the tables are due to rounding.

Other Publications of the Commonwealth Bureau of Census and Statistics
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A.C.T. 2600 or the Office of the Deputy Commonwealth Statistician in each State
capital

ALUMINIUM

		Quarters—				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced							
Bauxite	ton	4,876,822	7,796,003	2,139,139	2,003,994	1,747,079	2,192,164
Alumina (Al ₂ O ₃) content	"	2,633,447	4,211,363	1,156,233	1,071,932	932,370	1,179,273
Production: States (Al ₂ O ₃ content)							
New South Wales	"	4,511	4,780	867	1,373	1,167	586
Victoria	"	—	2,008	—	88	418	—
Queensland	"	1,905,342	3,049,917	839,587	738,293	634,199	355,925
Western Australia	"	723,594	1,154,658	315,779	332,176	296,586	342,762
Total contained alumina	"	2,633,447	4,211,363	1,156,233	1,071,932	932,370	1,179,273
Smelter and refinery production							
Alumina	"	1,288,776	1,900,519	503,610	507,779	462,919	514,603
Refined aluminium	"	95,810	124,423	28,842	38,760	48,495	49,080

IMPORTS (a)

Aluminium and aluminium base alloys						
Alumina	ton	2,964	2,821	641	790	828
Value	\$'000	551	506	140	158	220
Unworked shapes	ton	11,975	1,062	214	522	70
Canada	ton	3,762	1	—	—	156
Other	ton	8,193	1,061	214	522	70
Value	\$'000	5,822	726	157	329	106
Plates, sheets, strips and circles	ton	349	1,069	112	210	161
Value	\$'000	432	1,045	160	297	233
Pipes and tubes	ton	48	28	4	16	3
Value	\$'000	108	74	9	40	13
Bars, rods and angles	ton	553	1,278	320	252	92
Value	\$'000	561	1,261	270	226	89
Foil	ton	1,285	1,577	358	393	350
Value	\$'000	1,979	2,176	576	641	542
Powder	ton	418	158	15	60	106
Value	\$'000	282	122	19	39	67
Wire, single strand, uncovered	ton	289	186	36	46	40
Value	\$'000	481	282	50	86	49
Scrap (including re-melt)	ton	856	754	190	156	258
Value	\$'000	260	254	67	50	90

EXPORTS (a)

Aluminium and aluminium base alloys						
Unworked shapes	ton	5,577	19,453	3,735	9,314	18,573
Japan	ton	79	10,883	2,032	7,898	10,139
Hong Kong	ton	2,155	3,854	613	781	1,523
Philippines	ton	1,481	2,036	511	264	30
New Zealand	ton	1,002	1,295	216	93	1,763
Other	ton	860	1,285	364	278	5,118
Value	\$'000	2,745	9,175	1,905	3,903	8,525
Plates, sheets, strips and circles	ton	3,580	150	25	32	121
Value	\$'000	2,109	211	38	50	125
Pipes and tubes	ton	119	51	2	30	20
Value	\$'000	187	63	7	29	16
Bars, rods and angles	ton	286	776	160	137	423
Value	\$'000	153	521	106	86	240
Foil	ton	704	752	190	274	168
Value	\$'000	487	613	134	215	139
Powder	ton	—	—	—	—	—
Value	\$'000	—	1	—	—	1
Wire, single strand, uncovered	ton	24	53	17	28	13
Value	\$'000	37	50	25	12	20
Scrap (including re-melt)	ton	2,036	3,683	945	715	560
Value	\$'000	606	1,227	332	189	126

(a) Details of imports of bauxite, and exports of bauxite and alumina are not available for publication.

ANTIMONY

		Quarters—				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced							
Antimony ore	ton	3	—	—	—	—	—
Antimony content							
Antimony concentrate		241	218	67	63	—	—
Antimony content		154	142	44	43	—	—
Antimony content of minerals produced							
Antimony ore							
Antimony concentrate		159	142	44	43	—	—
Lead concentrate		672	749	207	193	148	208
Lead-zinc concentrate		11	19	9	10	—	—
New South Wales							
Queensland		842	905	260	246	148	208
			5				
Total contained antimony		842	910	260	246	148	208

IMPORTS

Antimony metal	ton	6	67	27	14	24
Value	\$ '000	5	66	28	18	74

ASBESTOS

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Chrysotile	short ton	897	825	219	199	180	228
New South Wales	"	822	795	219	169	130	228
Western Australia	"	75	30	—	30	—	—
IMPORTS							
Chrysotile	short ton	51 797	46 656	16 003	11 405	14 327	11 510
Canada		51 133	45 975	15 992	11 735	14 314	11 379
Others		664	681	11	270	13	131
Value	\$ '000	6 750	5 944	1 880	1 483	2 126	1 687
Amosite	short ton	10 108	9 779	2 350	2 073	2 595	2 046
South Africa	"	9 838	9 779	2 350	2 073	2 531	2 046
Others		270	—	—	—	64	—
Value	\$ '000	1 229	1 180	287	277	314	256
Other types	short ton	4 836	2 635	1 369	969	360	621
Value	\$ '000	339	247	115	64	19	66

EXPORTS

All types and grades	short ton	804	182	99	18	225	17
Value	\$ '000	186	43	21	6	64	3

CADMIUM

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Cadmium content of minerals produced							
Lead concentrate	ton	57	49	12	12	9	13
Lead-zinc concentrate	"	3	16	8	8		
Zinc concentrate	"	1,299	1,595	458	417	341	405
New South Wales							
Queensland	"	1,007	1,248	369	329	238	307
Tasmania	"	261	322	86	86	91	91
Northern Territory	"	74	76	18	20	19	19
Northern Territory	"	17	14	5	2	2	1
Total contained cadmium	"	1,359	1,660	478	437	350	418
Refinery production							
Refined cadmium	"	465	562	158	151	147	168

EXPORTS

Refined cadmium and cadmium alloys	ton	97	41	2	10	11
Ingot and blocks	ton	475	193	4	14	55
Value	\$ '000	250	383	145	85	143
Bars and rods	ton	1,061	2,209	889	509	900
Value	\$ '000	1,061	2,209	889	509	900

COAL

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Black coal	'000 ton	31	15	6	1		
Semi-anthracite		36,665	41,702	11,666	10,896	9,947	11,530
Bituminous		3,488	3,686	988	923	825	940
Sub-bituminous							
New South Wales		30,349	33,438	9,339	8,673	7,815	9,125
Victoria		26	6,536	2,418	2,275	2,185	2,485
Queensland		6,552	2,211	585	558	479	499
South Australia		2,078	1,091	288	274	267	330
Western Australia		1,087					
Tasmania		91	127	29	40	26	30
Underground		32,252	35,190	9,620	8,991	8,061	9,313
Opencut		7,931	10,213	3,039	2,859	2,711	3,158
Total		40,183	45,403	12,659	11,820	10,772	12,471
Brown coal (lignite)		22,971	22,911	6,487	5,322	5,308	6,811
Victoria		22,971	22,911	6,487	5,322	5,308	6,811
Coal products							
Metallurgical coke		3,891	4,381	1,142	1,202	1,177	1,260
Brown coal briquettes		1,552	1,464	429	329	340	368

IMPORTS

Coal	ton	9,278	12,023	368	299	1,340	8,302
Value	\$ '000	119	284	19	15	33	123
Coke (incl. petroleum coke)	ton	47,726	88,844	16,449	25,268	23,851	21,501
Value	\$ '000	1,430	2,173	473	748	726	616

EXPORTS

Coal	'000 ton	12,097	15,812	4,325	4,420	4,278	4,495
Japan		11,794	15,404	4,271	4,246	3,967	3,696
Other		303	408	54	174	311	658
Value	\$ '000	103,757	142,578	40,069	41,835	40,699	43,106
Coke	ton	202,167	333,645	154,202	113,435	135,937	44,127
Value	\$ '000	2,428	5,055	2,606	1,476	2,630	762

COPPER

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced							
Copper ore (a)	ton	39,202	27,122	13,956	7,250	5,243	5,656
Copper content	ton	2,747	1,679	510	415	369	375
Gold content	1 oz	136	87	10	14	—	1
Silver content	000 1 oz	4	2	1	1	1	1
Copper concentrate	ton	451,521	506,010	133,113	127,745	127,361	140,130
Copper content	ton	98,037	118,976	31,626	30,667	30,365	33,377
Gold content	1 oz	94,494	84,298	17,695	19,458	29,477	22,121
Silver content	000 1 oz	1,694	1,070	287	265	244	270,661
Lead content	ton	1,114	811	261	156	212	293
Zinc content	ton	2,124	1,687	350	362	434	415
Copper precipitate	ton	579	439	71	79	61	54
Copper content	ton	330	259	46	46	36	35
Gold content	1 oz	378	—	—	—	—	—
Silver content	000 1 oz	—	—	—	—	—	—
Copper content of minerals produced							
Bismuth concentrate	ton	130	138	38	30	35	15
Copper ore (a)	ton	2,747	1,679	510	415	369	375
Copper concentrate	ton	98,037	118,976	31,626	30,667	30,365	33,377
Copper precipitate	ton	330	259	46	46	36	35
Copper-iron concentrate	ton	169	570	161	156	196	205
Gold ore	ton	1	—	—	—	—	—
Lead concentrate	ton	3,683	3,756	1,015	919	739	1,034
Lead-copper concentrate	ton	1,333	1,576	334	384	363	334
Lead-zinc concentrate	ton	27	59	29	30	—	—
Nickel concentrate	ton	536	1,241	342	447	421	558
Zinc concentrate	ton	911	936	243	235	207	245
New South Wales							
Victoria	ton	12,279	15,041	3,999	3,841	3,476	3,726
Queensland	ton	5	65	41	20	11	11
South Australia	ton	69,447	85,875	23,810	22,745	21,017	23,346
Western Australia	ton	80	394	48	48	—	—
Tasmania	ton	1,591	2,149	526	670	584	716
Northern Territory	ton	16,601	18,685	4,318	4,523	5,818	6,675
Total contained copper	ton	7,903	6,777	1,650	1,482	1,825	1,707
Smelter and refinery production	ton	107,905	128,986	34,344	33,329	32,731	36,181
Blister copper (b)	ton	92,454	114,349	29,701	29,547	24,575	24,685
Refined copper	ton	84,269	99,261	24,610	26,151	27,842	26,512
IMPORTS							
Copper—							
Unrefined copper	ton	4,529	16	1	5	—	—
Value	\$'000	5,233	22	1	8	—	—
Refinery shapes	ton	397	47	6	25	2	10
Chile	ton	300	—	—	—	—	—
South Africa	ton	50	—	—	—	—	—
Others	ton	47	47	6	25	2	10
Value	\$'000	380	64	8	37	2	17
Bars, rods, angles and tees	ton	1	1	—	—	—	—
Value	\$'000	2	4	—	1	—	—
Plates, sheets and strips	ton	11	17	8	5	6	6
Value	\$'000	15	24	1	12	10	13
Pipes and tubes	ton	524	565	101	170	92	69
Value	\$'000	819	974	183	324	188	151
Wire	ton	25	19	4	4	4	5
Value	\$'000	68	47	9	12	12	18
Powder	ton	240	312	83	89	92	36
Value	\$'000	348	507	134	158	166	72
Scrap	ton	1,471	969	284	261	407	350
Value	\$'000	1,247	796	231	258	445	403
Copper-base alloys—							
Pigs, ingots and blocks	ton	46	27	4	3	5	21
Value	\$'000	45	31	8	5	9	23

COPPER

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
IMPORTS (continued)							
Copper-base alloys—Continued							
Rolls, drawn and extruded shapes	ton	585	472	276	237	150	140
Value	\$'000	941	1,096	428	369	286	243
Wire	ton	161	175	87	28	25	65
Value	\$'000	294	315	114	81	63	119
Scrap	ton	1,188	1,906	1,300	268	440	512
Value	\$'000	859	641	246	190	354	454
EXPORTS							
Copper—							
Copper concentrate	ton	36,494	49,888	20,131	11,101	9,411	24,053
Japan	ton	36,494	45,727	18,960	9,261	8,574	24,053
Other	ton	—	4,121	1,171	1,840	837	—
Value	\$'000	8,657	10,179	2,580	2,865	2,877	6,878
Copper precipitate	ton	222	230	105	—	—	—
Value	\$'000	140	150	79	—	—	—
Copper matte	ton	6,925	3,291	1,101	—	2,201	1,963
Belgium-Luxembourg	ton	6,925	2,400	1,101	—	2,201	977
Other	ton	—	891	—	—	—	986
Value	\$'000	3,008	1,761	628	—	1,458	1,213
Copper-lead dross	ton	4,927	5,581	2,500	2,001	1,501	1,001
Value	\$'000	1,567	1,547	694	542	414	275
Slags and residues	ton	855	402	75	22	5	32
Value	\$'000	21	40	12	2	4	4
Blister copper	ton	7,063	8,425	3,423	1,394	1,842	1,243
Japan	ton	7,063	8,425	3,423	1,394	1,842	1,243
Value	\$'000	9,459	12,994	5,241	2,315	3,293	2,406
Refinery shapes	ton	16,518	32,208	8,251	8,883	16,692	4,189
E.E.C.	ton	6,786	11,249	3,558	3,614	6,629	1,677
United Kingdom	ton	1,850	10,050	2,703	3,024	5,512	1,476
Other	ton	7,882	10,929	1,990	2,245	4,551	736
Value	\$'000	16,810	40,572	10,989	12,775	24,578	6,392
Bars and rods	ton	5,733	8,192	2,132	1,279	2,908	1,981
Value	\$'000	6,296	10,197	2,904	1,830	4,303	3,116
Angles, shapes and sections	ton	5	6	6	—	—	6
Value	\$'000	7	6	5	—	—	7
Plates, sheets and strips	ton	768	767	203	170	303	207
Value	\$'000	1,100	1,204	341	297	565	413
Tubes and pipes	ton	658	809	179	155	422	411
Value	\$'000	978	1,360	324	331	827	838
Wire	ton	41	162	60	100	136	98
Value	\$'000	58	229	78	147	207	154
Scrap	ton	—	—	—	—	—	—
Value	\$'000	—	—	—	—	—	—
Copper-base alloys—							
Refinery shapes	ton	7	27	—	25	25	2
Value	\$'000	7	36	—	33	32	4
Bars and rods	ton	2,966	3,220	1,086	1,061	1,061	953
Value	\$'000	2,299	3,005	1,002	1,054	1,245	1,079
Angles, shapes and sections	ton	105	97	36	41	36	35
Value	\$'000	104	99	33	37	37	36
Plates, sheets and strips	ton	246	295	87	72	112	64
Value	\$'000	305	417	131	104	175	100
Tubes and pipes	ton	24	23	4	12	63	37
Value	\$'000	34	35	5	20	82	67
Wire	ton	69	79	4	6	9	24
Value	\$'000	72	108	6	9	13	32
Scrap	ton	32	54	2	1	3	—
Value	\$'000	39	48	4	2	1	1
Copper and copper-base alloys—							
Foil	ton	4	—	—	—	—	—
Value	\$'000	3	—	—	—	—	—
Powders and flakes	ton	—	1	—	—	—	—
Value	\$'000	—	—	—	—	—	—
Copper content of concentrates, matte, etc., exported (c)	ton	13,988	11,850	3,279	3,007	3,902	7,463

(a) Includes cupreous ore for fertilizer. (b) Total production for refining in Australia and overseas. (c) Excludes copper in blister.

GEMS

		Quarters—					
		1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Gems	£'000	5,145	5,645	n.a.	n.a.	n.a.	n.a.
New South Wales		1,720	2,360	n.a.	n.a.	n.a.	n.a.
Queensland		8	71	n.a.	n.a.	n.a.	n.a.
South Australia		4,015	2,607	n.a.	n.a.	n.a.	n.a.
Sapphire		679	2,650	n.a.	n.a.	n.a.	n.a.
New South Wales		527	2,455	n.a.	n.a.	n.a.	n.a.
Queensland		146	1,000	n.a.	n.a.	n.a.	n.a.
Other gems		107	114	n.a.	n.a.	n.a.	n.a.
New South Wales		17	15	n.a.	n.a.	n.a.	n.a.
Queensland		120	89	n.a.	n.a.	n.a.	n.a.
South Australia		10	1	n.a.	n.a.	n.a.	n.a.
Western Australia		8	74	n.a.	n.a.	n.a.	n.a.
Tasmania		2	—	n.a.	n.a.	n.a.	n.a.

IMPORTS

Diamonds, gem	metric carat	31,499	31,470	7,019	10,658	8,764	8,844
Value	\$'000	4,727	5,290	1,170	1,426	1,439	1,410

EXPORTS

Gems—	£'000	7,361	8,870	2,126	2,680	1,529	2,240
Rough, not cut, or polished		3,152	3,336	1,038	875	969	970
Cut and polished		—	—	—	—	—	—

GOLD

		Quarters— 1969*				1970*	
		1968	September	October	November	March	June

PRODUCTION

Mine production

Minerals produced	ton	6	—	—	—	—	—
Gold ore	ton	30	—	—	—	—	—
Gold content	£	—	—	—	—	—	—
Silver content	£	—	—	—	—	—	—
Gold bullion (a)	908,286	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Gold content	623,032	554,268	130,744	133,180	132,705	107,501	107,501
Silver content	209,270	158,950	37,471	33,640	30,981	29,978	29,978
Gold content of minerals produced							
Bismuth concentrate	27,535	27,758	4,989	5,252	5,329	5,342	5,342
Copper ore	136	55	10	14	—	—	—
Copper concentrate	94,499	83,666	17,693	19,498	30,353	22,662	22,662
Copper precipitate	378	—	—	—	—	—	—
Gold ore	30	—	—	—	—	—	—
Gold bullion (a)	623,032	554,268	130,744	133,180	132,705	107,501	107,501
Lead ore	37	—	—	—	—	—	—
Lead concentrate	10,008	12,043	3,079	3,172	2,313	2,806	2,806
Lead-copper concentrate	21,557	22,928	6,398	6,606	6,313	7,055	7,055
Lead-zinc concentrate	223	2	1	1	—	—	—
Zinc concentrate	4,347	4,503	1,052	1,167	1,196	1,364	1,364
New South Wales	8,668	10,232	2,771	2,644	2,094	2,830	2,830
Victoria	11,069	8,817	2,999	1,503	1,060	2,801	2,801
Queensland	82,909	71,411	15,761	16,963	25,538	19,412	19,412
South Australia	38	414	—	—	—	—	—
Western Australia	515,944	440,065	105,348	102,975	102,522	81,349	81,349
Tasmania	36,509	40,266	9,299	11,056	11,269	11,954	11,954
Northern Territory	126,610	128,518	26,790	33,385	35,726	27,943	27,943
Total contained gold	781,782	659,223	162,968	168,870	178,209	146,730	146,730
Refinery production							
Newly won gold							
Australian origin	639,537	586,396	138,690	153,451	110,435	124,721	124,721
Overseas origin	126,178	116,957	27,230	29,581	31,461	37,966	37,966
Scrap							
Australian origin	13,460	17,810	5,643	4,926	4,253	3,639	3,639
Overseas origin	349	731	268	72	552	27	27
Total	779,314	721,894	171,831	188,030	146,701	166,353	166,353

GOLD

		Quarters— 1969*				1970*	
		1968	September	October	November	March	June

IMPORTS

Gold							
Refined forms (gold specie, leaf and foil)	ton	4,869	43,569	41,607	209	216	148
Value	\$'000	760	2,434	2,363	9	9	8
Unrefined bullion (gold content)	ton	125,738	117,725	32,190	30,996	27,609	37,890
For							
Papua and New Guinea	—	102,601	94,457	25,452	25,541	23,956	31,504
Other	—	20,157	23,268	7,738	5,429	3,653	6,349
Value	\$'000	—	—	—	—	—	—
		4,135	4,072	1,045	1,038	870	1,193

EXPORTS

Refined forms (gold specie, leaf and foil)	ton	385,976	597,089	263,440	95,354	16,955	97,662
For							
Hong Kong	—	358,279	444,676	115,064	94,679	15,995	95,954
Singapore	—	—	147,595	147,981	14	—	—
New Zealand	—	4,157	3,949	350	755	1,654	1,654
Other	—	23,546	339	25	50	205	54
Value	\$'000	13,126	21,139	9,715	3,056	537	3,070
Gold contents of concentrates, blister copper, etc. exported	ton	115,125	94,004	26,932	26,871	31,222	49,175

CHANGES IN STOCKS OF GOLD HELD IN AUSTRALIA

Supplies							
Refinery production (b)	ton	653,136	694,937	144,601	158,449	115,240	128,387
Imports		127,627	181,290	94,449	31,205	27,825	38,038
Total supplies		780,763	876,229	239,050	189,654	143,065	166,425
Disposals							
Exports		385,976	597,089	263,440	95,354	16,955	97,662
Net industrial consumption	—	177,072	435,482	132,405	114,686	90,403	89,969
Total disposals	—	563,048	1,032,571	395,845	210,040	107,358	187,631
Apparent change in stocks held in Australia (c)	—	+ 217,715	— 246,342	— 156,795	— 20,386	+ 35,707	— 21,206

(a) Mine bullion, alluvial, retorted gold, etc. Includes production from auriferous pyrites. (b) Refinery production from newly-won gold of Australian origin and scrap of domestic and overseas origin. (c) Excludes specie; includes changes in holdings in Australia by Official and Banking Institutions both on their own behalf and that of non-residents.

GYPSUM

		Quarters—				1970*	
		1969*					
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production	ton	843,744	897,705	256,192	217,530	185,752	202,053
New South Wales	"	32,323	31,637	6,292	9,439	9,059	6,638
Victoria	"	77,472	84,383	24,017	19,999	10,149	9,711
South Australia	"	630,020	717,287	201,799	170,811	154,067	148,806
Western Australia	"	103,929	64,398	22,084	17,281	12,537	36,898
EXPORTS							
Gypsum and anhydrite	ton	247,078	186,259	71,041	45,179	41,175	44,610
New Zealand	"	84,317	79,257	29,464	22,793	24,245	25,322
Philippines	"	52,317	42,171	33,010	—	—	—
China, Formosa	"	38,515	37,303	8,180	8,028	7,877	17,983
Other	"	71,929	28,528	387	14,308	9,053	1,525
Value	\$ '000	1,104	1,006	303	203	237	216

IRON

		Quarters—1969*				1970*	
		1968	1969* September	December	March	June	
PRODUCTION							
Mine production							
Minerals produced							
Iron ore and concentrate (a)	'000 tons	26,204	37,966	5,891	9,871	10,394	12,298
Iron content		16,920	24,450	6,357	6,356	6,693	7,857
Production, States, iron content							
South Australia	"	3,643	4,436	1,101	1,184	1,128	1,233
Western Australia	"	12,157	18,082	4,769	4,613	5,070	6,103
Tasmania	"	601	1,366	356	382	340	340
Northern Territory	"	519	566	131	177	155	181
Total contained iron	"	16,920	24,450	6,357	6,356	6,693	7,857
Iron and steel							
Iron ore pellets	"	2,952	5,778	1,525	1,496	1,399	1,292
Pig iron	"	5,484	6,010	1,489	1,552	1,387	1,469
Raw steel (b)	"	6,399	6,906	1,730	1,789	1,576	1,675
Blooms and slabs	"	5,588	5,951	1,500	1,546	1,349	1,404
Tinplate	"	234	277	69	76	74	63
IMPORTS							
Iron ore	'000 tons	244	—	—	—	58	17
New Caledonia	"	244	—	—	—	—	—
Other	"	—	—	—	—	58	17
Value	\$'000	547	—	—	—	6	2
Iron and steel							
Ferro-alloys (excl. powders)							
Ferro-chromium	ton	3,487	5,877	1,619	1,901	3,283	2,763
Value	\$'000	977	1,448	379	520	623	672
Ferro-manganese	ton	10,482	6,352	1,319	959	2,057	1,684
Value	\$'000	2,631	1,308	271	200	408	360
Ferro-molybdenum	ton	163	131	32	48	73	91
Value	\$'000	464	398	86	154	233	268
Ferro-nickel	ton	1,103	775	308	467	880	1,184
Value	\$'000	517	514	140	374	2,164	3,472
Ferro-silicon	ton	6,227	7,600	1,565	2,516	2,557	2,635
Value	\$'000	923	1,180	250	411	476	532
Other	ton	1,956	2,138	366	743	746	649
Value	\$'000	889	567	102	203	203	229
Tinplate	ton	8,438	2,593	508	790	625	755
Value	\$'000	1,651	511	131	141	109	135
EXPORTS							
Iron							
Iron ore and pellets	'000 tons	16,134	26,257	7,026	8,144	8,691	9,107
Japan	"	13,819	22,468	6,148	6,997	7,810	7,779
Other	"	2,315	3,789	878	1,147	881	1,328
Value	\$'000	139,816	229,930	59,938	70,783	73,227	72,278
Iron and steel							
Pig iron	ton	241,869	368,913	131,262	39,657	35,685	104,479
Japan	"	200,370	328,915	121,124	28,422	26,220	92,425
Philippines	"	14,150	14,273	5,329	2,377	2,056	4,704
Other	"	27,369	25,785	4,809	8,858	7,409	7,350
Value	\$'000	8,925	16,271	6,420	1,965	1,884	4,726
Ingot, blooms and slabs	ton	350,669	536,199	195,254	93,521	78,464	76,741
Value	\$'000	18,772	32,746	12,058	6,398	5,778	6,697
Scrap	ton	401,801	534,899	159,005	112,124	103,238	134,057
Value	\$'000	10,389	14,494	4,455	3,524	4,098	4,971
Tinplate	ton	42,576	57,413	18,321	16,771	11,258	10,004
Value	\$'000	5,359	7,704	2,528	2,442	1,649	1,447
Iron content of iron ore exported	'000 tons	10,475	17,120	4,547	5,372	5,560	5,874

(a) Iron oxide for metal extraction (b) Includes recovery from scrap

LEAD

			1968	1969*	September	December	March	June	1970*
PRODUCTION									
Mine production									
Minerals produced									
Lead ore (a)	ton		51,461	41,773	13,200	12,385	8,523		8,533
Lead content	"		3,337	3,387	874	750	660		657
Silver content	"	'000 t oz	145	69	39	26	50		50
Zinc content	ton		738	2,335	173	12	484		484
Gold content	t oz		37	23	—	—	—		—
Lead concentrate	ton		601,709	685,534	179,852	188,252	153,242		175,031
Lead content	"		361,487	420,819	113,589	113,344	93,721		111,367
Silver content	"	'000 t oz	17,773	20,132	5,293	5,510	4,803		5,100
Antimony content	ton		672	749	202	188	148		208
Cadmium content	"		57	49	14	14	9		13
Copper content	"		3,683	3,756	1,015	919	739		1,034
Gold content	t oz		10,045	12,210	3,079	3,149	2,499		2,806
Zinc content	ton		33,053	35,206	8,648	9,249	7,640		8,685
Sulphur content	"		50,244	57,028	15,519	14,499	11,028		14,944
Lead-copper concentrate	"		12,558	12,901	3,047	3,495	3,488		3,274
Lead content	"		4,679	4,580	1,085	1,160	1,217		1,136
Copper content	"		1,333	1,376	334	384	363		334
Silver content	"	'000 t oz	1,054	1,054	248	287	278		251
Gold content	t oz		21,557	22,908	5,398	6,606	6,700		7,055
Zinc content	ton		1,414	1,445	341	391	433		453
Sulphur content	"		3,260	3,374	780	940	903		861
Lead-zinc concentrate (b)	"		5,373	16,452	8,276	6,180	11,631		12,344
Lead content	"		1,788	3,545	2,085	875	2,817		3,652
Zinc content	"		441	4,449	2,327	1,998	2,402		1,911
Silver content	"	'000 t oz	167	516	215	242	376		461
Antimony content	ton		3	19	9	8	—		—
Cadmium content	"		27	59	29	30	—		—
Copper content	"		23	2	1	1	—		—
Gold content	t oz		223	2	—	—	—		—
Sulphur content	ton		589	2,971	1,560	1,370	—		—
Lead content of minerals produced	"		1,114	811	261	156	212		293
Copper concentrate	"		3,337	3,387	874	750	660		657
Lead ore	"		361,487	420,819	113,589	113,344	93,721		111,367
Lead concentrate	"		4,479	4,580	1,085	1,160	1,217		1,136
Lead-copper concentrate	"		1,788	3,545	2,085	875	2,817		3,652
Lead-zinc concentrate	"		10,266	11,757	3,215	3,162	3,016		3,264
Zinc concentrate	"		249,488	280,363	78,644	72,193	56,871		78,227
New South Wales	"		116,679	147,726	38,439	43,109	40,885		38,324
Queensland	"		43	48	—	5	—		—
South Australia	"		311	652	90	31	25		27
Western Australia	"		14,910	14,906	3,508	3,869	3,736		3,653
Tasmania	"		1,240	1,204	428	240	126		138
Northern Territory	"		382,671	444,899	121,109	119,447	101,643		120,369
Total contained lead	"		—	—	—	—	—		—
Smelter and refinery production									
Refined lead (c)	"		175,233	185,774	49,147	46,249	44,939		45,031
Lead content of lead bullion for export	"		116,133	153,134	42,891	43,266	39,157		44,392
EXPORTS									
Lead concentrate	ton		121,122	101,191	23,063	31,656	33,446		31,303
U.S.A.	"		36,362	39,435	5,700	13,347	12,771		17,203
Japan	"		29,006	36,097	8,783	8,863	5,806		3,533
United Kingdom	"		26,749	25,559	8,480	9,446	—		4,259
Germany F.R.	"		16,632	—	—	—	9,458		6,308
Other	"		12,373	100	100	—	5,411		6,077
Value	\$'000		23,636	19,438	4,565	6,375	5,950		6,077

Continued over page

LEAD

		Quarters—				1970*	
		1969*					
		1968	1969*	September	December	March	June
EXPORTS (continued)							
Lead bullion,	ton	107,325	135,605	37,768	38,481	51,966	38,839
United Kingdom	"	93,168	112,798	32,269	32,032	47,986	31,842
Netherlands	"	6,001	12,020	3,498	5,447	2,000	5,997
Belgium-Luxembourg	"	3,420	6,497	1,000	—	—	—
Germany F.R.	"	2,736	1,501	—	1,002	2,000	1,000
Other	"	2,000	2,789	1,001	—	—	—
Value	\$ '000	34,457	45,239	12,819	13,573	20,101	13,968
Refined lead, unworried	ton	137,542	131,512	42,140	37,009	49,554	30,792
United Kingdom	"	60,975	53,664	15,574	15,158	14,521	17,751
U.S.A.	"	40,616	42,017	16,989	11,830	27,224	1,650
India	"	16,029	15,692	4,135	4,831	3,703	5,825
Philippines	"	4,204	4,439	681	1,403	1,060	1,340
Netherlands	"	3,449	4,501	930	2,097	—	—
New Zealand	"	2,163	2,668	936	630	—	—
Italy	"	2,001	2,000	1,000	—	984	984
Other	"	8,105	6,531	1,995	1,062	1,840	2,076
Value	\$ '000	28,419	32,022	10,703	9,485	14,302	8,554
Rolled and extruded shapes	ton	888	653	183	124	153	293
Value	\$ '000	246	211	59	51	66	104
Antimonial lead	ton	1,132	4,557	1,217	1,528	1,225	1,926
Value	\$ '000	797	1,375	378	504	460	677
Scrap	ton	1,927	1,921	291	495	359	574
Value	\$ '000	240	286	82	93	131	—
Slags and residues	ton	2,547	4,454	731	944	707	790
Value	\$ '000	618	788	206	286	240	219
Lead content of concentrates, residues, etc. exported	ton	92,850	79,842	18,493	25,404	24,668	20,923
Lead content of lead bullion exported	ton	106,547	134,704	37,517	38,226	51,630	38,580

(a) Includes lead-silver and lead-zinc ores. (b) Product of dump re-treatment from primary sources. (c) Includes lead content of lead alloys from primary sources.

LIMESTONE

		Quarters— 1969*				1970*	
		1968	1969* September	December	March	June	
PRODUCTION							
Mine production (a)	'000 tons	8,470	9,456	2,517	2,420	2,206	2,252
New South Wales	"	2,686	2,908	785	725	709	762
Victoria	"	1,820	2,025	591	526	439	459
Queensland	"	(b)	(b)	(b)	(b)	(b)	(b)
South Australia	"	1,558	1,773	443	477	402	446
Western Australia	"	(b)	(b)	(b)	(b)	(b)	(b)
Tasmania	"	496	550	123	137	161	111
Cement, Portland	"	3,886	4,240	1,172	1,119	1,032	1,205
IMPORTS							
Limestone and calcareous stone	ton	416,619	510,996	109,810	120,686	101,640	131,526
Japan	"	416,611	510,996	109,810	120,686	101,640	131,526
Other	"	a					
Value	\$ '000	581	713	153	167	142	170
Calcium carbide	ton	10,298	10,096	11,292	4,839	2,079	1,604
Norway	"	5,604	5,945	722	2,315	695	870
South Africa	"	4,694	3,569	570	1,942	881	734
Other	"	"	582	"	582	503	"
Value	\$ '000	813	799	98	395	164	122
Cement, Portland	ton	54,160	70,953	18,593	19,044	16,177	23,761
Japan	"	36,212	32,004	9,375	14,458	12,375	15,285
United Kingdom	"	5,634	6,697	1,543	1,891	1,614	2,060
Other	"	12,314	32,252	7,675	2,695	2,188	6,416
Value	\$ '000	1,104	1,380	372	348	330	443
EXPORTS							
Cement, constructional	ton	4,739	4,160	509	2,549	1,725	5,182
Value	\$ '000	67	93	18	49	53	114

(a) Including shell and coral. (b) Not available for publication.

MAGNESITE

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production	ton	23 146	23 153	6 515	5 876	5 332	5 507
New South Wales	ton	22 861	23 102	6 464	5 876	5 283	5 421
South Australia	ton	319	51	51	—	49	86
Western Australia	ton	166	—	—	—	—	—
IMPORTS							
Magnesite calcined, dead burned	ton	24 308	12 944	2 104	3 009	1 580	3 895
Value	\$ '000	1 260	593	93	135	67	249
Magnesite calcined, other	ton	141	143	41	49	39	18
Value	\$ '000	61	56	17	22	17	7
Magnesite, other	ton	2	3	—	3	—	—
Value	\$ '000	1	1	—	—	—	—
EXPORTS							
Magnesite	ton	1 571	1 486	391	116	258	166
Value	\$ '000	126	130	38	10	21	12

MANGANESE

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced							
Metallurgical grade	ton	731,867	874,568	228,707	224,813	181,834	205,765
Manganese content	ton	339,519	415,743	108,537	106,778	88,249	96,602
Battery grade	ton	—	—	—	—	—	—
Manganese dioxide content	ton	—	—	—	—	—	—
Other grades	ton	210	673	154	265	—	—
Manganese dioxide content	ton	134	457	100	185	—	—
Manganese content of minerals produced							
Manganese contained in:							
Metallurgical grade ore	ton	339,519	415,743	108,537	106,778	88,249	96,602
Zinc concentrate	ton	5,880	6,402	1,810	1,650	1,264	1,672
Total contained manganese	ton	345,099	422,145	110,347	108,428	89,513	98,274
Production, States: metallurgical grade ore:							
Western Australia	ton	150,338	181,378	33,771	28,988	44,361	41,300
Northern Territory	ton	581,529	693,190	194,936	195,825	137,473	164,465
Total	ton	731,867	874,568	228,707	224,813	181,834	205,765
Manganese dioxide content of minerals produced							
Manganese dioxide contained in:							
Battery grade	ton	—	—	—	—	—	—
Other grades	ton	134	457	100	185	—	—
Total contained manganese dioxide	ton	134	457	100	185	—	—
Production, States: battery and other grades:							
New South Wales	ton	—	—	—	—	—	—
South Australia	ton	24	90	—	55	—	—
Northern Territory	ton	186	583	154	210	—	—
Total	ton	210	673	154	265	—	—
IMPORTS (a)							
Battery grade ore	ton	2,616	2,000	2,000	—	980	—
Value	\$'000	179	108	108	—	54	—
Other grade ore	ton	8,897	3,606	1,303	877	1,843	1,109
Value	\$'000	285	119	40	33	28	34
Metal and powder	ton	392	459	89	152	209	203
Value	\$'000	173	195	33	70	104	91
EXPORTS							
Manganese ore	ton	555,743	642,760	163,357	187,069	110,728	119,992
Japan	ton	316,821	424,514	127,428	127,428	103,935	91,741
Other	ton	238,922	218,246	35,929	72,857	6,793	28,251
Value	\$'000	10,827	11,644	2,887	3,361	2,127	2,091

(a) Imports of ferro-manganese are shown on page 8.

MONAZITE

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Monazite concentrate	ton	2,055	3,794	1,013	990	958	1,180
Monazite content	"	1,849	3,420	912	891	862	1,061
Production: States							
New South Wales	"	476	332	135	124	24	207
Queensland	"	243	175	—	67	8	16
Western Australia	"	1,130	2,913	777	700	830	957
Total	"	1,849	3,420	912	891	862	1,180
EXPORTS							
Monazite concentrate	ton	2,575	2,652	649	59	510	1,545
U.S.A.	"	2,505	2,203	620	—	—	303
Other	"	70	449	29	59	510	1,242
Value	\$ '000	348	329	82	7	68	213

NICKEL

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Nickel concentrate	ton	36,880	91,909	24,644	36,317	39,771	54,413
Nickel content	"	4,603	11,004	3,034	4,303	4,250	6,293
Cobalt content	"	121	105	30	29	45	75
Copper content	"	538	1,241	342	447	421	558
IMPORTS (a)							
Nickel—							
Pigs, ingots and blocks	ton	1,477	1,255	357	221	494	175
Value	\$ '000	2,879	2,785	781	700	2,003	693
Pellets, shot, granulated	ton	261	196	11	58	3	20
Value	\$ '000	489	503	22	232	37	52
Electroplating anodes	ton	176	111	24	34	47	24
Value	\$ '000	480	464	84	234	450	84
Bars, rods, angles, shapes and sections	ton	238	171	—	1	—	—
Value	\$ '000	484	389	—	3	—	—
Plates, sheets and strips	ton	19	17	2	11	31	14
Value	\$ '000	64	126	10	101	296	45
Pipes and tubes	ton	1	—	—	—	—	1
Value	\$ '000	7	6	2	—	2	1
Wire	ton	31	6	3	—	6	4
Value	\$ '000	105	28	11	—	22	1
Powder	ton	10	15	7	7	9	3
Value	\$ '000	24	53	24	24	33	20
Nickel-base alloys—							
Unworked shapes	ton	828	189	48	23	35	53
Value	\$ '000	940	447	169	80	141	141
Bars, rods, angles, shapes and sections	ton	108	136	32	25	28	38
Value	\$ '000	247	390	111	85	93	133
Plates, sheets and strips	ton	154	211	65	43	51	62
Value	\$ '000	476	643	197	134	174	234
Pipes and tubes	ton	64	57	22	19	22	8
Value	\$ '000	203	187	67	57	33	33
Wire	ton	176	216	58	50	38	41
Value	\$ '000	616	712	195	164	166	206
Powder	ton	27	36	8	13	6	5
Value	\$ '000	128	310	74	124	66	60

(a) Imports of ferro-nickel are shown on page 18

Note: Details of exports of nickel concentrate are not available for publication

PETROLEUM

		Quarters—				1970*	
		1968	1969*	September	December		
PRODUCTION (Source: Fuel Branch, Department of National Development)							
Petroleum production							
Crude oil	'000 bbls	13,877	15,765	3,923	4,875	5,801	16,106
Natural gas	MM cu ft	216	9,375	3,272	4,202	7,831	12,236
Refinery operations							
Input of feedstock	'000 bbls	163,589	165,937	42,458	44,034	41,659	47,037
Products							
Refinery gas (a) (b) (c)	"	1,249	1,487	437	334	282	329
Liquefied petroleum gas	"	2,887	3,334	990	823	739	815
Aviation gasoline	"	312	219	60	34	64	65
Motor spirit	"	56,085	58,721	14,631	15,124	14,771	15,817
Power kerosene	"	551	450	83	105	104	144
Aviation turbine fuel	"	6,374	6,764	1,590	2,027	2,010	2,428
Lighting kerosene	"	1,323	1,260	417	351	344	357
Heating oil	"	2,201	2,744	1,068	463	338	1,065
Automotive distillate	"	19,105	20,982	5,137	5,660	5,244	5,979
Industrial diesel fuel	"	7,543	8,106	2,248	2,190	1,815	1,929
Furnace fuel (b)	"	44,729	38,913	9,593	10,811	10,366	10,291
Solvents	"	1,107	1,355	352	340	299	342
Lubricating oil base stock	"	2,402	2,258	612	625	644	604
Bitumen	"	2,540	2,692	531	785	784	664
Other marketable products	"	2,657	3,891	1,212	1,000	946	1,122
Refinery fuel—							
Liquid	"	5,685	6,050	1,792	1,492	1,237	1,421
Gas and coke (a)	"	9,610	9,290	2,083	2,271	2,529	2,407

IMPORTS

Natural crude	'000 bbls	120,166	123,848	30,354	32,799	30,618	25,713
Value	\$ '000	169,892	175,045	43,309	45,178	40,855	34,559
Enriched crude and other refinery feedstock	'000 bbls	27,356	25,688	6,749	5,813	7,250	6,425
Value	\$ '000	43,100	39,545	10,466	8,512	10,593	9,373
Gasoline, solvents and other petroleum spirits	'000 bbls	4,535	5,442	1,263	2,027	1,245	2,015
Value	\$ '000	15,379	18,299	4,518	7,185	4,056	6,609
Kerosene and aviation turbine fuel	'000 bbls	833	1,074	446	219	97	85
Value	\$ '000	3,146	3,941	1,606	822	353	306
Automotive distillate, industrial and marine diesel fuels and heavy distillates n.e.i.	'000 bbls	1,285	1,886	479	645	229	752
Value	\$ '000	3,610	5,210	1,334	1,686	615	1,800
Residual oils	'000 bbls	922	7,437	2,269	2,174	1,600	1,348
Value	\$ '000	1,522	10,225	3,050	2,918	2,080	1,788
Lubricating oil	'000 bbls	347	262	47	62	94	45
Value	\$ '000	3,664	3,107	601	789	924	659

EXPORTS

Gasolines, solvents and other petroleum spirits	'000 bbls	2,597	1,529	411	462	212	554
Value	\$ '000	10,075	6,237	1,604	1,936	930	1,988
Kerosene and aviation turbine fuel	'000 bbls	910	575	146	206	314	428
Value	\$ '000	3,720	2,425	607	866	1,150	1,500
Automotive distillate, industrial and marine diesel fuels and heavy distillates n.e.i.	'000 bbls	1,793	1,731	359	612	487	697
Value	\$ '000	5,467	5,237	1,075	1,914	1,306	1,874
Residual oils	'000 bbls	2,818	1,194	166	232	1,544	991
Value	\$ '000	6,291	1,940	300	370	1,791	1,280
Lubricating oils	'000 bbls	621	488	88	93	211	273
Value	\$ '000	6,707	5,956	1,144	1,151	2,208	2,777

(a) Fuel oil equivalent. (b) Excluded refinery fuel. (c) For sale as fuel

PHOSPHATE

		Quarters—					
		1969*		1970*			
		1968	1969*	September*	December*	March	June
PRODUCTION							
Mine production	ton	5,744	18,255	n.a.	n.a.	n.a.	n.a.
Phosphate rock	ton	5,744	18,255	n.a.	n.a.	n.a.	n.a.
South Australia	ton	5,744	18,255	n.a.	n.a.	n.a.	n.a.
Production of superphosphate (a)	1000 tons	4,175	3,787	802	952	1,033	771

IMPORTS

Phosphate rock	1000 tons	3,431	2,742	557	712	630	701
Hauri	ton	1,620	1,432	336	418	406	399
Christmas Island (Indian Territory)	ton	551	775	251	184	196	210
U.S.A.	ton	511	151	32	10	—	—
Other	ton	499	586	78	100	88	92
Value	\$'000	34,140	28,595	7,478	7,630	5,492	7,510

(a) Source: Department of Primary Industry. Includes double and triple superphosphate and ammonium phosphate expressed in terms of single superphosphate, i.e. 22 % P₂O₅ equivalent.

SALT

		Quarters—					
		1969*		1970*			
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production	ton	899,704	1,653,478	n.a.	n.a.	n.a.	n.a.
Victoria	ton	(a)	(a)	n.a.	n.a.	n.a.	n.a.
Queensland	ton	(a)	241,414	n.a.	n.a.	n.a.	n.a.
South Australia	ton	610,827	565,442	n.a.	n.a.	n.a.	n.a.
Western Australia	ton	(a)	(a)	n.a.	n.a.	n.a.	n.a.

IMPORTS

Salt, common	ton	7,910	7,728	1,711	2,059	1,987	2,300
Value	\$'000	119	121	26	33	33	37

EXPORTS

Salt	ton	224,854	701,643	230,819	346,794	339,420	464,561
Value	\$'000	854	2,703	819	1,248	1,197	1,673

(a) Not available for publication.

SILLIMANITE

		1968	Quarters— 1969*		1970*	
			September	December	March	June

PRODUCTION

Mine production	ton	2,115	1,674	411	269	354	201
New South Wales	ton	1,760	1,113	314	166	302	201
South Australia	ton	355	561	97	113	52	—

IMPORTS

Sillimanite	ton	758	302	3	6	—	—
Value	\$'000	36	16	1	1	—	—

SILVER

		1968	Quarters— 1969*		1970*	
			September	December	March	June

PRODUCTION

Mine production							
Silver content of minerals produced							
Bismuth concentrate	'000 l oz	5	5	1	1	2	1
Copper ore	ton	4	2	1	1	1	3
Copper concentrate	ton	894	1,071	287	265	244	271
Gold ore	ton	—	—	—	—	—	—
Gold bullion	ton	209	159	33	34	31	102
Lead ore	ton	145	169	40	26	50	50
Lead concentrate	ton	17 773	20 132	5 293	5 510	4 803	5 100
Lead-copper concentrate	ton	1 054	1 054	248	287	278	251
Lead-zinc concentrate	ton	167	516	215	242	376	461
Zinc concentrate	ton	1 143	1 448	419	386	387	422
New South Wales	ton	9 521	10 749	2 995	2 828	2 350	3 108
Victoria	ton	—	—	—	—	—	—
Queensland	ton	9 624	11 539	3 005	3 364	3 289	2 964
South Australia	ton	1	1	—	—	—	—
Western Australia	ton	187	135	41	35	31	82
Tasmania	ton	1 748	1 744	406	467	459	442
Northern Territory	ton	312	289	94	56	43	67
Total contained silver	ton	21 394	24 457	6 542	6 751	6 172	6 662
Refinery production							
Refined silver	ton	9 813	10 389	2 705	2 912	2 298	2 672

IMPORTS

Silver	'000 l oz	65	81	16	33	23	18
Silver and alloys	'000 l oz	53	35	10	9	9	8
Fiji	ton	4	13	3	4	8	6
New Zealand	ton	8	33	3	20	6	4
Other	ton	137	137	24	58	38	27
Value	\$'000	137	137	24	58	38	27

EXPORTS

Silver, refined	'000 l oz	14,542	7,490	827	2,173	2,880	1,523
Mint bullion	'000	29,339	12,485	1,266	3,616	4,877	2,792
Value	\$'000	1,270	344	22	113	21	380
Refined, other	'000 l oz	2,366	571	37	169	36	557
Value	\$'000	2,366	571	37	169	36	557
Silver content of concentrate, matte, etc. exported	'000 l oz	3,598	3,382	667	1,145	1,052	864
Silver content of lead bullion exported	ton	7,674	9,743	2,715	2,746	2,971	2,781

SULPHUR

		Quarters—				1970*	
		1969*					
		1968	1969* September	December	March	June	
PRODUCTION							
Mine production							
Pyrite concentrate (a)	ton	165,265	158,389	31,144	25,168	26,121	51,487
Sulphur content		71,792	70,655	13,654	11,214	11,426	20,587
Sulphur content of minerals produced							
Lead concentrate	ton	50,244	56,028	15,519	14,499	11,028	14,944
Lead-copper concentrate	ton	3,260	3,374	780	940	903	861
Lead-zinc concentrate	ton	589	2,971	1,560	1,370	—	—
Pyrite concentrate	ton	71,792	70,655	13,654	11,214	11,426	20,587
Zinc concentrate	ton	224,109	270,419	75,712	70,101	58,977	71,226
Production: States, tin content							
New South Wales	ton	203,231	247,636	71,630	64,151	47,882	62,283
Queensland	ton	41,961	55,106	14,226	18,831	17,475	18,632
South Australia	ton	35,837	25,873	6,701	4,352	5,708	5,032
Western Australia	ton	14,433	8,236	1,610	2,734	631	—
Tasmania	ton	53,071	65,871	12,591	9,817	10,471	21,241
Northern Territory	ton	1,457	1,235	459	239	137	125
Total contained sulphur	ton	349,990	403,447	107,225	98,124	82,334	107,618
Sulphuric acid production							
	'000 tons	1,860	1,837	413	483	470	382

IMPORTS

Sulphur, elemental	ton	548,563	583,886	107,262	117,257	129,230	73,555
Canada	ton	315,400	255,829	11,739	69,886	105,108	47,394
United States	ton	19,542	51,250	14,055	19,457	22	8,292
Mexico	ton	90,654	105,825	31,067	27,879	13,789	17,830
Other	ton	23,167	20,973	10,403	36	10,311	39
Value	\$'000	21,632	12,513	3,196	3,315	2,660	1,446

(a) Gold content not recorded separately included in gold content of gold bullion.

TALC (a)

		Quarters—				
		1969*			1970*	
		1968	1969* September	December	March	June
PRODUCTION						
Mine production	ton	38 280	49 267	10 320	20 726	12 265
New South Wales	ton	2 587	712	380	532	1 114
South Australia	(b)		12 262	57	8 094	
Western Australia	(b)	36 293	9 503	12 300	11 151	8 434

IMPORTS

Talc	ton	3,433	1,754	762	768	858	1,012
China (Mainland)	ton	2,403	984	492	393	393	88
U.S.A.	ton	462	435	106	233	130	63
India	ton	425	210	130	20	329	758
Other	ton	243	85	34	15	6	73
Value	\$'000	117	77	28	18	43	45

EXPORTS

Talc	ton	24,992	33,599	10,203	12,416	9,221	6,760
Netherlands	ton	18,725	21,895	5,495	5,228	5,805	2,055
Belgium-Luxembourg	ton	3,024	—	—	—	—	—
Other	ton	3,233	11,714	3,708	7,188	3,416	4,705
Value	\$'000	661	963	261	316	233	177

(a) Includes steatite, chlorite, etc. (b) Not available for publication.

TIN

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Fluorite produced							
Copper-tin concentrate	ton	877	3,303	1,019	833	896	901
Copper content	"	169	570	161	156	196	205
Tin content	"	60	159	38	31	44	46
Tantalite-tin concentrate	"	387	—	—	—	—	—
Tantalite content	lb	19,985	—	—	—	—	—
Tin content	ton	11	—	—	—	—	—
Tin concentrate	"	10,420	13,072	3,273	4,083	3,529	3,698
Tin content	"	6,477	7,947	2,075	2,329	2,014	2,171
Production: States, tin content							
New South Wales	"	1,448	1,520	294	445	386	444
Victoria	"	64	9	2	6	2	2
Queensland	"	1,249	1,144	380	341	273	378
Western Australia	"	624	502	197	69	167	194
Tasmania	"	3,126	4,902	1,241	1,485	1,211	1,184
Northern Territory	"	26	29	9	14	19	15
Total contained tin	"	6,537	8,106	2,113	2,360	2,058	2,217
Smelter and refinery production							
Refined tin	"	3,692	4,156	1,135	1,018	1,025	1,459

IMPORTS (a)

Refined tin	ton	159	104	24	19	32	28
Value	\$'000	448	323	77	61	110	99

EXPORTS (a)

Tin concentrate	ton	5,366	5,915	1,218	1,821	2,456	1,532
Value	\$'000	7,574	8,642	1,813	2,774	3,567	2,236
Base metal alloys, unworried	ton	234	632	182	91	83	272
Value	\$'000	592	1,676	561	275	247	825
Value of concentrates exported	ton	3,135	3,524	722	1,111	1,258	780

Production and overseas trade details for tinplate are shown on Page 8.

TITANIUM

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced	ton	551,501	701,172	179,179	200,048	192,854	200,008
Ilmenite concentrate	ton	301,069	380,219	97,854	107,691	104,513	110,340
Titanium dioxide content	"	1,607	7,970	1,971	2,470	2,522	2,387
Leucocaine concentrate	"	1,444	6,996	1,731	2,143	2,420	2,094
Titanium dioxide content	"	287,617	356,039	91,776	94,429	83,715	94,729
Rutile concentrate	"	276,207	341,986	88,076	90,819	80,336	90,917
Titanium dioxide content	"	301,069	380,219	97,854	107,691	104,513	110,340
of minerals produced	"	1,444	6,996	1,731	2,143	2,420	2,094
Titanium dioxide contained in:	"	276,207	341,986	88,076	90,819	80,336	90,917
Ilmenite concentrate	"	1,444	6,996	1,731	2,143	2,420	2,094
Leucocaine concentrate	"	276,207	341,986	88,076	90,819	80,336	90,917
Rutile concentrate	"	276,207	341,986	88,076	90,819	80,336	90,917
Total contained titanium dioxide	ton	578,720	729,201	187,661	200,653	187,268	203,351
Production: States							
In ilmenite concentrate (a)							
New South Wales	ton	5,282	5,174	1,279	1,385	1,325	1,047
Queensland	"	2,040	12,121	267	11,234	13,319	6,893
Western Australia	"	295,191	369,920	98,039	97,215	89,869	102,137
Total	ton	302,513	387,215	99,585	109,834	104,513	110,077
In rutile concentrate							
New South Wales	ton	185,209	217,354	54,779	54,883	49,929	57,764
Queensland	"	90,184	117,796	31,263	33,395	28,071	31,083
Western Australia	"	814	1,903	527	713	566	436
Tasmania	"	—	4,933	1,507	1,828	1,770	1,634
Total	ton	276,207	341,986	88,076	90,819	80,336	90,917

Continued over page

TITANIUM (continued)

		Quarters—				
		1968	1969*	1970*		
			September	December	March	June
IMPORTS						
Titanium oxide—						
Anatase	ton	480	522	158	70	20
Value	\$ '000	180	185	54	28	10
Rutile	ton	832	662	172	173	172
Value	\$ '000	329	304	82	75	79
Titanium white pigment	ton	215	146	30	66	41
Value	\$ '000	95	70	15	32	23

EXPORTS

Ilmenite concentrate (a)	ton	395,911	566,520	104,923	157,394	144,673	182,624
United Kingdom	"	154,593	230,951	52,633	47,624	65,374	42,211
France	"	120,210	110,071	14,710	25,256	12,829	34,697
Japan	"	67,412	119,222	24,785	48,919	24,516	77,265
U.S.A.	"	29,959	36,688	270	7,392	41,693	18,337
Other	"	23,697	69,588	12,525	28,203	281	10,114
Value	\$'000	4,090	6,032	1,100	1,650	1,591	1,691
Rutile concentrate	ton	284,995	299,113	80,926	85,454	78,797	101,372
U.S.A.	"	146,900	150,344	43,666	43,814	44,166	40,945
Japan	"	30,813	28,867	6,324	8,659	6,816	8,635
Canada	"	23,794	2,672	637	2,005	25	10,002
United Kingdom	"	16,582	31,047	11,964	7,580	4,579	14,129
Other	"	67,106	86,183	18,335	23,396	23,211	27,661
Value	\$'000	21,865	25,491	7,263	7,235	7,152	9,192

(a) includes leucostene concentrate

TUNGSTEN

		1968	Quarters— 1969*		1970*	
			September	December	March	June

PRODUCTION

Mine production							
Minerals produced							
Scheelite concentrate	ton	1,465	1,530	275	444	315	330
Tungstic oxide (WO ₃) content	unit	105,432	109,242	19,729	31,901	22,554	23,476
Wolfram concentrate	ton	559	884	211	261	251	294
Tungstic oxide (WO ₃) content	unit	39,060	62,599	15,124	18,735	18,099	21,153
Tungstic oxide (WO ₃) content of minerals produced							
Tungstic oxide contained in:							
Scheelite concentrate							
	unit	—	—	—	664	—	—
Tasmania	..	105,432	109,242	19,729	31,237	22,554	23,476
Total contained in scheelite	..	105,432	109,242	19,729	31,901	22,554	23,476
Wolfram concentrate							
New South Wales	..	43	36	—	—	—	—
Queensland	..	2,600	17,570	4,480	4,270	3,500	4,690
Western Australia	..	34	—	—	—	—	—
Tasmania	..	34,615	43,910	10,644	14,465	14,599	16,463
Northern Territory	..	1,768	1,083	—	—	—	—
Total contained in wolfram	..	39,060	62,599	15,124	18,735	18,099	21,153
Total contained in tungsten minerals	..	144,552	171,841	34,853	50,636	40,653	44,629

EXPORTS

Scheelite concentrate	ton	1,434	1,601	371	361	267	410
Value	\$'000	3,532	4,361	1,088	1,083	824	1,230
Wolfram concentrate	ton	497	799	181	244	218	336
Value	\$'000	1,294	2,412	551	785	812	1,442
(Tungstic oxide (WO ₃) content of concentrates exported	unit	132,173	195,012	38,171	41,000	34,023	51,631
In scheelite concentrate	"	87,520	108,929	25,255	24,576	18,320	27,900
In wolfram concentrate	"	34,653	56,089	12,916	16,424	15,703	23,731

ZINC

		1968	Quarters— 1969*		1970*	
			September	December	March	June

PRODUCTION

Mine production							
Minerals produced							
Zinc ore	ton	2,700	8,500	—	—	—	—
Zinc content	"	810	2,550	—	—	—	—
Zinc concentrate	ton	718,311	861,823	241,715	222,291	187,241	224,101
Zinc content	"	377,142	454,176	127,254	117,021	98,101	117,546
Lead content	"	10,266	11,757	3,215	3,162	3,016	3,264
Silver content	000 l oz	1,143	1,448	418	386	387	422
Gold content	l oz	4,347	4,721	1,052	1,167	1,320	1,364
Cadmium content	ton	1,299	1,595	456	416	341	405
Cobalt content	"	114	135	36	32	29	33
Copper content	"	911	936	243	235	207	245
Manganese content	"	5,580	6,402	1,810	1,650	1,264	1,672
Sulphur content	"	224,105	270,419	75,712	70,101	58,977	71,226
Zinc content of minerals produced							
Copper concentrate	"	2,124	1,687	350	362	434	415
Lead ore	"	738	2,335	173	12	484	484
Lead concentrate	"	33,053	35,206	8,648	9,249	7,640	8,685
Lead-copper concentrate	"	1,414	1,445	341	391	433	453
Lead-zinc concentrate	"	441	4,449	2,327	1,998	2,402	1,911
Zinc ore	"	810	2,550	—	—	—	—
Zinc concentrate	"	377,142	454,176	127,254	117,021	98,101	117,546
Production by State							
New South Wales	"	280,219	343,480	100,546	88,385	68,397	88,426
Queensland	"	84,090	104,018	26,159	27,227	28,232	28,186
South Australia	"	810	2,550	—	—	—	—
Tasmania	"	48,739	50,207	11,839	12,770	12,705	12,744
Northern Territory	"	1,864	1,593	549	651	160	138
Total contained zinc	"	415,722	501,848	139,093	129,033	108,494	129,494
Smelter and refinery production							
Refined zinc	"	204,992	242,433	65,471	63,596	61,990	66,819

EXPORTS

Zinc							
Zinc concentrate	ton	321,027	363,885	73,579	102,987	127,446	127,015
United Kingdom	"	165,105	174,809	45,680	40,275	58,726	51,452
Japan	"	87,026	128,790	19,626	48,211	31,299	59,387
Norway	"	22,627	19,752	—	14,501	9,000	—
Other	"	46,269	40,534	8,273	—	28,421	16,176
Value	\$'000	21,660	25,888	5,679	7,058	8,791	8,976
Refinery-type shapes	ton	97,177	138,336	40,779	35,756	39,086	36,879
U.S.A.	"	18,609	30,857	6,056	8,145	10,009	3,083
India	"	16,361	5,049	—	1,453	2,090	5,992
Thailand	"	11,260	10,921	2,343	3,637	4,169	1,964
Other	"	50,947	91,609	31,400	22,521	22,818	25,840
Value	\$'000	22,597	33,454	9,966	9,041	10,103	9,684
Plates, circles and strips	ton	245	250	120	62	167	66
Value	\$'000	133	121	64	27	69	28
Slags and residues	ton	8,353	5,472	1,368	1,879	757	1,580
Value	\$'000	394	375	91	134	64	108
Zinc content of ores and concentrates, slags, residues, etc. exported	ton	177,319	200,108	40,768	56,855	68,948	64,380

ZIRCONIUM

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
PRODUCTION							
Mine production							
Minerals produced							
Zircon concentrate	ton	294,195	369,296	96,592	92,740	84,027	93,110
Zircon content	"	290,919	356,602	95,632	91,593	82,951	91,359
Production: States, zircon content							
New South Wales	"	184,431	219,062	57,103	53,741	49,403	55,380
Queensland	"	78,986	81,715	22,637	22,824	18,289	20,801
Western Australia	"	27,502	49,861	13,946	13,169	13,315	14,107
Tasmania	"	—	5,964	1,946	1,859	1,944	1,071
Total contained zircon	"	290,919	356,602	95,632	91,593	82,951	91,359
EXPORTS							
Zircon concentrate	ton	266,121	311,242	60,419	95,814	81,532	108,584
Japan	"	59,138	70,907	20,915	18,720	34,576	35,589
U.S.A.	"	57,446	74,255	10,623	25,908	11,201	25,036
United Kingdom	"	39,779	34,679	2,060	11,280	4,481	9,521
France	"	25,406	23,827	9,672	3,821	6,033	12,166
Other	"	84,354	107,574	17,149	36,085	25,241	26,272
Value	\$'000	11,013	12,379	2,505	3,743	3,166	4,038

MINOR MINERALS

		Quarters— 1969*				1970*	
		1968	1969*	September	December	March	June
BARITE							
Mine production	ton	39,155	39,562	304	18,699	4,923	15,419
Imports (including witherite)	"	1,619	2,616	321	833	686	320
Value	\$'000	52	101	8	49	20	10
Exports	ton	19,564	23,995	7,268	3,033	3,923	1,568
Value	\$'000	789	812	195	108	155	71
BERYLLIUM							
Mine production	ton	15	7	—	2	1	1
BeO content	unit	178	67	—	17	10	5
Exports	ton	135	9	7	—	2	16
Value	\$'000	53	6	4	—	1	7
BISMUTH							
Mine production	ton	1,553	1,678	524	386	540	287
Bismuth concentrate	lb	403,200	441,205	147,168	117,824	129,472	83,852
Bismuth content	oz	27,535	22,330	4,989	5,232	4,281	4,402
Gold content	ton	130	138	38	30	35	18
Copper content	ton	5	5	1	1	2	1
Silver content	'000 t oz						
Imports	lb	31,997	32,189	14,470	7,035	2,830	7,718
Bismuth metal	lb	118	147	63	42	21	67
Value	\$'000						

MINOR MINERALS

		1968	1969*	Quarters— 1969*		1970*	
				September	December	March	June
CLAYS							
Mine production							
Brick clay and shale	'000 tons	6,422	7,807	1,862	1,775	1,597	1,768
Imports							
Bentonite and bentonitic clay	ton	43,810	58,155	18,394	15,593	6,800	30,883
Value	\$'000	984	1,123	304	342	181	524
Clay, ball	ton	18,349	18,641	5,655	5,676	3,061	4,071
Value	\$'000	410	448	133	145	84	112
Clays and earths, activated	ton	5,461	7,251	1,468	1,543	1,298	993
Value	\$'000	419	517	124	111	104	93
Clay, white	ton	25,549	24,276	7,658	8,404	9,583	8,594
Value	\$'000	620	627	206	196	191	284
Fireclay	ton	4,991	4,749	425	396	1,868	2,321
Value	\$'000	173	112	18	16	69	82
Clays, n.e.i.	ton	12,379	12,969	4,168	4,841	2,926	6,826
Value	\$'000	548	590	186	234	116	206
Exports							
Clays (except activated)	ton	3,714	5,960	1,565	1,419	1,373	1,280
Value	\$'000	158	165	38	38	49	39
COBALT							
Mine production							
Cobalt content of minerals produced							
Cobalt contained in	ton	121	105	30	29	45	75
Nickel concentrate	"	114	135	36	32	29	33
Zinc concentrate	"	235	240	66	61	74	108
Total							
Imports							
Cobalt oxide and hydroxide	ton	31	4	2		2	21
Value	\$'000	101	14	6		6	97
Cobalt and cobalt base metal alloys (excl. powder)	ton	73	70	17	19	29	13
Value	\$'000	285	270	61	76	133	56
CRYOLITE, NATURAL							
Imports (including chiolite)	ton	201	266	58	65	87	55
Value	\$'000	38	59	12	18	17	12
DIAMONDS, INDUSTRIAL							
Imports	carats	869,931	815,554	279,563	231,544	224,786	225,707
Value	\$'000	2,725	3,021	863	937	910	917
Exports (a)	carats	60,097	53,837	11,564	15,799	44,108	11,970
Value	\$'000	340	328	105	88	180	96
DIATOMITE							
Mine production	ton	6,725	2,374	857	782	560	705
Imports	ton	5,126	8,300	3,286	1,584	1,827	1,147
Value	\$'000	334	505	155	109	121	86
DOLOMITE							
Mine production	ton	316,731	291,838	77,000	76,841	80,854	81,097

(a) Excludes powder and dust.

MINOR MINERALS

		Quarters—					
			1969*	1969*		1970*	
		1968	September	December	March	June	
FELSPAR							
Mine production	ton	4,838	4,937	449	1,255	583	983

FLUORSPAR

Imports	ton	14,921	20,022	3,081	3,249	11,364	2,170
Value	\$'000	518	667	115	116	368	79

KYANITE

Imports	ton	1,776	3,240	608	1,501	2,215	36
Value	\$'000	75	229	35	124	127	3

LITHIUM

Mine production	ton	738	710	86	300	244	135
Lithium ore	unit	3,112	2,982	361	1,261	1,025	567

MERCURY

Refinery production	lb	4,099	3,625	895	655	899	780
Imports	lb	104,549	63,193	18,335	17,948	20,025	20,582
Italy	"	68,144	26,222	"	9,109	"	761
Mexico	"	9,925	10,220	1,673	8,515	7,602	761
Other	"	26,480	26,750	16,662	324	12,423	19,060
Value	\$'000	714	381	110	101	121	118

MICA

Imports							
Slab, block or sheet	'000 lb	37	32	2	5	9	6
Value	\$'000	83	65	5	17	17	17
Splittings (not cut or stamped)	'000 lb	172	215	59	34	31	30
Value	\$'000	91	124	31	25	20	18
Ground or pulverised	'000 lb	859	436	169	185	42	146
Value	\$'000	60	38	11	11	14	15
Other	'000 lb	1,422	1,244	299	365	348	201
Value	\$'000	31	34	7	11	9	8

PLATINUM and PLATINUM GROUP METALS

Imports							
Ingot, blocks, pigs, etc.	oz	6,426	9,655	2,354	2,407	2,517	4,012
Value	\$'000	436	635	143	161	152	254
Powder	oz	11,001	6,250	20	21	40	75
Value	\$'000	155	35	1	1	2	3
Wire	oz	1,841	3,017	726	800	668	418
Value	\$'000	205	288	50	75	44	43

POTASSIUM

Imports							
Potassium chloride (fertilizer grade)	ton	121,834	107,075	22,870	28,891	47,109	11,308
Value	\$'000	3,044	2,497	497	647	1,237	303
Potassium sulphate (fertilizer grade)	ton	14,046	14,594	5,617	2,909	7,978	580
Value	\$'000	527	645	260	135	325	27

TANTALUM and COLUMBIUM

Mine production	lb	238,134	340,631	37,856	76,698	2,912	49,818
Tantalite-columbite concentrate	"	56,179	89,927	13,353	18,907	925	13,466
Ta ₂ O ₅ + Nb ₂ O ₅ content	"						
Exports							
Tantalite-columbite concentrate	ton	59	90	17	27	42	20
Value	\$'000	212	305	57	81	131	77

Summary Tables

MINE PRODUCTION OF PRINCIPAL MINERALS: AUSTRALIA

Mineral	Unit of Quantity	Quarters— 1969*				1970*	
		1968	September	December	March	June	September
Bauxite	'000 tons	4,877	7,796	2,094	1,747	2,192	2,704
Black coal	"	40,183	46,403	11,820	10,772	12,470	13,319
Brown coal	"	22,971	22,911	5,322	5,308	6,811	6,629
Copper (a)	ton	107,906	126,986	33,329	32,731	36,181	35,451
Gold (a)	'000 f oz	782	499	169	178	147	140
Iron ore and concentrate (b)	'000 tons	26,204	37,966	9,871	10,394	17,298	13,447
Lead (a)	'000 tons	382,671	444,899	119,447	101,643	120,369	116,338
Manganese ore, metallurgical	ton	731,867	874,568	224,812	181,834	205,765	223,579
Nickel (a)	"	4,603	11,004	4,303	4,260	6,293	8,442
Petroleum—							
Crude oil	'000 bbls	13,877	15,765	4,875	5,801	16,106	19,830
Natural gas	MM cu ft	216	9,375	4,202	7,831	12,236	17,002
Silver (a)	'000 f oz	21,394	24,457	6,751	6,172	6,662	6,393
Tin (a)	ton	6,537	8,106	2,360	2,058	2,217	2,288
Titanium—							
Mineral concentrate (c)	"	551,501	701,172	200,048	192,854	200,008	207,578
Rutile concentrate	"	287,617	353,642	94,429	87,715	94,729	78,140
Tungsten concentrates (d)	unit	144,552	171,841	50,836	40,653	44,629	33,621
Zinc (a)	ton	415,722	501,848	129,033	109,494	129,454	129,145
Zircon concentrate	"	294,195	356,602	92,740	84,027	93,110	77,455

(a) Total metallic content of minerals produced. (b) Excludes iron oxide not intended for metal extraction. (c) Excludes manganese. (d) Tungstic oxide content.

SMELTER AND REFINERY PRODUCTION OF PRINCIPAL METALS: AUSTRALIA

Metal	Unit of Quantity	Quarters— 1969*				1970*	
		1968	September	December	March	June	September
Alumina	ton	1,288,776	1,900,519	567,779	462,919	514,603	551,780
Aluminum (refined)	"	95,810	124,423	36,760	48,495	49,080	51,413
Cadmium (refined)	"	465	562	151	147	168	148
Copper (refined)	"	82,454	114,349	29,547	24,575	24,685	28,507
Copper (blister) (a)	"	84,269	99,261	26,151	27,842	26,512	27,551
Gold (refined)—							
Australian origin	'000 f oz	639	586	153	110	125	112
Total	"	766	703	183	142	163	141
Lead	ton	175,233	185,774	46,249	44,939	45,031	43,131
Lead content of lead bullion	"	116,133	153,134	43,266	39,159	44,392	46,331
For export	"	5,484	6,010	1,552	1,687	1,469	1,728
Pig iron	'000 tons	6,399	6,906	1,789	1,576	1,675	2,315
Raw steel (c)	"	9,613	10,369	2,912	2,298	2,672	2,315
Silver (refined)	'000 f oz	3,692	4,156	1,018	1,025	1,459	1,221
Tin (refined)	ton	204,992	242,432	63,596	61,990	66,619	66,086
Zinc (refined)	"						

(a) Total production for refining in Australia and overseas. (b) Includes lead content of lead alloys from primary sources. (c) Includes recovery from scrap.

Note: Particulars of crude oil and natural gas were collected by Fuel Branch, Department of National Development and (c) Includes recovery from scrap.

refined aluminium, cadmium, copper, lead, nickel, silver, tin and zinc were collected by the Bureau of Mineral Resources.