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MINERAL RESOURCES OF AUSTRALIA

by

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INTRODUCTION

This paper attempts to give a broad picture of Australia's mineral industry, and of the varied and widespread resources on which it is founded. It includes a quick glance at the domestic requirement for the principal minerals and ores, some notes on the chief deposits and centres of production, reference to some of the industrial activities dependant on minerals, remarks about recent important events in mineral exploration, and an attempt to foresee what lies ahead. Two important minerals, coal and underground water, are being dealt with by other speakers to the Course and, though both are of vital importance to the national economy, they will not be included in the present discussion.

2. Even with these exceptions, the topic is still very large. Australia's known mineral wealth has increased with every decade since the first discoveries more than a century ago, and the end still seems far from sight. Our growth as a nation has owed much in the past to the flow of population and capital which followed the early mineral discoveries. This flow reached a peak towards the end of the last century, then slackened for almost fifty years; it has begun again in the last decade in the wake of exciting discoveries from which great new sources of wealth are foreshadowed. Today there is promise of development on a scale not to have been imagined even a few years ago.

3. One feature of the new epoch, perhaps worthy of comment, is the degree to which Governments have become involved with industry both in exploration and development of major mineral deposits. At the end of these notes reference is made to some of the policies followed in recent years with the intention of encouraging development or of conserving national resources. Attached also is a summary table of the degree of self-sufficiency attained in securing our vital supplies. The degree of sufficiency is also illustrated in the block diagram showing values of imports and exports of minerals in 1969, which is attached at the end of the report. The table and block diagram are perhaps more effective in illustrating the present satisfactory situation than any amount of text can hope to be.

4. The minerals discussed are grouped under the following headings -

(a) Iron, manganese, chromium and other metals commonly used in the manufacture of steel;
(b) Base metals - copper, lead, zinc, and tin;
(c) Uranium, thorium and other metals used in or in connection with the production of nuclear energy;
(d) Beach Sand Minerals - rutile, ilmenite, zircon;
(e) Other metals;
(f) Non-metallic minerals;
(g) Fertiliser minerals;
(h) Petroleum (i.e. oil and natural gas).

Mineral statistics given are those for 1969, the latest calendar year for which complete figures are available.

5. Iron and Steel: Production of iron ore for iron and steel making in 1969 was about 38 million tons, an increase of 42 percent above the output in 1968, due largely to expanding export contracts. Production of ingot steel in Australia in 1969 rose by 8% from 6.4 to 6.9 million tons, and production of pig iron by 9% from 5.5 to 6.0 million tons. Most of the steel was consumed on the domestic market; some 536,000 tons worth $32.7 million were exported in 1969.

6. Australia has for a long time been largely self-sufficient in the production of iron and steel, and exports have acted chiefly as a buffer between domestic production and demand. Some special steels and shapes and some 60% of our ferroalloys are imported.

7. The main supplies of iron ore for the Australian blast furnaces came from two sources the Middleback Range in S.A. and Yampi Sound near Derby, W.A. These two localities produced 6.9 million and 2.5 million tons of iron ore respectively. An additional 1.1m tons was mined at Koolyanobbing near Southern Cross, W.A. to feed a small charcoal-iron plant at Wundowie near Perth which produces special grades of pig. Imports of iron ore with high manganese content from New Caledonia for blending with domestic ore have been falling in recent years and totalled only 126 tons in 1969 compared with 244,000 tons in 1968. In addition to the iron ore consumed in Australia, about 21m tons of ore and 5m tons of pellets were exported; this compares with 14 million tons of ore and 2 million tons of pellets in 1968. The Northern Territory and Tasmania continued an export trade, and the overall effect was a 62% increase in exports during the year.

8. In the not too distant past, the chief cause of concern in matters of iron and steel was the rather low figure of domestic reserves. However since 1961 the figures for known resources of iron ore have undergone a transformation and we have emerged suddenly as one of the world's major potential producers. This is all the more interesting because until late in the 1950's most authoritative opinions still held the reserve figure as too low for safety in comparison with our long-term industrial needs, and few foresaw the possibility of major new discoveries. Because of this a complete embargo on the export of iron ore had been maintained for more than twenty years. Since the embargo was eased in 1960, new discoveries have shown that we possess within our shores one of the most important iron provinces in the world, and a major export trade has already been established.

9. To illustrate the spectacular change in our reserves it may be noted that in 1959 the official estimate of demonstrated reserves amounted only to 369 million tons. At that time exploratory drilling in several States had raised hopes that intensified search might reveal some worthwhile new deposits. Among the principal prospects at the time were - Savage River, in western Tasmania, where air-borne magnetic surveys had shown a belt of intense anomalies extending over a length of several miles; Constance Range, in north-west Queensland, where preliminary testing beneath silica-rich ironstone outcrops had shown a marked improvement in quality at depth and some prospect of large tonnages of ore suitable for deep mining methods; and Mt. Goldsworthy, near Port Hedland, Western Australia, where drilling had shown a more substantial body than was indicated by outcrop and surface sampling.

10. Encouraged by these hopes the Commonwealth Government eased the export embargo in 1960, and soon afterwards a series of discoveries in the Pilbara district, east of Onslow, Western Australia, focused attention on an area hardly touched by modern large-scale mineral prospecting. In the space of little more than a year important deposits were reported from such localities as Deepdale, Robe River, Mt. Tom Price, and Mt. Newman all lying in this neglected north-western part of the State. Recent discoveries in Western Australia include deposits of hematite and of limonite; early development at Mt. Tom Price, Mt. Whaleback, Mt. Goldworthy and at Koolanooka are based on hematite deposits but development of limonite deposits at Robe River to produce pellets and iron ore fines is now underway.

11. Deposits in Western Australia have since been subjected to vigorous testing and extremely large tonnages of high-grade ore have been demonstrated. Though the full extent is not yet known, informed guesses have placed the total reserves at around 20,000 million tons, and some believe much more. In other words since 1959 our known resources

have increased some forty-fold at least and all anxiety for adequate domestic supplies has been removed for many years to come.

12. In fairness one should remark, however, that not all the increase in reserves has come from the discovery of new deposits. Metallurgical research aimed at making possible the use of low-grade ores, of which there is an abundance in several States, has also contributed to the changed picture and may have a greater long range effect than is presently realised. As a result of successful research carried out in the B.H.P. laboratories, low-grade jaspilites of the Middleback Range, previously discarded as waste, are now capable of being economically upgraded for use as furnace feed, and the full benefit accruing at this locality, and to other low-grade Australian deposits, has yet to be assessed.

13. When the export policy was altered, the change was expected to lead to an increase in prospecting with reasonable chances of proving new reserves. The result, however, exceeded the most optimistic expectations, and led to a situation in which the development of an export trade in ore has become the paramount consideration and one which may play an increasing part in the national balance of payments. The first small-scale export began in March 1966 from Geraldton; and after extraordinarily vigorous construction schedules, large-scale exports began from new ports at Dampier and Port Hedland in the later part of the year. The extent of this export market can be gauged from the details of the export contracts shown in Table 1 involving the sale of some 832 million tons of iron ore of which all but a few million tons will be exported to Japan. The expected yearly quantity of export earnings from this source are shown in Table 2.

14. On the industrial side of the picture, rapidly expanding iron and steel plants exist at Port Kembla, Newcastle, Whyalla, and Kwinana; and a small Government owned charcoal-iron plant functions at Wundowie, Western Australia.

15. Investment in the iron and steel plant has been running at above a hundred million dollars annually for several years. New major plant items commissioned since 1962 were a ferro-alloy plant at Bell Bay, Tasmania; an electrolytic tinning line, a new open hearth furnace a high-speed pickle line and a second hot roll processing line at Port Kembla, New South Wales; a basic oxygen steel-making plant and associated rolling mill facilities as well as a continuous steel casting plant, at Newcastle.

A second blast furnace and an integrated steel plant at Whyalla opened in 1965, where an iron ore pelletizing plant was commissioned in 1968. At Kwinana, the first stages of an iron and steel complex were constructed, and a cold rolling plant was completed at Unanderra, where a vacuum degassing plant also commenced operations. A new major expansion programme at a cost of 150 million has been announced recently for Port Kembla; an de a pelletizing plant in northern Tasmania came on steam in 1968.

16. Manganese is one of the key metals in the manufacture of steel, its chief use being as a de-oxidizer and a de-sulphurizer in the plant process; adequate supplies of its ores are an essential for the long-range security of the steel industry. Current usage requires about 30 lbs, of manganese dioxide for every ton of steel produced. It is also a hardening constituent in many grades of steel; and high-quality manganese dioxide is used in the manufacture of dry cell batteries. In 1969 126,000 tons of metallurgical grade manganese ore were required by our industries and this amount is increasing rapidly. Our self-sufficiency in this mineral for most purposes has only recently been proved.

17. For many years the known Australian resources of manganese ore were small. Between 1916 and 1927, the steel industry depended upon deposits in New South Wales; as these were worked out, small deposits in South Australia took their place from 1940 to 1944; subsequently Western Australia became the main source. Recently, cheap supplies became available from South Africa, and Australian production slumped, but has recovered again to meet the requirements of a developing export trade, mainly to Japan.

18. As with iron ore, manganese was subject to a long-standing embargo on exports, but this was partly relaxed in 1956 to allow for shipments of a portion of any new discoveries made. This was designed to encourage exploration and resulted in a burst of prospecting activity in north-western Western Australia, during which many new small deposits were revealed, amounting in all to several million tons. In 1960 a discovery of much greater importance was made by the Bureau of Mineral Resources at Groote Eylandt, on the Gulf of Carpentaria, where B.H.P. have now established an open cut mine and treatment plant. An agreement was entered into with the Commonwealth Government for the Company to erect a ferromanganese plant in the Northern Territory when this can be done economically. Shipments of ore from Groote Eylandt have increased to supply most of Bell Bay's ferromanganese requirements, plus an export surplus. This deposit can supply all of Australia's requirements for metallurgical grade ore for a long period to come; however, we have no supplies of battery-grade ore and continue to use imported ore at the rate of about 1100 tons per year.

19. Australian production of manganese ore in 1969 was 875,000 tons, of which 643,000 tons were exported mainly to Japan. Imports have shown a marked decline from 1965 and were about 5,600 tons of ore with 255 tons of manganese metal in 1969. Australia's production of high carbon ferromanganese now satisfies local demand. The principal localities of production of manganese ore were in the western part of Western Australia, between Meekatharra, and Port Hedland, and at Groote Eylandt.

20. Tungsten: Since tungsten became of commercial importance about 1900, Australia has been an important producer of its ores - wolfram and scheelite - but the scale of production has varied in the face of widely fluctuating overseas prices. The greater part of the product has always been exported. Domestic consumption is small and there should be little difficulty in meeting Australian requirements for ore from known resources whenever the need arises, although we do not currently produce metal or alloys.

21. The principal deposits are in Tasmania and the Northern Territory. Wolfram comes mainly from Avoca, Tasmania, where Aberfoyle and Storey's Creek mines have been the principal producers; and from Hatches Creek, Northern Territory, which has a satisfactory potential in an emergency, and provided 4 tons of concentrate in 1967. A major deposit of scheelite exists on King Island, Bass Strait, but fluctuating world prices have made operations irregular in recent years and for a time the mine depended upon the receipt of a Government subsidy. A fresh contract has revived operations in recent years, and known reserves have increased sharply from 1.47 to 6 million tons. Efforts by producer countries, supported by Australia, to achieve an international arrangement leading to price stability, have not met with success, but world prices remained reasonably firm during 1969 and improved in 1970.

22. Australian production in 1969 (expressed as concentrates of 65% WO_3 content) was 2414 tons, and recent enhanced prospects on King Island promise higher production of scheelite in the future. The total domestic consumption would seldom exceed 100 tons per annum, its main use being in the manufacture of tungsten-carbide tipped tools.

23. Molybdenum: Before 1920 substantial quantities of molybdenite were produced in Australia but for many years production has been small; there was no recorded production in 1967 but about 10 tons of concentrates were produced in 1968 and about 90 tons in 1969. Imports in 1969 amounted to 358 tons of ore and concentrates, 131 tons of ferro-molybdenum, 30 tons of molybdic acid for use in fertilizer manufacture and a few tons of other molybdenum salts.

24. Most of the molybdenite deposits in Australia occur in pipes for which development at any depth is costly. One exception occurs at Yetholme, New South Wales where some 800 tons of molybdenite lie at shallow depth beneath a comparatively thin overburden. During World War II the Commonwealth sponsored exploration for new deposits, but results were generally not encouraging. Recently there have been reports of some success in testing extensions of an old deposit near Mareeba, Queensland, and a small mine near Glen Innes, N.S.W. which was worked in 1966. Possible recovery of molybdenum at King Island in the future could supply only a fraction of our demand.

25. In times of emergency Australia might look to the United States or Chile to supplement any local supplies, but the total requirement is not large enough to create any real difficulty.

26. Chromium: Chromite, the ore which yields the metal chromium, has two uses in the steel industry:- as an ingredient in the production of alloy steel; and as a chemically inert furnace lining. Its other main use is for the manufacture of chemicals. Australian annual consumption of chromite runs at about 14,000 tons all of which is normally imported. In 1969, 19,000 tons of chromite were imported, mainly from the Philippines, since Rhodesian supplies were not available because of sanctions.

27. The largest known Australian deposit of chromite is at Coobina, Ophthalmia Range, Western Australia where reserves are estimated to be at least 200,000 tons. This deposit, however, is in a remote locality far from coast or railhead, and the cost of working it has been so high that production has only taken place intermittently. It was last worked in 1957, when 1312 tons were mined. There was no production in 1966; 138 tons of chromite were produced from Victoria in 1967, and 86 tons in 1968, but no production was recorded in Australia in 1969.

28. In general, because of cheaper overseas sources, Australia has been an importer of chromium and its alloys and compounds. Chromium metal is not manufactured locally but small quantities of high-carbon ferro-chrome are produced at Newcastle. In time of emergency we could almost certainly revive our own domestic ore production to meet the necessary demand.

29. Nickel: Australia's resources in the past have been small and no domestic production was recorded after 1938. All our requirements were imported and the level had been rising in recent years because of the increased demand for special steels and the greater use of nickel anodes for electroplating. Imports of nickel increased from 1,100 tons in 1966, to 1,914 tons in 1967, while imports of nickel products also rose significantly.

30. Nevertheless because of the tightening position of world supplies there has been intensive exploration in recent years in Australia, and many important deposits have come to light. At Kambalda, in Western Australia the Western Mining Corporation has proved reserves estimated at 15.5 million tons of sulphide ore averaging 3.4 nickel, plus 1 million tons of silicate and oxidised ores.

Drilling by Great Boulder Gold Mines and North Kalgurli (1912) Ltd. at Scotia near Kalgoorlie has revealed over 1 million tons of high grade (3%)nickel sullphide ore plus 1.5 million tons of 1.6% nickel at neighbouring Carr Boyd Rocks and mining at Scotia commenced in 1970. Ore shoots discovered by Anaconda-C.R.A., Poseidon and B.H.P. - International Nickel promise additional production in the future and extensive exploration continues.

Furthermore, recent prospecting for lateritic nickel deposits in Australia has discovered major deposits at Wingellina in Western Australia but close to the border with South Australia, and smaller deposits at Greenvale and near Rockhampton, Queensland; feasibility studies completed in 1970 by International Nickel indicates that deposits at Wingellina are not currently viable but a partnership of Metal Exploration and Free Port Sulphur plans to develop the Greenvale deposit to produce 25,000 short tons of nickel in nickel oxide and 1200 short tons of cobalt yearly from a refinary at Townsville from 1974.

Production of nickel concentrates commenced in June, 1967 at Kambalda and the output by the end of the year was 15,800 tons with a nickel content of 2061 tons, all of which was exported mainly to Japan. Production of nickel in concentrates increased to 4573 tons in 1968 - roughly equalling Australia's consumption of nickel - and to 11,000 tons in 1969. Current mineand mill developments promise about 30,000 tons of nickel in concentrates from Western Mining Corporation and about 4,000 tons from Great Boulder-North Kalgurli in 1971. A nickel refinery installed by Western Mining Corporation at Kwinana, Perth, with a capacity of 17-18,000 tons of metal per year came on-stream in early 1970.

31. Not far from our shores there are large deposits of lateritic nickel ores in New Caledonia, the existence of which, in any case, makes the supply position fairly safe. Other sources are Canada, which produces nearly 60% of the world's supply, and the United States.

BASE METALS

32. Copper: Australia, which has again become entirely self-sufficient in copper, had an important early history of production which began as early as 1842 in South Australia; during the first half of this century her main deposits were slowly exhausted, no new ones

were found, and it looked as though she would become largely dependent upon imports. This possibility was dispelled some years ago in the mid-fifties by the discovery of very large reserves of copper ore adjacent to the lead-zinc lodes at Mount Isa. Since then other deposits have been found in several parts of the continent, and working mines like Mt. Lyell have been shown to have greatly increased reserves. Active exploration is being continued in Australia and New Guinea and today we can provide not only for our own needs but for a significant export trade as well. Planned production from Bougainville is likely to reach 160,000 tons of metal per year in a few years time.

33. The Australian scene is dominated by Mount Isa which produced 60% of the total in 1969 and which has reserves sufficient to support a high rate of production for well over 20 years. Other important centres are Mount Morgan, Qld., Mount Lyell, Tas., Tennant Creek, N.T. and the recently rejuvenated C.S.A. mine at Cobar now in production with an annual output expected to reach over 20,000 tons metal in the mid 70's which is likely to make it the third largest domestic producer.

34. It is interesting to observe that the full potential of the Mount Isa deposits was not realised until the early 1950's although copper was mined for emergency purposes from some minor lodes during the war years. After the discovery by drilling of high-grade copper lodes, a major new enterprise got under way in 1953 and output has grown steadily. It fell, following the 1965 industrial upset, to 55,000 tons of metal but a substantial recovery and expansion took place with the completion of the job of relaying the Mount Isa-Townsville railway line for heavier traffic. As a result, record levels of production were achieved in 1966.

35. Australia has two copper refineries - at Port Kembla and at Townsville. A third at Mt. Lyell was closed down a year or two ago. The refinery at Townsville, a wholly owned subsidiary of Mount Isa Mines, with an annual capacity recently expanded to 95,000 tons, is by far the largest of the three. It was commissioned in 1959 and refines the whole of the Mount Isa output.

36. In 1965, industrial trouble at Mount Isa affected mine production, and 90,000 tons of copper were mined in Australia. 1966 saw a rise of 24% to a record level of 110,000 tons; but continuation of K57 shaft development at Mount Isa again reduced the Australian output, to 90,000 tons in 1967, rising to 108,000 tons in 1968 and to 129,000 tons in 1969. Apparent consumption of primary copper in 1969 was 73,000 tons. The sources of production in 1968 are shown below.

		Tons
Queensland		
Mt. Isa	76,993	
Mt. Morgan	8,010	85,875
Others	872	
New South Wales		
Cobar	11,172	
Broken Hill	3,693	
Others	176	15,041
Tasmania (Mainly Mt. Lyell)		18,685
Western Australia (Mainly Ravensthorpe)		2,149
South Australia		394
Northern Territory (Mainly Peko)		6,777
Victoria		65
		128,986

37. Lead: Lead and zinc are usually discussed together because nearly all Australia's production is obtained from orebodies containing both metals which are mined in the same operation. The separation of the lead from the zinc is then achieved by crushing and concentrating processes.

38. Since the discovery, in 1883, and the development of the Broken Hill orebody, perhaps the richest of any in the world, Australia has been a major producer of lead and zinc ores; and her already dominant position was reinforced by the discovery and exploitation of Mount Isa in the years following 1923. It is interesting to note that Australian Metal Mining began with lead in South Australia in 1841. We have been amongst the world's leading producers of lead for a number of years past and in 1969 with a production of 437,000 tons we ran close behind the U.S.S.R. with 443,000 tons and the United States with 473,000 tons Our known resources, are sufficient to allow us to continue as a major exporting country for several decades to come.

39. Mine production of lead has run uniformly high in recent years, after being below capacity in 1960/61, when it was affected by an international arrangement under which a substantial part of Australian production was voluntarily curtailed.

40. Details of lead in all mine products from the States in 1969 is as follows:

		Tons
New South Wales		
All Broken Hill Mines	277,160	
Others	3,203	280,363
Queensland		
Mt. Isa		147,726
Tasmania		
Read-Rosebery		14,906
Other States		1,904
		444,899

41. Most of our lead concentrates are smelted in Australia. There are smelters at Port Pirie, S.A., Mount Isa, Qld, and Cockle Creek, N.S.W., and a lead refinery at Port Pirie, which in 1969 produced 186,000 tons of primary refined lead. Exports amounted to 132,000 tons of refined lead, 136,000 tons of bullion (lead content) and 101,000 tons in concentrates (lead content). Domestic consumption was 67,000 tons (including 26,000 tons from scrap).

42. Zinc: For a number of years Australia has ranked fourth behind Canada, the U.S.A. and U.S.S.R. as the world's leading producers of zinc ores. Although domestic mine production increased by 8% to a record 400,000 tons in 1967, refined zinc output remained at the 1966 level of 194,000 tons, due to power restrictions in Tasmania. In 1968, mine production rose to 416,000 tons and, with the easing of power restrictions in Tasmania, refined zinc output increased to 205,000 tons to more than match the 1965 level of 199,000 tons. In 1969, mine production increased to 502,000 tons and refined zinc output to 242,000 tons.

Details of 1969 production are as follows:

			Tons
New South Wales			
	Broken Hill Mines	334,627	
	Others	8,853	343,480
Tasmania			
	Read-Rosebery		50,207
Queensland			
	Mt. Isa		104,018
Other States			4,143
			501,848

43. There are three zinc refineries in Australia - a large electrolytic plant at Risdon, Tasmania based on relatively cheap hydroelectric power; a small "Improved Vertical Furnace" at Cockle Creek, N.S.W. of a type developed within the last decade, and at Port Pirie, a new refinery to recover high-grade zinc from a slag dump estimated to contain 1 million tons of zinc derived from the treatment of lead concentrates, has been completed and production of zinc has commenced. The plant has a rated capacity of about 40,000 tons of zinc per year.

44. About 50% of our total zinc concentrates (all from Tasmania, and some from Broken Hill) were treated at these plants. The remainder of the concentrates from Broken Hill and all of those from Mount Isa were exported. In 1969 production of refined zinc was 242,000 tons. Domestic consumption was 109,000 tons.

45. - Tin: From being a country with a once considerable export surplus, Australia became partly dependent on imports about 1947; indeed Australia led the world in tin production for nearly a decade around 1883. Recent developments in the revival of several old mining centres radically changed this position and Australia became again a net exporter of tin in 1966.

46. In 1969 production of tin in concentrates rose from 6,500 tons in 1968 to 8,100 the highest since 1913, and smelter production of refined tin was 4,200 tons. Imports were 104 tons of ingots, exports 3,500 tons tin in concentrates and 632 tons in ingots; and apparent consumption was 3800 tons of primary tin.

Domestic consumption rose sharply to about 4,500 tons following the commissioning of new electrolytic plant at Port Kembla in 1962, but has declined marginally in recent years following the swing to electrolytic tin-plating. Domestic consumption of primary tin (3763 tons in 1969) is not expected to exceed 4,500 tons per annum in the immediate future, due to the swing towards lighter tin coatings, and we are likely to remain a net exporter (of tin concentrates) for some years ahead.

47. For some time past the main tin producing centres have been alluvial deposits inland from Cairns and in north-eastern Tasmania. Lesser, but useful production, has come from lode mining in New South Wales, Western Australia and Tasmania. Important new discoveries have been made in recent years at Renison Bell and Mount Cleveland, both on the western side of Tasmania, where drilling has revealed extensions of the old sulphide tin lodes. Both these properties are now in production, and at Cleveland mine a township has been built and a concentration mill was commissioned in 1968. Production at Renison rates the mine as a major tin producer even by world standards. At Greenbushes, W.A., a former alluvial field, modern equipment has been introduced to work lower grade ground previously left behind as unprofitable, but progress has been uncertain. Exploration in 1967 and 1968 concentrated on proving additional reserves at established mines, rather than testing new areas.

48. Some of the greatest tin producing countries in the world viz. Malaya, Thailand and Indonesia lie immediately to the north of Australia as our nearest sources of supply, much further afield lie Nigerian and Bolivian deposits, but it would seem very unlikely that we could not supply our own needs in emergency in the foreseeable future.

URANIUM, THORIUM ETC.

49. Uranium: Australia is not a consumer of uranium although small quantities of uranium-derived fuels are imported for use in research at the atomic reactor at Lucas Heights near Sydney. A few years ago we passed through a brief but spectacular interlude as a producer of uranium ore and now appear to be on the threshold of becoming a more important producer. The national search for deposits began in 1944 and bore its real fruit in the discovery of Rum Jungle in 1949, and of Mary Kathleen in 1953. Some small deposits had been known in South Australia as early as 1906, and others, which were to become useful but minor contributors to the output, were found in the South Alligator River area in

the early 1950's. Treatment plants for the production of uranium oxide were erected at Port Pirie, where for several years rather high-cost material was produced from ores mined at Radium Hill, Rum Jungle, where the plant is still in operation treating stockpiled ores, Mary Kathleen, now closed down on a care and maintenance basis, and Moline, N.T. which after fulfilling the last part of an overseas contract for uranium was modified to treat Ag-Pb-Zn ores from Mount Evelyn pending resumption of uranium mining.

50. All these discoveries were made at a time when there was strong demand for uranium for military purposes, and when world supplies were still so uncertain that prices had to be arbitrarily established by Governmental agreement. In the event the prices secured by Australia in several of her long term contracts turned out to be extremely good, and long before the contracts were fulfilled alternative sources overseas were able to supply more cheaply. At the same time dwindling defence needs, and the lack of any comparable requirement for peaceful purposes led to a situation in which no market existed for the Australian product, once contracts were fulfilled.

51. Reserves have been sufficient for any likely domestic need. When Mary Kathleen was closed down, the company stated that there were more than 3 million tons of commercial grade ore remaining in the reserves, and additional exploration has more than doubled these reserves.

On the other hand Rum Jungle has mined out both of its known ore bodies and the plant is continuing to operate on stockpiled ore, and is stockpiling the uranium oxide product in a programme that is scheduled to continue till 1971. Several years ago it was announced that a total of 1,625 short tons of oxide has been produced during the life of the Rum Jungle plant and that total revenue over the period of operation had been $42 million. Mary Kathleen produced oxides worth $90 million but there has been no production since 1964.

52. Meanwhile, the easing of the total export embargo, announced by the Commonwealth Government in 1967, has stimulated prospecting for new reserves with notable success. New deposits have been found in the Westmoreland area, N.W. Queensland, deposits of sedimentary uranium are being assessed near Lake Frome and at other localities in South Australia and, of prime importance, are new and substantial deposits at the Ranger 1 prospect and at Narbelec about 140 miles east of Darwin, in the Northern Territory. New figures for reserves of uranium ore, mineable at prices up to $10 per lb. U_3O_8, most await the complete of current exploration programmes, but the figure of about 1800 short tons of U_3O_8 quoted in 1970 is expected to increase many fold.

53. The marketing of uranium still faces difficulties because the demand for nuclear power is developing at a slower rate than was forecasted; however, some overseas contracts are expected and demand will probably quicken later in the 70's.

Australia is assured of natural uranium fuel for any likely nuclear power programme and plans are in hand for the first nuclear power station at Jervis Bay. The bulk of known reserves of uranium in the western world are held in Canada, U.S.A. and South Africa.

54. Thorium and Cerium: The main commercial source of thorium, which has been of interest because of its possible nuclear uses, is in the mineral monazite, a by-product of beach sand operations in various parts of Australia. Notwithstanding the use of thorium in several United States experimental reactors, large scale nuclear uses are said to be unlikely until after 1980; demand for nuclear purposes will probably not exceed a few hundred tons over the next 15 years. However this situation could conceivably be changed as a result of new technology, or beneficiation and refining advances.

55. An increasing interest in monazite results from its rare-earth minerals content, two of which are cerium and yttrium. The rare-earths are used in the ceramics industry in metal alloying and in nodulising cast iron. Lately they have attracted increased interest because of their developing use in nuclear control rods, light amplification, cryogenic, thermo-electric and electronic devices, as a superior red phosphor in colour television, and in many alloys for laser application. Cerium is also present in the mineral allanite, large quantities of which are found in the Mary Kathleen uranium deposit.

56. High grade monazite concentrates are recovered from beach sands in Western Australia, Queensland and New South Wales. The monazite recovered in Western Australia is a by-product of ilmenite production, but elsewhere of rutile and zircon production. In 1969 production was 3794 tons of concentrates containing 3420 tons of monazite, 80% of which came from Western Australia. Installed capacity for the recovery of high grade monazite near Bunbury, Western Australia is now about 3,500 tons and the plant is almost fully employed. All sales were overseas, before 1969 but rare earths now partly replace monazite concentrate as an export, as a former uranium plant, purchased from the South Australian Government at Port Pirie, was commissioned in May 1969 to produce mixed rare earth oxides, yttrium oxide and thorium oxide from monazite.

57. Australia is undoubtedly self-sufficient in these minerals for any foreseeable requirement but alternative sources of supply would be South Africa, Malaya, India, Brazil and the United States.

58. Beryllium: Beryllium is a light-weiglht metal processed mainly from the mineral beryl, good crystalline specimens of which are better known perhaps as semi-precious stones. The metal has become of particular interest since the development of nuclear technology, but its main use is still in alloys of copper, nickel and aluminium, which it toughens for industrial uses. Domestic demand is small, if any.

59. Australian production of beryl began in 1939 and reached a peak in the war years. It fell away soon afterwards and production in 1967 was only 55 tons containing some 6.9 tons of beryllium oxide. However, the same year saw exports totalling 637 tons of beryl, nearly half to Japan, obtained largely from stockpiled material in Western Australia; there has been no subsequent record of exports to Japan. Production fell to 15 tons of ore in 1968 and to 7 tons of ore in 1969.

60. Most of the Australian production has come from a mine near Broken Hill, with some from the goldfield districts of Western Australia. In time of emergency, particularly if production costs were not the principal consideration, the small scattered deposits already known could most likely produce sufficient for our foreseeable requirements. Overseas sources are Brazil, South Africa, Rhodesia, Uganda, the Congo and the United States.

61. Lithium: The main uses are in the glass, ceramics and pharmaceutical industries and in the preparation of greases and welding and brazing fluxes; as it seems particularly suitable as a battery anode material, and much interest in battery research was generated in 1967, a significant market could develop in the future. No detailed information is available on the consumption of lithium products in Australia but it is quite small and, except for occasional purchases from local production, requirements are usually imported. South Africa dominates the world production scene but Canada and the United States are alternative sources.

62. There has been an irregular production of lithium ores since 1905. In 1969 amounts totalling 710 tons were produced in Western Australia.

63. Several years ago a mining company undertook drilling tests on lithium prospects near Kalgoorlie and Ravensthorpe, W.A., and extensive reserves are said to have been proved. These deposits would seem to ensure Australia's supplies in any future emergency, but marketing difficulties militate against present large scale production.

OTHER METALS

64. Aluminium: One of the most rapidly expanding sectors of our mineral industry is that of the production of aluminium and its ores - bauxite, the raw ore; and alumina, a partly processed product. Little more than two decades ago Australia appeared to have a serious deficiency in bauxite resources. Although exploration during the war years had shown that there were small domestic reserves, and the decision was reached to establish an aluminium smelting industry at Bell Bay, Tasmania, it was nevertheless believed that the industry would at most time be dependent upon imported ores with local ores held in reserve.

65. A series of spectacular discoveries was to change this picture completely. They began in 1949 when relatively small deposits of bauxite were found at Marchinbar Island off the coast of Arnhem Land; this was followed by more substantial deposits on the mainland near Gove. Later, in 1956 very large deposits of bauxite were found at Weipa on the Cape York Peninsula; and in 1958 important new sources were identified at Jarrahdale, in the Darling Ranges close to Perth. Most recently, in 1965, an announcement was made of the discovery of further large deposits inland from Admiralty Gulf in the Kimberley district of Western Australia. In late 1970 exploration for possible bauxite deposits beneath the Gulf of Carpentaria, offshore from Weipa commenced and exploration on land south of the Weipa deposits was reported as indicating two million tons of bauxite although the grade has not been specified. Production of ore from Weipa and Jarrahdale has mounted rapidly since 1962 and in 1969 reached 7.8 million tons. Australian reserves are now known to be very large at least 3000 million tons and almost certainly the largest of any country in the world.

66. On the industrial side, developments have also been rapid, but some imports of alumina were required in 1967 because export contracts did not leave enough alumina for domestic smelting; imports amounted only to about 3000 tons in 1968 and 1969. The Bell Bay plant, owned by Comalco Industries Pty. Ltd. has been expanded to a capacity of 94,000 tons of metal per year, and is being supplied with alumina from Gladstone derived from bauxite from Weipa where extensive mining and shipping facilities are installed. An alumina plant at Kwinana, near Fremantle, W.A., with a present capacity of some 1.25 million metric tons per annum is supplying feed to the smelter at Geelong. The Geelong smelter of Alcoa of Australia Ltd came into production with an initial capacity of 20,000 tons of metal and was later expanded to 40,000 tons; capacity has been increased further to 90,000 tons annually. Alumina is also being shipped from Kwinana to Japan and the United States.

67. The C.R.A. - Kaiser group, in partnership with several major overseas companies, constructed an alumina plant at Gladstone, Qld. with an output of some 900,000 tons of alumina per annum; this will be

expanded to 1,275,000 tons per annum by early 1971. Part of this production will be used as feed for a smelter at Bluff, New Zealand, to be constructed by 1971 by Comalco in partnership with Showa Denko K.K. and Sumitomo Chemical Company. About half the Bell Bay alumina requirement will be provided by Gladstone; the bulk of Gladstone's output will be sold overseas but part will go to Newcastle where Alcan Australia Ltd. established a 50,000 ton per annum primary smelter using coal as a source of power in 1969 with an initial production of 30,000 tons of metal now approaching 50,000 tons per year.

68. Early in 1969 an agreement was completed between the Commonwealth Government and Swiss Aluminium and Australian partners for a project at Gove, N.T., to produce 1 million tons of alumina and up to 2 million tons of bauxite for export. The current position in Australia therefore is, resources of bauxite of the order of 3000 million tons and plant capacity for the production of 2.5 million tons of alumina and of 234,000 tons of aluminium with further expansions in train or planned.

69. Antimony: Antimony is used principally to impart hardness and stiffness in lead alloys, and as an ingredient in type metal, Babbit metal, Britannia metal, pewter and in the plastics industry.

70. Domestic production of antimony concentrates in 1969 was 218 tons containing 142 tons of metal, which was all converted into antimonial lead. In addition 768 tons of antimony from Broken Hill concentrates was contained in antimony alloys produced at Pt. Pirie. All told, over 6000 tons of antimonial lead and other alloys were produced in 1969 but the main source of antimony for these alloys was lead scrap.

71. Exports of antimonial lead alloy in 1969, mainly to Japan, amounted to 4,557 tons. No antimony metal was produced in Australia in 1969 and only 67 tons were imported; Mainland China has been the chief supplier in the past.

72. Antimony ores have been produced in Australia since the middle of the last century but most deposits have been worked out. Recently the only significant production has come from a mine at Guyra in north-eastern N.S.W. - 1969 production was 136 tons of antimony in concentrates. A deposit near Dorrigo, N.S.W. has been tested by a Canadian company which reports reserves of over 500,000 tons grading 4.1% Sb. Underground development has been commenced. About 5 tons of antimony in concentrates were produced in the Herberton area, Queensland.

73. Australian production is expected to increase under the influence of world shortage and record prices; Australia is already self-sufficient in antimonial lead but requires minor imports of high purity antimony each year.

74. Titanium: Australia's resources of titanium minerals (rutile and ilmenite) are considerable. In 1969 our production of rutile concentrates was a record 356,339 tons which represented over 90% of the world production: and of ilmenite concentrates, a record 698,622 tons which held our position as third below Canada and the United States in the list of principal western producers.

75. The traditional uses of rutile have been in the manufacture of welding rods and the production of titanium metal; more recently by virtue of the chloride method of processing, it has come into use in the manufacture of a superior pigment for high-gloss white paint. Ilmenite usage is largely confined to pigment, which is held in only a little less esteem than the rutile product. However, the commercial application of processes by which ilmenite is up-graded to approach rutile in TiO_2 content (benefitiated ilmenite or synthetic rutile) will provide a feed for either pigment or metal via the chloride process; beneficiated ilmenite is likely to become a competitor in substitute for natural rutile by the mid 1970's.

76. The principal Australian resources of rutile are sands on and adjacent to the beaches of the eastern coast, although at current levels of production, reserves seem limited to 15-18 years. Production is sustained by long term contracts with the United States. World demand for our rutile has been rising rapidly but our production is not likely to rise much beyond 350,000 tons of concentrates per year. On the eastern coast much of the ilmenite which accompanies the rutile and zircon has too high a chromium content to be saleable for pigment and for the most part has been discarded; however a major new ilmenite project on low-chrome deposits near Gladstone, Qld, from which production of synthetic rutile is eventually planned, commenced production in 1969, although production ceased, probably temporary in 1970.

77. The principal ilmenite industry has been built up along the south-western coast of Western Australia. The quality of the ilmenite from this source is most satisfactory for the manufacture of titanium white, and as ilmenite is the main heavy mineral constituent of the sands, its recovery forms the basis of the growing industry. By-products of ilmenite mining are monazite, zircon and rutile. A beneficiation plant at Capel, W.A. was commissioned in 1968 by Western Titanium Ltd. The plant is at present operating on a semi-commercial scale but an increasing proportion of ilmenite is expected to be processed for export in the future.

A TiO_2 pigment plant was commissioned several years ago at Bunbury, W.A. based on local supplies of ilmenite. Ilmenite is shipped to Burnie (Tas.) where a pigment plant has been operating since 1949. In addition ilmenite concentrates at the rate of several hundred thousand tons per annum are being shipped from Bunbury where substantial bulk loading facilities have been brought into operation.

78. Zirconium: Australian resources of this metal, in the beach sand mineral zircon, are considerable and are of the same order as those of rutile. Mining operations on the eastern and western coasts yield zircon as a co-product or by-product respectively. The market for zircon, principally required for foundaries in the form of moulds, facings and cores, faced oversupply in 1970 but is expected to firm in 1973 or 4; as temporary assistance to the industry, the Commonwealth Government early in 1971 supported a stockpiling scheme initiated by industry by controlling the minimum price of zircon in export contracts. In 1969 production of zircon concentrates was 309,000 tons - the largest of any country in the world. Almost the entire output was exported.

79. Australia's reserves of beach sands render her self sufficient in these minerals, and particularly in ilmenite, for many years to come.

80. Cobalt and Cadmium: Both these metals are by-products in our lead-zinc industry. They have a variety of uses which include (for cobalt) high temperature alloys, high speed steels and magnetic materials, and (for cadmium) electroplating, bearing metals, alloys, solders, and pigments.

81. In 1969 the production of cobalt oxide at Risdon, all from zinc concentrates shipped from Broken Hill, was 23 tons (metal content 16 tons), about ten percent of Australia's requirement; the rest was imported in the form of metal and compounds. Main sources are the Congo, (which is the world's principal producer), Canada, Morocco and Zambia. The United States is an alternative source from which imports are also obtained.

82. Cadmium is an important metal in alloys for high-pressure bearings which have a low expansion coefficient, and has other uses in cadmium plating of steel, in pigments and chemicals, and in fusible alloys for electric fuses and automatic fire extinguishers.

83. Production of refined cadmium in 1969 was 562 tons of metal; 356 tons came from Risdon and 173 tons from Cockle Creek and 33 tons from Port Pirie. Mine production was 1660 tons. Domestic sales in 1969 were about 233 tons and the rest was exported including cadmium contained in lead-zinc concentrates. Australia is more than self sufficient in this metal but United States, Canada and Japan are alternative sources.

84. Tantalum-Columbium: Tantalum and Columbium are metals used in alloying, in high-temperature corrosion-resistant chemical ware, for tipped tool cutting purposes, and in anodes and grids for electronic equipment. Australia was formerly a prominent producer of the ores of these metals (tantalite and columbite) but production has fallen to very small levels. In Western Australia there is commonly a small annual output as a by-product of tin mining. This amounted to 40 tons of combined oxides in 1969, and was all exported. At present, plans are afoot to develop tantalite production in Western Australia and the Northern Territory. There is no domestic demand but if one arose in time of emergency it is most likely that some of the known deposits could be reopened to provide the requirement.

85. Magnesium and Calcium: These are derived from the similar sources, dolomite and limestone, of which Australia has abundance. Magnesium is well known as a light-weight metal, being only 2/3 of the weight of aluminium. Suitably alloyed to increase its strength, it has been used increasingly in the aircraft and allied industries. Calcium is a soft metal, of little use on its own, but effective as a hardener of lead. Neither metal is produced in Australia, although magnesium was smelted in limited amounts at Newcastle during the war. Australian resources for production are more than ample.

86. Gold: Annual production, once steady at above 1 million ounces, has been falling slowly for a number of years. In 1968 reflecting the difficulties confronting the industry, production fell to 702,00` oz., 63 percent of production in 1968 came from Western Australia. Ore reserves are sufficient to maintain this rate of production for a long time provided costs can be held. A major disability suffered by the industry is that whereas the price of gold has been fixed for more than 30 years, the cost of production has mounted steadily. In order to keep marginal mines in operation and to maintain existing communities in a number of isolated places, the Commonwealth Government has introduced various forms of assistance including a subsidy on production which has recently been extended to 30th June 1973. Gold's main use is as a dollar earner, with a world price of $US35 per troy oz. However, the International Gold Pool agreed to a two-tier system under which gold might be traded at higher than the official price.

87. Silver: All Australian silver is won as a by-product from mining other metals, more particularly lead and zinc. Mine production in 1969 was 24.4 million ounces, most of which came from the lead-zinc industry.

Silver refined in Australia in 1969 was 10.6 million ounces and almost all the rest of the mine product was exported in concentrates or bullion.

88. Platinum Group Metals: The main uses are in chemical ware, in jewellery, in alloys for electrical purposes, and in the petroleum and glass industries. There has been a small erratic production of platinum and osmiridium for over 70 years but known resources have never amounted to much. Small deposits have been worked in Tasmania, New South Wales and Papua/New Guinea, but very little production has been recorded from them since 1958; however, interest is resuming in the Adamsfield area of Tasmania and the West Sepik district of New Guinea. A small amount is commonly recovered annually as a by-product of gold refining at Port Kembla, but no output was recorded in 1969. However, platinum will be recovered from nickel ore in Western Australia if smelting of concentrates eventuates; it is not recovered at the nickel refinery at Kwinana. In 1969, 473 troy ounces of platinum and 321 troy ounces of palladium were contained in, and realised from nickel concentrates from Kambalda exported to Japan. Platinum ore was reported from the Pilbara region, W.A., in 1970 but is still under investigation.

89. Imports in 1969 amounted to 18,900 troy oz. and some 6,570 oz. were exported. Canada and South Africa are among the world's leading producers and overseas demand is strong. The producer price for platinum was stable at $U.S.120-125 during 1969 but rose to $130 at the end of the year. The 'free market' price declined from $U.S.280 to $165 during the period.

90. Selenium and Tellurium: Selenium is used in small quantities in the electronic, chemical, glass and metallurgical industries but is being replaced in some of its uses with the cheaper materials silicon and germanium. There is some production from tankhouse slimes containing .33% selenium in the electrolytic copper refineries at Port Kembla but no statistics are available. However neither production nor domestic consumption are large. Leading overseas producers are the U.S., Canada and Japan.

91. Tellurium, a by-product of copper and lead refining, and a notable constituent of the gold ores from Kalgoorlie, is used in metal alloys, in ceramics and rubber manufacturing and in the military and space industries. Australian consumption is small, and recovery, which takes place only periodically, from tankhouse slimes at Port Kembla, was nil in 1969.

92. Bismuth: There has commonly been a small annual production of concentrates of this metal as a by-product of tin and tungsten concentrates from the Northern Territory and Western Australia. In 1967, the Juno gold mine at Tennant Creek recorded the first production since 1962. Production in 1969 was a record 197 tons of bismuth

contained in 16,244 tons of concentrates produced at Tennant Creek with a very small contribution from Wolfram Camp, Queensland. Imports have dwindled since 1965, when a world scarcity developed, and substitutes were developed for some uses. Present uses are for low melting point alloys and for the production of salts used in the pharmaceutical and chemical industries. Chief sources are the United Kingdom, Peru, Mexico, Canada and Japan.

93. Mercury: Australian reserves are negligible but mercury was produced early in 1967 for the first time since 1945. In 1969, 3,625 lbs were recovered as a by-product from the treatment of Rosebery ores at Risdon. The metal has lately been finding increasing use in the electronic industries and in 1968 some 63,200 lbs were imported from Italy, Spain, Mexico, Mainland China and the Philippines. World production during 1969 was some 21.3 million lbs.

94. Vanadium: This metal, used in both ferrous and non-ferrous alloys, and in the chemical industry, is a common constituent of minerals but is rare in economic deposits. None has been produced in Australia and local consumption is negligible. Sources of supply, if required, would be the United States, South Africa, Mexico, Finland and Venezuela. Western world production in 1969 was about 10400 tons.The discovery of a vanadium deposit containing some 100 million tons averaging 1.52% V in the Jameson Range, W.A. was reported by the W.A. Mines Department in recent years; the deposit was investigated by companies, but was subsequently relinquished.

95. Indium: Another alloy metal not commonly found in economic deposits but derived mainly from flue dust in lead and zinc smelters. Australia's consumption is negligible and there are no production or known reserves. It can be obtained from Canada, the United States, Belgium, Western Germany or Japan.

NON-METALS

96. Abrasives: Australia is deficient in resources of natural hard abrasives, such as diamond, used in many industrial cutting processes; and in corundum and emery. Production of all these is negligible. Small amounts of industrial diamonds were once obtained as a by-product of gold dredging in the Macquarie River, New South Wales but today the total domestic requirement of some 445,000 carats is imported. The Union of South Africa is the world's major producer followed by other African countries and in recent years there has been some uneconomic production from off-shore dredging along the West African coast. Some interest has been expressed from time to time in the possibility of diamond deposits in Australia; at present at least one company is active in Western Australia - but so far without discovery.

Corundum and emery have been mined on a small scale in Western Australia but there is now no domestic production, and imports commonly amount to several hundred tons, mainly for use in optical polishing. Rhodesia is the world's leading producer followed by India, South Africa and U.S.S.R.

97. More than 50% of our requirement of garnet is normally obtained as a by-product of mining beach sands along the eastern coast: imports, almost exclusively from the U.S.A. fulfill the remainder of our requirements. Sales of garnet totalled 82 tons in 1969.

98. Soft abrasives such as diatomite and ground feldspar are produced in Australia in the quantities required, and production could be expanded at will.

99. Arsenic: Used in insecticides, sheep dips, weed killers, wood preservatives, and in glasses and enamels, is now all imported (1236 tons in 1969). A considerable amount was at one time obtained as a by-product from gold mining at Wiluna, W.A., and a number of other domestic sources are known but are not economically exploitable under present conditions. Mexico, Sweden and France are the world's principal producers.

100. Asbestos: Australia has large resources of blue asbestos (crocidolite) in the Hamersley Range, W.A.; but only minor ones of amosite and of white asbestos (chrysotile). Because of its fineness, strength, flexibility, and suitability for spinning fibres, white asbestos is the most valuable variety. The main deposit being worked at present is at Baryulgil, N.S.W. where some 795 short tons were produced in 1969; in addition, 30 short tons were produced from old dumps at Lionel, in the Pilbarra region, W.A. A chrysotile deposit under development at Barraba, N.S.W. is reported to contain over 18 million tons of fibre-bearing rock and production shortly to commence will supply some of our needs and provide export of short fibre. However, much of our supply will continue to depend on imports.

101. Blue asbestos, which lacks many of the desirable properties of the white, but is stronger and more resistant to chemical action, continues in good demand in the manufacture of asbestos cement products such as building sheets, pipes, guttering etc. Extensive deposits exist near Wittenoom, W.A. which were worked till 1966, producing 13,000 tons in that year, but production has since ceased because of rising costs.

102. Canada and South Africa are sources of supply for imported white asbestos. South Africa is also a source of amosite. Imports in 1969 were 47,000 tons of chrysotile; 10,000 tons of amosite, and 2,600 tons of other varieties.

103. Barite: Australia has adequate resources of this mineral the principal use of which is in oil drilling muds, and lesser uses in paints, chemicals and paper manufacture. Production can probably be increased to meet any future domestic requirement but in recent years it has fluctuated widely because of the varying demand by oil drilling. Since 1967, there has been a steady demand by secondary industry and production increased to about 39,000 tons in both 1968 and 1969, mainly due to an increased demand for drilling muds in off-shore drilling and to increased export sales. 22,000 tons were exported in 1969 mainly to Brunei and New Zealand; 3,800 tons of barium chemicals were imported.

105. Bentonite and Fuller's Earth: The demand for bentonite has risen sharply since 1967 because of increased need for drilling mud, in iron ore pelletizing and the steady demands of foundries. The rise has been met by expanded imports. An important use continues to be as a bonding agent for moulding sands. Local production of bentonite in 1969 was 456 tons, (compared with 303 in 1968) and imports 58,000 tons; production of Fuller's earth was 30 tons. Recently, during regional geological mapping, extensive seams of bentonitic clays were discovered in the Carnarvon Gorge in Queensland and a great deal of testing has been going on to decide their economic worth. Testing of deposits of bentonite in other States is also taking place and it is possible that Australian production may rise substantially in the future. The United States and Italy are the main world producers of the high quality bentonites which are in heavy demand for drilling muds.

106. Diatomite: There are many small deposits of this mineral in Australia, which consumes some 11,000 tons annually. Production has been almost continuous since 1896, and amounted to some 2,400 tons in 1969, the shortfall being met from imports. Diatomite is extensively used in filtration processes in the manufacture of foods and beverages, as an insulating medium in furnaces and boilers, and as a light-weight filler for paints, varnishes and synthetic plastics. The Australian product is not entirely suitable for filtering processes and some 8,300 tons were imported mainly from U.S.A. in 1967. Resources for other purposes are adequate.

107. Feldspar: Uses are mainly in the glass and ceramics industries and as an abrasive. Australian resources are large and more than enough for any likely requirement. Present centres of production are Londonderry, W.A., Broken Hill and Duckmoloi, N.S.W., for the potash varieties; and Gumeracha, S.A. for the soda varieties. 1969 production was 4,900 tons. This could be expanded almost at will, but consumption has declined, due to the greater suitability of nepheline for some applications.

108. Fluorspar: This mineral is used in steel production, in foundries, and in chemicals, glass and ceramics. Australia has never been a large producer and the extent of her resources is not known. In recent years local production has died away to nil in 1969 because of the ready availability of high quality material from overseas at a low price. However, some production began at Walwa in Victoria in 1970. Imports have mounted steadily and in 1969 were 20,000 tons mainly from United Kingdom, and South Africa. China, France, Italy, the United States and Mexico are important world producers. As demand is rising, and known world reserves are limited, it may be necessary to establish an industry some time in the future.

109. Graphite: This mineral has extensive uses as a lubricant, and is employed in many manufacturing processes, for moulding, for graphite crucibles and in lead pencils. Local production is minor and so far no high-grade deposits have been discovered in Australia, although possible resources have not been fully investigated. All our requirements are met by imports, which amounted to some 2600 tons in 1969 mainly from Ceylon, Mainland China and Malagasy; Korea, Austria, Mexico and Germany are also important world producers.

110. Gypsum: Australia's resources are very large indeed, known reserves being in excess of 760 million tons with the probability of a great deal more. The deposits are associated with salt lakes and occur in the drier parts of South Australia, Victoria, New South Wales and Western Australia. The chief use is in the manufacture of plaster, cement and products such as building boards. In 1969 production increased to 898,000 tons, of which 185,000 tons were exported.

111. Limestone, Dolomite and Magnesite: These have been referred to earlier in connection with metals magnesium and calcium. Resources are very large and production could be increased indefinitely. In 1969 limestone production was 9.5 million tons and dolomite production was 292,000 tons. Production of both could be increased almost at will. Magnesite production was 23,000 tons.

112. Mica: Although Australia's resources are probably large, her production, in the face of cheap overseas supplies, has virtually ceased. The main fields, in the Harts Range in central Northern Territory, now support only a few fossickers.

113. While the Commonwealth Mica Pool operated, during and after the war years, a series of small mines in this locality produced most of our requirement. With the winding up of the Mica Pool in 1960, the market disappeared and most of the small recent production has been from scrap from dumps. Imports in 1969 amounted to about 860 tons mainly from India, South Africa and the United Kingdom and Norway. In the event of emergency Brazil, Argentine and Malagasy are possible sources, but Australia's own domestic industry could probably be revived to meet her requirements.

114. Pigments and Ochres: The term is here used to mean natural earth pigments such as the iron oxides, stained clays and slate powder which are used to give colour or body to paints, plaster, cements, linoleum and rubber. A number of small deposits have been worked over the years and Australia undoubtedly has large resources of the iron oxide variety. Some of these are at Wilgie Mia and Weld Range, W.A.; Rumbalara, N.T.; Dubbo and Glen Innes, N.S.W., and Peason, Spalford and Deep Creek in Tasmania. Domestic consumption is very small and production in 1969 amounted to about 670 tons most of which came from Western Australia. Some 5300 tons were imported in 1968/69, while 40 tons were exported.

115. Quartz Crystal - Silica: Australia is self-sufficient in various forms of silica used in glass making, foundry sands, refractory bricks etc., but there has always been an acute Australian shortage of high quality quartz crystal which has piezo-electric properties that are extremely useful for stabilizing frequencies in radio communications. Quartz crystal is also used in optical instruments. A wide search made by Government agencies during the war failed to disclose any substantial deposits, and an intermittent search by industry in the years since has met with no better success. The last recorded Australian production was in 1952 from an occurrence near Glen Innes. Imports of quartzite and natural quartz amounted to 774 tons in 1969/70. Recent developments overseas

in synthesising quartz crystal have eased pressures on the need to discover indigenous sources. Some 340,000 tons of high-grade silica sand is being exported to Japan over a three year period.

116. Salt and Sodium Compounds: Common salt, sodium chloride, can be produced abundantly in certain climatic localities in Australia, either by the evaporation of sea-water or by harvesting the annual deposits from salt lakes and pans in the drier parts of the continent. Production has been growing in recent years as a worthwhile export trade is being built up. South Australia contributed about 70% of the 900,000 tons produced in 1968 but Western Australia produced about half of the total of 1.7 million tons in 1969. New developments include a seawater project at Shark Bay, W.A. with a planned output of 250,000 tons p.a., most of which will be exported to Japan and an underground brine evaporator at Port Alma, Qld., which finally might produce 450,000 tons p.a., to supply a chlorine-caustic soda plant at Botany Bay. Seven hundred acres of land have been released for salt production near Rockhampton, and seawater projects at Port Hedland (2 million tons p.a.); Dampier (1.5 million tons p.a.); Lake Lefroy (200,000 tons p.a.) and Lake McLeod are being put into operation. In the event of these new projects being fully developed Australia's salt production could reach 10 million tons by 1975. As Japan is unlikely to absorb all the increase, and additional outlets are uncertain, some downward revision of production targets may become necessary.

117. In recent years several oil wells in the central and northern parts of Australia have revealed large subterranean masses of salt, a type of occurrence well-known in oilfields abroad. Regional geological mapping has indicated the likely positions of several more. These could offer interesting possibilities if necessity arose but their geographical isolation is such that there seems little likelihood of commercial development at the present time. Sodium compound production does not yet fulfil the home demand.

118. Sillimanite and Kyanite: These minerals are consumed chiefly in the manufacture of high-alumina refractory linings used in furnaces. Deposits of sillimanite are known in several parts of Australia, mostly in remote localities and are being worked in N.S.W. and S.A. Production was on the increase in recent years to meet increasing demands from industry but fell sharply, after a peak of 3,500 tons in 1963, to 2,600 tons in 1964. Production in 1969 was 1,700 tons and an additional 300 tons was imported mainly from South Africa; 3200 tons of kyanite were imported, and none produced locally.

119. India, South Africa and the United States are major producers but it is likely that Australia could meet her own requirements in any emergency, the present difficulty being essentially economic and mainly cost of transport.

120. Sulphur-bearing materials: Comsumption of sulphur in Australia, almost all of which is used as sulphuric acid, steadily increased up to 1967 in which a record 1.99 million mono-tons were consumed. Comsumption has decreased marginally since then as a reflected of drought years and decreased use of fertilizers. Production of acid was 1.824 million mono-tons in 1968 and 1.840 in 1969. Some 30% of the acid was produced from indigenors sources in 1969 with the remaining 70% coming from imported elemental sulphur.

121. Commercial deposits of native sulphu r and sulphur-bearing ("sour") natural gases are unknown in Australia but there are large resources of sulphurous materials such as pyrites, base metal sulphides (ores of lead, zinc etc.) and gypsum. When brimstone was in short supply overseas in the early 1950's, the Commonwealth introduced incentives to encourage the use of domestic raw materials for the production of sulphuric acid. These were in the form of bounties on production. Later, when changing circumstances abroad made brimstone plentiful, the Government announced that bounty payments would not be renewed after June 1965: this decision was later reconsidered and the Act extended to 1969.

122. Sulphuric acid is produced direct from sinter gases from the treatment of lead concentrates at Port Pirie and Cockle Creek; and from zinc concentrates at Cockle Creek and Risdon. Pyrite concentrates are produced from direct mining operations at Nairne, S.A., and as a by-product from copper and gold treatment plants at Mount Lyell, Mount Morgan and Kalgoorlie. Sulphur is also recovered from oil refinery processes at Altona, Victoria, Port Stanvac, S.A., Clyde, N.S.W. and Bulwer Island, Qld., Alkyalation sludges and hydrogen sulphide from some oil refineries or spent oxide from gas works are used in sulphur production.

123. Imports of elemental sulphur were 549,000 tons in 1968, but fell to 384,000 tons in 1969; U.S.A., Mexico and Canada were the main sources of supply. The non-Communist World production of sulphur in all forms in 1969 was 28.8 million tons of which 60% was elemental sulphur. World shortage of elemental sulphur in recent years has eased and the price is steadily falling indicating no shortage of sulphur in the foreseeable future. Australia will shortly produce over 40% of required acid when a new acid plant comes on stream at Burnie (Tas); more emphasis is falling on the search for elemental sulphur in sedimentary basins where, to date, insufficient exploration has been carried out to properly assess prospects.

124. Talc, Steatite and Pyrophyllite: The chief consuming industries are cosmetics, rubber, ceramics, and paint. Small deposits are known in most of the States and, in recent years, South Australia and Western Australia have been the chief producers. Production in 1969 amounted to some 52,000 tons of which 34,000 tons were exported. Imports, mainly of varieties not available domestically, were 1,800 tons. The United States and Japan are the world's leading producers, but Australian imports have come from Mainland China United States and India as well as Italy and Norway.

125. Vermiculite: This mineral has the unusual property of expanding to many times its original volume when subjected to high temperatures and is used for fire and rot-proofing, as an insulator in electrical and heating equipment, in the manufacture of building plaster and as a light weight concrete aggregate. There has been no Australian production since 1956, although several deposits are known to exist in Western Australia. A small amount is imported annually (3,500 tons in 1969) usually from South Africa. The United States and South Africa supply almost the entire world production.

126. Fertilizers: Gypsum and limestone are not strictly fertilizers but are used in many places for agricultural purposes. They have been dealt with elsewhere in this paper and it need only be said that supplies are abundant. Phosphorite (or phosphate rock) is the main mineral component of manufactured fertilizer.

127. Phosphate Rock: is used in large quantities for the production of superphosphate (2.7 million tons in 1969 almost all of which was imported.) Local sources capable of present production are almost negligible and are mostly unsuitable for superphosphate manufacture.

128. Australia's supplies of phosphate rock are drawn chiefly from Ocean Island and Nauru in the Pacific, and from Christmas Island in the Indian Ocean. Christmas Island is owned jointly by Australia and New Zealand; Nauru is now independent but New Zealand, Australia and United Kingdom are partners in agreements to share production from Nauru and Ocean Islands. These supplies have been supplemented for many years from other overseas sources and in 1969 some 7% of total imports came mainly from the U.S.A. Imports, other than from nearby island sources, decreased in 1969 from 26% of imports reflecting the fall in total imports from 3.4 million tons in 1968 to 2.7 million tons in 1969 due to falling consumption of fertilizers in drought years. Although the rock from the island sources is extremely high-grade by world standards, the deposits have limited life - approximately to the end of this century. Some years ago a widespread search for additional island deposits was made jointly by the Australian and New Zealand Governments, but no discoveries of

importance resulted. It was therefore accepted that the chances of finding any new deposits of island phosphate to supplement the existing supplies were small and emphasis was placed on exploration within Australia in late 1964.

129. Small quantities of domestic phosphate rock have been mined intermittently in Australia for many years and have mostly been used for direct application as a fertilizer. South Australia was the only producer with an output of 18,000 tons in 1967. A discovery made near Rum Jungle in 1961, of an unusual type of phosphate deposit in ancient Precambrian rocks has been tested extensively by drilling and pitting. However, the proven reserve is only about 5 million tons of which 1 million has P205 content ranging from 20-27% and the rest is low grade. However, the higher grade material is too refractory to constitute an economic source for the manufacture of superphosphate, although the deposit may yet be useful locally as the material, when calcined, is suitable for direct application to the ground. Thin beds of phosphate rock were also found in the Amadeus Basin in the Alice Springs region in 1963 but these proved un-economic.

130. In 1964 Commonwealth and State Governments encouraged mineral exploration companies to search for phosphate and this resulted in much increased activity on the Australian continent. About the same time, the Bureau of Mineral Resources arranged for two overseas specialists to assess the phosphate potential of Australian waters and on the Australian continent. Recommendations on the continent emphasised eastern Australia and north-west Queensland, and a study by the B.M.R. of some of the oil wells which had been drilled in the Georgina Basin indicated abnormally high phosphate content in some formations. Further systematic testing of oil wells by companies led to the delineation of the most favourable formation and this in turn to the discovery of phosphate rock about 30 miles south of Duchess in 1966. Continued exploration discovered similar but smaller deposits in the Yelvertoft area about 150 miles north of Duchess and drilling and assessment have now proved major deposits of phosphate rock in north-west Queensland with reserves of at least 2000 million tons averaging about 17% P_2O_5 (with considerable tonnages of 20-22 % material) and for the most part, capable of upgrading to produce source material for superphosphate. These deposits assure Australia's supplies of phosphate rock in the long term; feasibility studies are continuing to determine when any of these deposits can be profitably brought into production.

Potash: All Australian requirements of potash salt are imported. In 1968/69 Australia imported some 135,000 tons of potash fertilizers and potash salts for chemical purposes. Half of this came from the U.S.A.; West Germany, Canada and France are other important sources.

132. Commercial deposits of the stratified type (such as are typical of Stassfurt, Germany) have not been discovered so far, though there may be deposits of this type or of others not yet recognised. In particular, evaporite salt deposits could conceivably occur in the beds of some of the numerous dry lakes which are a feature of our arid central areas. A little scattered boring in some of these lakes has not so far revealed anything of importance. Another possibility may exist in the salt domes discovered during the course of oil drilling.

133. At Lake Chandler in Western Australia an effort was made at the end of the war to produce commercial potash from an estimated 12 million tons of mud with a content of 60 percent alunite, a potassium-aluminium mineral. The State Government sponsored this attempt, and a plant was erected which for a while attained a production rate of 1,000 tons a year; the operation proved uneconomic and the plant was closed in 1949. However a company is at present developing a project at Lake McLeod, W.A. with planned production of salt and potash, the latter intended to eventually reach 200,000 tons per year. Salt domes inland from Shark Bay, W.A. are also under exploration for potash.

134. Nitrates: A significant growth trend is developing in the use of nitrogenous fertilizers which seems likely to change the accepted Australian pattern. The emphasis on ammonium sulphate is being diminished and nitrogenous phosphates are coming into demand. Several sorts of nitrogenous compounds are now produced domestically including ammonium phosphate, sulphate and nitrate; urea; ammonia; etc. Statistics for some of these are not available for publication but production figures for sulphate of ammonia in 1968/69 were 107,000 tons and about 309,000 tons of nitrogenous fertilizers were imported. Main sources of supply are Canada, Belgium, Western Germany and Italy. The U.S. is the world's leading producer.

135. No commercial deposits of nitrates are known in Australia although the demand for these fertilizers has been increasing significantly both for the cane industry in Queensland and for the wheat industry in Western Australia.

136. Petroleum: Australia's main mineral deficiency has long been that of indigenous petroleum, the lack of which has compelled her to import an ever growing volume of crude oils and refined products to

meet her increasing consumption. In 1969 the imports of refinery feed-stock and refined products represented over 90% of consumption; the cost was $263 million. The rate of increase in consumption was 9.5% over the previous year and the demand is expected almost to double in the next 10 years.

137. With the first full year of production from Moonie in 1965 the first step was achieved in the national effort to become self-sufficient. In 1967 output from Moonie, Alton and Barrow Island was 7.6 million barrels; an increase of 124% brought about mainly by Barrow Island coming into production. This represented 5.1% of consumption as compared to 2.7% in 1966. In 1968, Australian indigenous production was 13.8 million barrels, and in 1969, 15.8 million barrels, or 8.8% of total petroleum consumption. Production will rise rapidly from this point of time as the Gippsland Shelf fields come on stream and by 1971/1972 should attain 67% of the nation's consumptim at that time.

138. Since the mid 1950's an Australian-wide search has been going on with mounting intensity in recent years. In 1966 some 134 wells were drilled (compared with 14 in 1959), in 1967 the number rose to 274, in 1968, the total was 232, and in 1969 the number of wells completed was 322. The increase has been stimulated by a number of important gas and oil discoveries since 1964, the most significant of which occurred in the Gippsland Shelf area, offshore Victoria.

139. Part of the reason for the increasing tempo of oil search in Australia undoubtedly derives from the Commonwealth's policy of subsidising private companies' expenditure under a scheme first introduced in 1958, extended to June, 1969 and again extended to June 1974. Under this scheme selected operations were at first reimbursed by 50 percent (later reduced to 30 percent) of the cost.

Incentive has been further increased by the commercially viable oil and gas discoveries encountered during the years since 1960. These include the gas fields in the Roma area in Queensland now supplying Brisbane with natural gas: the Gidgealpa - Moomba (and the nearby Toolachee) gas fields in South Australia, now supplying Adelaide with natural gas: the Gippsland shelf major gas/oilfields Barracouta and Marlin. Melbourne is now receiving natural gas from this area. Other gas fields which have not yet been exploited are Mereenie - Palm Valley in the Northern Territory and Dongara, Mondarra, Gingin and Yardarino in Western Australia. Delivery of natural gas from Dongara to Perth is expected in the foreseable future. Other considerable gas discoveries have been at Uramu, Pasca (offshore Papua), and Burata, Iehi, Barikewa, Kuru and Puri (onshore Papua). Gas has also been discovered in the Petrel well, 100 miles west of Darwin.

Crude oil was discovered at Moonie and Alton in Queensland, and these fields have been, producing since 1964. Following this, the Barrow Island oilfield discovery in Western Australia began commercial production in December 1966. The most prolific crude oil discoveries were the Kingfish Halibut Marlin and Barracouta fields in the Gippsland Shelf, and commercial production began from Barracouta in late 1969.

Other significant discoveries which have yet to be developed, are the Snapper, Flounder and Tuna fields, also situated in the Gippsland Shelf.

The Commonwealth also contributes to exploration activities in Australia by carrying out extensive geophysical surveys and geological mapping programmes over sedimentary basins.

140. At the present time exploration permits are held over the surface areas of most of our known sedimentary basins and drilling has been going on in all States and Territories. Of late, the chief focus of interest has turned to the offshore localities where extensive sedimentary basins exist under the shallow waters of the continental shelves. Drilling offshore is a more expensive operation than drilling on land, but the prospects are considered good. The first offshore rig, Glomar III, a drilling ship now named Barracouta was brought to Australia in 1964 at a cost of $2 million. With its first well, some 30 miles from the Gippsland coast of Victoria, it discovered gas of considerable significance.

The same drilling unit discovered the Marlin gas field shortly afterwards, and the major, Kingfish and Halibut oilfields in rapid succession, followed by hydrocarbon encounters in the Tuna, Bream, Flounder, Mackerel and Snapper structures.

Production of crude oil and gas from this prolific area began in 1969, and by the end of 1971, crude oil production should be some 300,000 barrels per day. Natural gas production from this area also began in 1969 and will be some 200 million cubic feet per day by late 1971.

Further offshore drilling units arrived in Australia, and by mid-1969, six mobile units were operating in Australian coastal waters. Three of these units were drilling ships, two were semi-submersible platforms and one was a jack-up unit. In early 1970 five units were operating, and one was idle. However, only 4 offshore rigs were operating in early 1971 emphasising the urgent need for further discovery, particilarly of oil, offshore to encourage continued exploration.

In early 1970, some 326 wells were producing from the Barrow Island field, and total daily production was around 43,000 barrels per day; in 1971 this production is stabilised at about 50,000 barrels per day. The success of the water flood technique introduced in this field in early 1968 has stimulated production, and it is hoped that this daily will be sustained for some time.

The year 1969 saw the completion of the three major natural gas pipelines:- the 110 mile, 30 inch pipeline from Datsun to Dandenong commenced delivery to Melbourne and its environs in early 1969, and is currently delivering about 100 million cubic feet per day, eventually to rise to 200 million cubic feet per day.

Brisbane received its first delivery of natural gas from the Roma area in March 1969 through the 10 3/4 inch, 257 mile pipeline. Production from this area will be sustained at a daily rate of some 20 million cubic feet per day.

In late 1969, Adelaide received natural gas through the 22 inch 486 mile pipeline from the Gidgealpa - Moomba field. Production through this line reached some 100 million cubic feet per day in 1970.

141. In the early 1970's indigenous crude oil production from proven fields will supply about 67% of Australia's requirements. However, the crude oils discovered so far are deficient in the heavier distillation fractions required by heavy industry and road and paving construction, and thus importation of crudes rich in these fractions must continue, at 30-40% of total consumption, until an adequate source is found in Australia. Also since national consumption is increasing at about 9% per year, further substantial Australian discoveries are essential in order to maintain or reduce the deficit gap between indigenous production and importation. Should we not be successful in establishing additiona petroleum reserves within our own boundaries, it will be necessary to turn our thoughts to other and less convenient source materials for fuel, and to other sources of power such as uranium. Petroleum can be distilled from oil shale, and considerable attention is now being directed to our shale deposits, particularly those in Queensland; on the other hand our very extensive resources of coal may provide an alternative source if economic methods of synthesis can be developed to suit them. A great deal of attention has been given, for several years, to setting up the research facilities necessary to examine all possibilities connected with making full use of our coal, and a good deal more is being done in this regard than is generally realized. The U.S.A. has already advanced far, both in research and applied technology, in this field.

142. The Role of Government in Assisting Mineral Exploration and Development: One of the prime needs for any systematic search for minerals by modern methods is for adequate base maps - topographic,

geological and geophysical. It is by provision of these maps, as well as of geological and geophysical services generally, that Government makes its main contribution to the search.

143. It is perhaps not generally known how much effort goes into the mapping programme, or how far it has already advanced. The Department of National Development provides a focus for the various Government agencies engaged in this widespread and important activity. Overall direction of the topographic programme is provided by the Advisory Committee on Commonwealth Mapping, chaired by the Secretary of the Department and comprising representatives of the Navy, the Army and the Institution of Surveyors. A second body, the National Mapping Council, consisting of the Director of National Mapping (Chairman) and the Surveyors-General of the States and Commonwealth, is a high-level technical body which co-ordinates State and Commonwealth programmes.

144. The Commonwealth undertakes all topographic mapping within its own territories and in some States; in others it subsidises the work of the State agency. Commonwealth agencies are the Army Survey Corps, responsible for the work in largely northern areas, and the Division of National Mapping responsible for the rest. The aim of the topographical programme is to prepare maps at a scale of 1:250,000 in accordance with boundaries established by the international grid. This programme is nearing completion and the compilation of maps at a scale of 1:100,000 has commenced.

145. Both Commonwealth and State agencies undertake regional geological mapping. Programmes are agreed upon in consultation between the Bureau of Mineral Resources and the State Geological Surveys, but the work is necessarily a good deal slower than that of topographical mapping and the time required to complete a similar 1:250,000 coverage of the continent will be several times as long at least. However, over 60% of the continent has been covered since World War II.

146. Geophysical surveys are largely a Commonwealth responsibility and a great deal of work has been done using airborne equipment. The ultimate aim is to provide nation-wide coverage by gravity, magnetic, radiometric and seismic measurements. Only one State, South Australia, is sufficiently equipped to take a real share in this geophysical programme, but the increasing demands of oil exploration have brought into operation a number of private contractors who have carried out a great many useful surveys over parts of the sedimentary basins. Comparable surveys in the field of metalliferous exploration have increased very substantially during the past two years.

147. Generally speaking there is very satisfactory co-operation in mineral exploration between the Commonwealth, the States, and private industry. Programmes of work involving contributions of men or equipment from all three sources are not unusual. One common type of arrangement is for Government agencies to carry out geological and geophysical surveys after a prior understanding that the companies will embark upon any subsequent testing that appears warranted.

148. Other direct contributions to mineral search are made by the Commonwealth in the form of bounties and subsidies. Examples are bounties on the production of gold, and sulphuric acid; subsidies toward the cost of oil exploration. Concession freights by rail are a form of assistance often granted by State Governments.

149. Another important though indirect form of Commonwealth assistance is through taxation concessions. The object of these is to encourage exploration by making exploration costs recoverable, or to promote development by allowing the recovery of capital outlays either within a relatively short period, or over the estimated life of a mineral deposit.

150. On occasions, particular minerals have been given specifically favourable taxation treatment when it was felt that a national need existed to foster their exploration: examples are uranium and petroleum. Gold mining, for other reasons, has been free of income tax since 1924. At certain times other sections of the industry have be n temporarily protected by licensing imports of cheaper overseas products.

151. Government action has also been used to hasten the development of the domestic industry by prohibiting the export of unprocessed raw materials. The beach sand industry, which has been a consistent dollar earner, owes much to this procedure. Initially Australian exports comprised unprocessed sands of low value; but when Government regulations were introduced to prohibit the export of material other than high-grade concentrates, local processing plants quickly came into existence.

152. Stockpiling has also been employed occasionally as a means of encouraging production e.g. monazite and beryl, although no current stockpiling is in force.

153. A policy of permitting partial exports of manganese ores, even when reserves were low, brought satisfactory results some years ago. At a time when manganese was in critically short supply, the export of its ores had been prohibited; however the subsequent easing of the embargo to allow the export of one-third of any newly discovered reserves touched off an intensive prospecting campaign which brought new deposits to light.

154. Concluding Remarks: The intention of this paper has been to present a picture of Australia's mineral requirements and the manner in which they can be met from her own resources. It need hardly be said that the picture is a favourable one. With a few notable exceptions we can provide for all of our own needs and, in many cases, an exportable surplus as well. One may confidently expect that with the passage of time all deficiencies will be rectified. It is, in fact, difficult to think that if programmes of vigorous exploration keep pace with the growing demands on our mineral deposits, important discoveries will not continue.

TABLE 1 AUSTRALIAN IRON ORE CONTRACTS WITH OVERSEAS STEEL MILLS, AS AT 1.3.71 (a)

Mining Organization	Quantity(b) (Million tons)	Number of Contracts(c)	Duration (years)	Estimated value (f.o.b. $Am)
Cliffs Western Australian Mining Co. Pty Ltd	158.0	3	12-21	1238
Dampier Mining Co. Ltd	16.2	6	1-10	110
Frances Creek Iron Mining Co. Pty Ltd.	10.0	4	3-8	75
Goldsworthy Mining Ltd.	84.4	9	2-10	674
Hamersley Iron Pty. Ltd.	284.3	12	1-16	2144
Morgan Mining and Industrial Co. Pty. Ltd.	1.4	1	7	11
Mt. Newman Consortium	217.7	9	1-15	1579
Savage River Mines	45.0	1	20	494
Broken Hill Pty. Co. Ltd.	9.9	1	8	104
Western Mining Corporation and Partners	5.1	1	8	36
Totals	832.0			6465

TABLE 2 ESTIMATES - IRON EXPORTS FROM AUSTRALIA 1970-75 (based on contracts as at 1.3.71)

Year	1970(d)	1971	1972	1973	1974	1975
Total Quantity (million tons)	40.2	46.5	55.5	61.6	63.7	65.6
Total Value ($A million)	322	370	443	493	510	525

(a) Taken from published reports.
(b) Of the total (816.7 m. tons) approximately 90 million tons has been exported between 1966 and 1970.
(c) Contracts for which the delivery period exceeds 1 year.
(d) 1970 as recorded.

SUMMARY OF ORE RESERVES AND MINERAL PROCESSING

A summary of ore reserves and capacities for mineral processing in Australia, directed particularly toward the performance of the mineral industry in times of emergency, has been attempted in the accompanying table. Ore reserves have been classified under general categories likely to be significant in terms of industrial mobilization. These categories are based on the expected life of known reserves at current rates of production and are defined as follows:-

Very large - sufficient for more than 100 years ahead

Large - sufficient for 30-100 years ahead

Adequate - sufficient for 15-30 years ahead

Small - sufficient for 5-15 years ahead

Very small - less than 5 years ahead

In some cases, the uncertainty of reserves is indicated..

The table draws attention to a number of cases where mineral reserves are available but with no associated capacity to produce the metal or processed material needed in the manufacturing industry.

SUMMARY OF AUSTRALIAN MINERAL INDUSTRY
1969

Metal or Mineral	Resources: Distribution	Resources: Reserves	Resources: Current Imports	Mineral Processing: Level of Processing	Mineral Processing: Distribution	Mineral Processing: CurreCurrent Imports	Possible Disadvantages in Emergency
Ferrous							
Iron ore	Well distributed	Very large	-	Ores and pellets to steels and fabrications	Steel - Well distributed.	Ferro alloys-special steels	-
Nickel	West Australia Qld - (developing)	Adequate	-	Concentrates. Metal	W.A.	Metal & alloys.	Metal available but remote from most industrial centres.
Chrome	Minor-Victoria	Very small (?)	Bulk of requirements	Ferro-chrome	Newcastle	Ferro-chrome	Largely dependent on imports.
Manganese	Groote Eylandt, N.T. W.A. (Westralia Ores etc.)	Adequate (metallurgical)	Battery Grade	Ferro-manganese	Tasmania only	Some ferro-manganese and metal	Main reserves N.T. No battery grade No metal capacity
Tungsten	King Island, Tasmania. Minor-N.S.W., Qld., N.T.	Adequate	-	Concentrates	-	Tungsten	No metal capacity (but could be produced).
Molybdenum	Minor -N.S.W. Tas.	Very small	All requirements of ore and concentrates	-	-	Ferro-molybdenum molybdic acid	No domestic capacity of acid and ferro-molybdenum in emergency

SUMMARY OF AUSTRALIAN MINERAL INDUSTRY

	Resources			Mineral Processing			
Metal or Mineral	Distribution	Reserves	Current Imports	Level of Processing	Distribution	Current Imports	Possible Disadvantages in Emergency
Non-Ferrous							
Tin	Well distributed. Major-Tasmania	Adequate	-	Metal	Sydney only	Some Tin-plate	Major deposits off mainland. Only one smelter.
Lead	Well distributed	Adequate	-	Concentrates, bullion and metal.	Metal, N.S.W., S.A.	-	-
Zinc	Well distributed	Adequate	-	Concentrates, metal	Metal, Tas., N.S.W., S.A.	-	-
Copper	Mainly eastern Australia	Adequate	-	Concentrates, blister, metal and fabricated	Metal, Qld. & N.S.W.	-	-

SUMMARY OF AUSTRALIAN MINERAL INDUSTRY

	Resources			Mineral Processing			
Metal or Mineral	Distribution	Reserves	Current Imports	Level of Processing	Distribution	Current Imports	Possible Disadvantages in Emergency
Mineral Sands							
Titanium	E. and S.W. coasts	Adequate	-	Concentrates & pigments	Pigment W.A. & Tas.	Any metal required	No metal capacity
Zirconium	E. and S.W. coasts	Adequate	-	Concentrates		-	No metal or oxide capacity
Monazite	E. and S.W. coasts	Adequate	-	Concentrates and some rare earths	Pt. Pirie - rare earths		-

SUMMARY OF AUSTRALIAN MINERAL INDUSTRY

	Resources			Mineral Processing			
Metal or Mineral	Distribution	Reserves	Current Imports	Level of Processing	Distribution	Current Imports	Possible Disadvantages in Emergency
Light Metals							
Aluminium	Northern and S.W. Australia	Very large	-	Alumina and metal	Metal, N.S.W., Vic., Tas.	Minor shapes	Major resources N. Aust. Alumina S.W. Aust. remote from refineries.
Magnesium	Well distributed (magnesite)	Adequate	35% magnesite imported	No metal produced	-	All metal	Metal can be produced as in last war.
Nuclear							
Uranium	Northern Australia	Adequate	-	U_3O_8 (yellow cake) radioisotopes	Northern Australia Sydney	Radio-isotopes	Current reserves in Qld. and Northern Territory
Berylium	N.S.W. & W.A.	Small but uncertain	-	No processing	-	-	No metal capacity.
Fuels							
Coal	Eastern Australia mainly	Very large	Some high quality anthracite	Coke, coal gas	Coke-Qld., N.S.W., S.A.	Petroleum Coke	No chemical plants
Petroleum	Well distributed	Inadequate-self-sufficiency 1971 - 60%+	about 35% crude supplies	Refinery products	Well distributed	Some refinery products	major supplies offshore. Import of heavy crudes

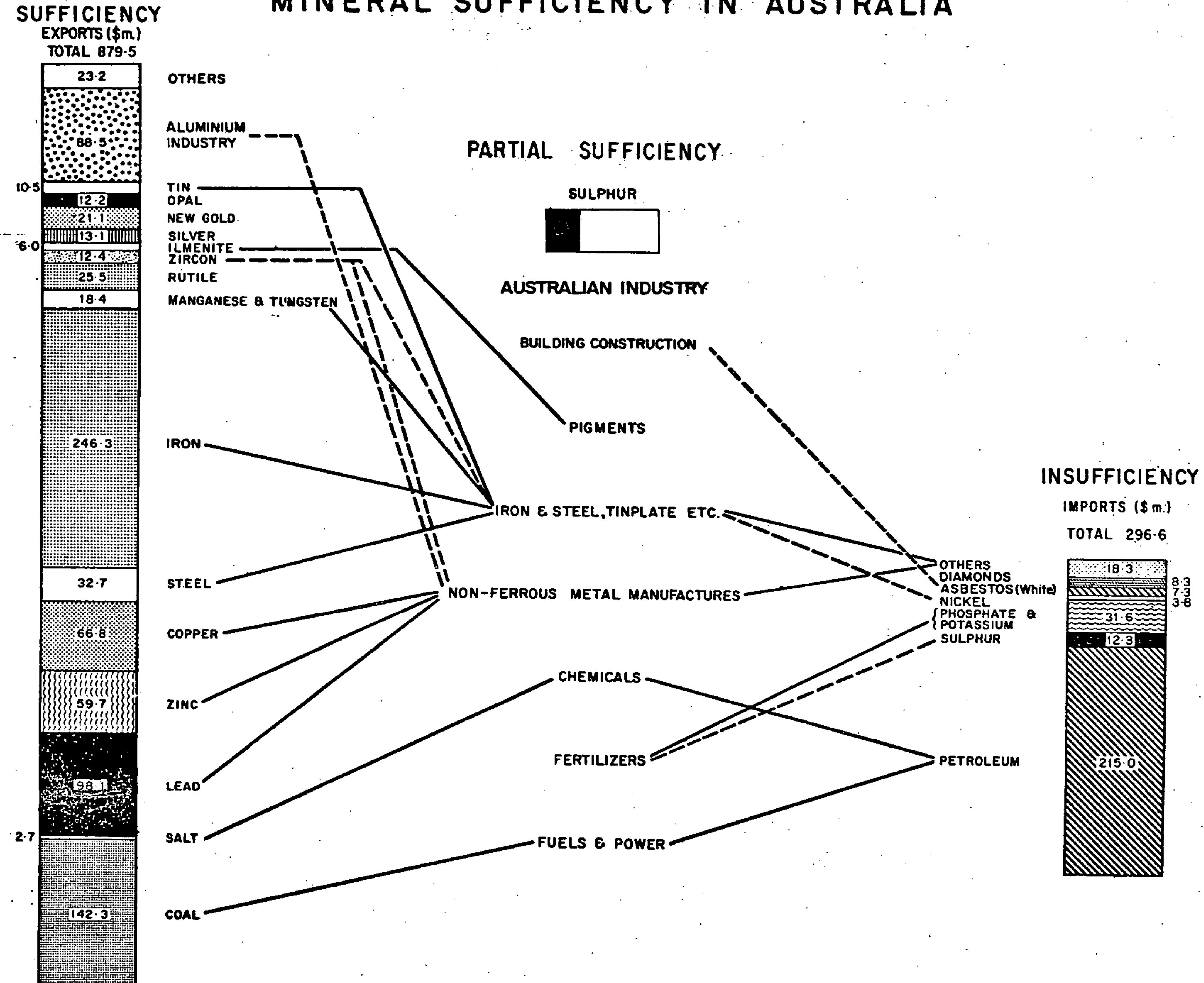
SUMMARY OF AUSTRALIAN MINERAL INDUSTRY

	Resources				Mineral Processing		
Metal or Mineral	Distribution	Reserves	Current Imports	Level of Processing	Distribution	Current Imports	Possible Disadvantages in Emergency
Chemical Fertilizers							
Phosphorus (Phosphate rock)	N.W. Qld.	Adequate	All requirements	-	Super made in all states.	Some mixed fertilizers	Dependent on imports until N.W. Qld.deposits exploited-domestic resources only in N.W.Qld.requiring coastal transport
Potassium Fertilizers	W.A.	Appear adequate	All requirements.	-	Fertilizers all states	Some mixed fertilizers	Dependent on imports until Lake McLeod in production. Deposits remote from factories.
Sulphur	(sulphides) well distributed	Elemental nil, Sulphide adequate	70% of requirements as elemental	Acid plants	Well distributed	-	Imports needed beyond capacity of sulphide acid plants.
Salt	Well distributed	Adequate	-	Sodium,salt, chlorine	Well distributed	Some chlorine 50% caustic required.	-

SUMMARY OF AUSTRALIAN MINERAL INDUSTRY

	Resources			Mineral Processing			
Metal or Mineral	Distribution	Reserves	Current Imports	Level of Processing	Distribution	Current Imports	Possible Disadvantages in Emergency
Minor Metals							
Vanadium	W.Aust. Qld (oil shale)	Probably adequate - not developed	-	-	-	All vanadium & composites	No production
Bismuth	Well distributed - mainly N.T.	Adequate - N.T.	-	-	-	All metals	No metal capacity
Cobalt	Eastern Australia W.A.	Small - uncertain (main potential from nickel ores)	-	Oxide (by-product)	Tasmania W.A.	50% Cobalt plus alloys	No metal or alloy capacity
Mercury	Eastern Australia	Small but uncertain	-	Metal (by-product)	Tasmania	Almost all requirements	Very little normal production - could be increased.
Mica	Central - Western Australia	Adequate	-	-	-	All grades	No current operations,but could be produced
Cadmium	Broken Hill Mount Isa	Adequate	-	Metal (by-product)	N.S.W.,S.A., Tasmania	-	-

MINERAL SUFFICIENCY IN AUSTRALIA



BASED ON FIGURES FOR 1969

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