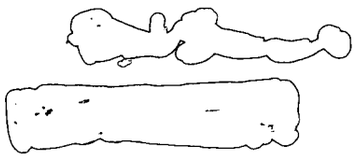

COMMONWEALTH OF AUSTRALIA.

DEPARTMENT OF NATIONAL DEVELOPMENT.

BUREAU OF MINERAL RESOURCES GEOLOGY AND GEOPHYSICS.

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D. O'Driscoll

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RESTRICTED

INDUSTRIAL MOBILISATION COURSE, 1964

Lecture No. 19

THE MINERAL RESOURCES OF AUSTRALIA

by

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INDUSTRIAL MOBILISATION COURSE

MINERAL RESOURCES OF AUSTRALIA

C O N T E N T S

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MINERAL RESOURCES OF AUSTRALIA

INTRODUCTION

This lecture will cover the main features of the mineral resources of Australia - resources which are both abundant and widespread: it will make a quick survey of the main deposits and centres of production, will look particularly at some of the industrial activities dependant on minerals, will say something about recent important events in mineral exploration, and will attempt some forecast of what lies ahead.

2. It may be remarked at the outset that there are two important minerals which will either be omitted or made the subject of only brief reference : - Coal, a subject in itself, will be dealt with by another speaker: and Water, perhaps the most important of all our minerals will be similarly dealt with (except at the Canungra lecture, when the notes provided in an Appendix will be appropriate).

3. The subject I propose to cover is still very large. Australia is a land whose known mineral wealth has increased with almost every decade and the end is yet far from being in sight. Our progress to nationhood owes much to the flow of population and capital which followed early discoveries - a flow that reached giant proportions towards the close of the last century, then slackened for a time, but has now resumed, inasfar as capital at least is concerned, in an atmosphere of exciting discoveries from which great new sources of wealth are foreshadowed. Today the nation stands on a threshold whence the way ahead is fraught with the promise of developments on a scale not to be imagined a few short years ago.

4. In dealing with resources I shall have in mind particularly the state of our resources to our domestic consumption. At the end of these notes will be found a summary statement of the degree of self-sufficiency we have so far achieved in our vital supplies. Reference will be found, too, to policies aimed at encouraging development or conserving our mineral resources. A notable feature of recent years is the degree to which Government policies have become involved and interlinked with the activities of industry in searching for and developing these resources.

5. Comments about mineral resources will be presented under the following headings :

(a) The ores of 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) Other metals;

(e) Non-metals;

(f) Fertilisers;

(g) Petroleum (i.e. oil and natural gas)

IRON, MANGANESE, ETC.

6. Iron : As recently as five years ago Australia's resources of iron ore were regarded as comparatively small in relation to her long term requirements, and for twenty years previously a complete embargo had been maintained on the shipment of iron ore for export. Recent discoveries have transformed the position and left no doubt that she has within her shores one of the most important iron ore provinces in the western world.

7. Prior to the new discoveries the chief deposits were those of the Middleback Range, S.A. and Yampi Sound, W.A. where the present-day production continues to yield the bulk of the nation's requirements. Iron ore produced from these localities in 1962 was 3,510,265 tons and 1,320,355 tons respectively. The only other production worth mentioning was that of Koolyanobbing, W.A., 83,917 tons. Imports, wholly from New Caledonia amounted to 260,431 tons; but this was not a vital source and could probably have been replaced by production from Australian deposits without any strain.

8. To illustrate the growth of our resources of iron it may be noted that in 1959 the demonstrated reserves from deposits then known amounted 369 million tons. In addition, prospects which were being tested in several States had raised hopes that intensified exploration campaigns might result in the opening up of worthwhile new deposits. Among such prospects were Savage River, in western Tasmania, where air-borne surveys had shown sharp magnetic anomalies over a distance of several miles; Constance Range in north-west Queensland, discovered in the course of regional geological mapping, where drilling had shown a marked improvement in the quality of ore at depth; and Mount Goldsworthy, near Port Hedland, W.A., where testing was beginning to show a more substantial body than had been indicated by outcrop.

9. Following upon the relaxation of the export embargo by the Commonwealth Government in 1960, several new discoveries were made in other parts of Australia and attention was soon focussed on the Pilbara district, east of Onslow, W.A. In a comparatively short space of time deposits were reported from Hamersley Range, Robe River, Roy Hill, and Ophthalmia Range localities all of which lie in the north-western part of the State.

10. Some of these deposits have since been subjected to vigorous testing campaigns and enough is known to be sure that they represent an iron province of the first importance. Though the full extent is not yet decided, authorative estimates have placed the total reserves at around 8,000 million tons and some believe much more.

11. Other possible sources occur in the Yilgarn area, W.A. where aeromagnetic surveys have shown the presence of a number of intense magnetic anomalies possibly due to concealed deposits of iron ore.

12. Not all the advance has come from the discovery of new deposits. Metallurgical research, in making possible the use of low-grade ores of which there is a super-abundance, has also contributed to the changed picture of Australia's iron ore resources. It is worth mentioning that investigations by the operating company have shown that some low-grade jaspilites of the Middleback Range, previously discarded as waste, may be economically upgraded for use as feed in the furnace. Because of the established industry close by, it is possible that this source may be utilised before some of the remote high grade resources are fully exploited.

13. When the new export policy was introduced it was expected to lead to an increase in prospecting and the proving of new reserves. The result has exceeded the most optimistic expectations, and lead to a situation in which the development of an export trade is viewed as a possible important contributor to the balance of payments. The first small scale export is likely to begin in 1965, and subject to satisfactory marketing arrangements large scale exports may begin in 1967.

14. Since the first easing of the embargo in December, 1960 conditions for the export of iron ore have been liberalized to an extent where potential exporters now feel very little restriction upon their plans. In the interest of securing the maximum national advantage, however, the sale price of export ore still requires Ministerial approval, and export is prohibited from all major deposits being worked prior to 1960.

15. On the industrial side of the picture, rapidly expanding iron and steel plants exist at Newcastle, Port Kembla and Whyalla; and a small Government owned charcoal-iron plant functions at Wundowie,W.A. In 1962 Australia's production of pig was 3,434,000 tons. Investment in the steel industry has amounted to more than £50 million in the latest period of little more than a year and capacity is now above 5 million tons.

16. Consumption of steel in Australia rose in 1962 from 3.8 to 4.1 million tons and resulted in a slight decrease in exports which were valued at £33.6 million. Export trade in the past has acted largely as a buffer to take up the difference between domestic production and consumption but the time may not be far distant when Australia will be in a fit position to exploit the growing demand for steel in Asian markets.

17. New major plant items commissioned since 1962 were a ferro-alloy plant at Bell Bay, Tasmania; an electrolytic tinning line and a new open hearth furnace at Port Kembla, New South Wales; and a basic oxygen steel-making plant and associated rolling mill facilities at Newcastle. A second blast furnace and an integrated steel plant is expected to be commissioned at Whyalla in 1965.

18. 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. It is also a constituent in many grades of steel and adequate supplies of its ores are as essential for the steel industry as are supplies of iron ore. It is required in much smaller quantities however, current usage being about 30 lbs. of manganese dioxide for every ton of steel produced. High quality manganese dioxide is also used in the manufacture of dry cell batteries. At the present level about 60-70,000 tons per annum of manganese ore is required by our industries and this amount is increasing.

19. For years the known Australian resources of manganese ore were small. Between 1916 and 1927, the steel industry depended for its supplies upon deposits in New South Wales; as these became worked out, deposits in South Australia were utilized from 1940 to 1944; subsequently Western Australia became the main source. Recently, domestic production has almost ceased as cheap supplies have become available from South Africa.

20. As with iron ore, manganese was subject to a long-standing embargo on exports, but this was partially relaxed in 1956 to permit shipments of a proportion of any new discoveries made subsequently.

One result was 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 the last year or two a discovery of perhaps greater importance has been made at Groote Eylandt, on the Gulf of Carpentaria, where manganiferous outcrops were detected in the course of regional geological mapping. A good deal of testing has since been carried out on these deposits by a private company, and although the results are not complete, indications are that they may be large enough to supply our needs for some time.

21. Australian production of manganese ore in 1961 was 87,000 tons; it declined to 72,000 in 1962 and fell away rapidly in 1963. The principal localities of production are now all in the western part of Western Australia between Meekatharra and Port Hedland. In an emergency these deposits are quite sufficient to provide for Australian industry for a considerable time.

22. Tungsten: Since tungsten became of commercial importance about 1900, Australia has been an important producer of its ores - wolfram and scheelite - but the rate of production has varied irregularly in the face of widely fluctuating overseas prices. A greater part of the production has been exported. Domestic consumption is very small and there should be no difficulty in meeting Australian requirements from known resources for a considerable time to come.

23. 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, closed down at the present time but with a satisfactory potential in an emergency. A very large deposit of scheelite exists on King Island, Bass Strait, but falling world prices have brought about a drastic curtailment of operation since long term-market contracts expired, and the mine is subsisting at present only by the receipt of a Government subsidy. A recent effort by producer countries, supported by Australia, to achieve an international arrangement leading to price stability, has not met with success.

24. Production in 1962 was : wolfram concentrates, 504 tons, scheelite concentrates 1063 tons. The total domestic consumption would not exceed 100 tons per annum.

25. Molybdenum: Until 1920 substantial quantities of molybdenite were produced in Australia but current production is negligible: in 1962 it amounted to about only 1 ton of concentrates from Queensland. Imports in the same year amounted to 134 tons of molybdenum compounds, of which 63 tons was ferro-molybdenum for steel manufacture.

26. Most of the molybdenite deposits in Australia occur in pipes for which development at any depth is costly. The principal exception occurs at Yetholme, N.S.W. where some 800 tons of molybdenite lie at shallow depth beneath a comparatively thick overburden. During the second world war the Commonwealth sponsored exploration for new deposits but results were generally not encouraging. Recently there have been reports of one company meeting with some limited success in testing extensions of the deposit near Mareeba, Queensland.

27. 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.

28. Chromium: Chromite, or chrome ore, has two uses in the steel industry - as an ingredient in the production of alloy steel and as a chemically inert furnace lining. Its main other use is for the manufacture of chemicals. Australian consumption of chromite seldom exceeds 25,000 tons per annum and at present is somewhat below this figure. The main world suppliers are the Soviet, Turkey, Rhodesia and the Philippines.

29. The largest known Australian deposit is at Coobina, W.A. where reserves are estimated to be at least 200,000 tons. This deposit, however, is in a remote arid locality 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. In 1962 the only Australian production of 369 tons came from a small deposit at Rockhampton in Queensland.

30. In general, because of cheaper overseas sources, Australia has been an importer of chromium and its alloys and compounds. In 1962, 8538 tons of chromite and 1974 tons of ferro chrome were imported, mainly from the Philippines, Rhodesia and Japan. Chromium metal is not manufactured locally but small quantities of high quality ferro chrome are produced at Newcastle.

31. Nickel: Australia's resources are small and no domestic production has been recorded since 1938. All our requirements are imported and the level has been rising in recent years because of the renewed demand for special steels and an increase in the use of nickel anodes for electroplating. However the total is not great - 1050 tons of metal and 1177 tons of nickel salts in 1963.

32. In recent years there has been sporadic exploration in the north-western corner of South Australia, in the northern part of Tasmania, and in the highlands of New Guinea. Nothing of importance appears to have been revealed so far. A substantial belt of favourable ultrabasic rock types occurs in the mandated Territory and some large deposits of lateritic nickel ores occur over the border in Dutch New Guinea. It is possible therefore that this area will receive increased attention from prospecting companies in the years to come.

33. There are large deposits of lateritic nickel ores in New Caledonia, the existence of which makes Australia's supply position fairly safe. Other sources are Canada and the United States.

BASE METALS

34. Copper: Australia had an important early history of copper production but during half a century or more her main deposits became exhausted so that eventually it looked as though she was to become largely dependent upon imports. This possibility has been removed chiefly by the discovery of very large reserves of copper ore adjacent to the lead lodes at Mount Isa, and of some lesser deposits in several other parts of the continent. Today Australia is much more than self-sufficient in copper and is earning a significant income from exports.

35. The scene is dominated by Mount Isa where reserves are sufficient to support a high rate of production for at least 50 years. Other important centres are Mount Morgan, Qld., Mount Lyell, Tas., and Tennant Creek, N.T.

36. The potential of the Mount Isa deposits was not realized until the early 1950's. Smelting was resumed there in 1953 after a brief war-time interlude when copper was produced for emergency purposes from the limited known reserves; in 10 years since 1953 production has increased more than four-fold. Last year it reached almost 75,000 tons and a further substantial expansion is planned to follow the completion of the rehabilitation of the Mount Isa - Townsville railway line in 1965-1966.

37. Australia has three copper refineries - at Mount Lyell, Port Kembla and Townsville. The refinery at Townsville, a wholly owned subsidiary of Mount Isa Mines, has an annual capacity of 75,000 tons and is by far the largest of the three. It was commissioned in 1959 and refines the whole of the Mount Isa output.

38. An event of some importance in New South Wales was a decision made several years ago to bring into production the old C.S.A. mine at Cobar where diamond drilling had shown substantial reserves below the abandoned workings. This mine will probably go into operation in 1965 with an annual production of 18,000 tons, and become a source of supply for the smelters at Port Kembla which have recently experienced difficulty in securing the necessary amount of concentrates from existing producers.

39. Apparent consumption of primary copper in Australia in 1962 was about 64,000 tons. Mine production rose above 110,000 tons (in concentrates) as follows :

	Tons
Queensland	
Mt. Isa	74,775
Mt. Morgan	7,365
Others	440
New South Wales	
(Mainly Broken Hill)	3,747
Tasmania	
(Mainly Mt. Lyell)	14,482
Western Australia	1,488
South Australia and Victoria	13
Northern Territory	
(Mainly Peko and Rum Jungle)	8,378
	110,688

40. Lead. Lead and zinc are usually discussed together because nearly all Australia's production is obtained from orebodies which contain both metals and they are mined in the same operation. The separation of the lead from the zinc is achieved later by concentration processes.

41. Since the discovery, in 1883, and the development of the Broken Hill orebody, the richest of any known, Australia has been a major producer of lead and zinc ores. The already favourable position was enhanced by the discovery and exploitation of Mount Isa in the years following 1923. We have been amongst the world's leading producers of lead for a number of years past and in 1962, with a production of 370,000 tons, ranked equally with the U.S.S.R. at the top of the list with an output 70 percent greater than that of the United States. Our known resources are so large that we may expect to continue as an exporting country for several decades at least.

42. Mine production of lead, after being below capacity for some years, rose sharply in 1962 to provide an increase of more than 100,000 tons on the previous year's figures. This was due to the termination of an international arrangement under which a substantial part of Australian production had been voluntarily curtailed. Production is likely to be again substantially increased in 1965-66 when the new plant at Mount Isa is commissioned.

43. Details of the production from States is as follows :

	Tons
New South Wales	
All Broken Hill Mines	290,710
* Lake George Mine	1,620
Others	51
Queensland	
Mt. Isa	62,643
Others	32
Tasmania	
Read-Rosebery	14, 138
Others	616
Western Australia	306
	370,116

44. Most of the lead concentrates are smelted in Australia. There are smelters at Port Pirie, S.A., Mount Isa, Qld. and Cockle Creek, N.S.W. There is a lead refinery at Port Pirie. In 1962, 190,000 tons of refined pig lead were produced; in addition, lead content in bullions was 73,000 tons. Exports amounted to 197,000 tons of refined lead, 76,000 tons in bullion and 109,000 tons recoverable in concentrates. Domestic consumption was 44,700 tons and the total value of output was some £26 million.

45. Zinc: In 1962 Australia ranked fourth behind the U.S.A., Canada and U.S.S.R. as one of the leading producers of zinc ores. Output was 337,000 tons of contained metal, an increase of 26,000 on the previous year. Details are as follows :

* Lake George Mines has now ceased production and closed down in March, 1962.

	Tons
New South Wales	
Broken Hill Mines	241,917
* Lake George Mines	2,946
Tasmania	
Read-Rosebery	47,918
Queensland	
Mt. Isa	44,704
South Australia	47
	337,532

46. There are two zinc refineries in Australia - an electrolytic plant at Risdon, Tas., with a capacity of 23,000 tons per annum; and a fairly recently commissioned plant (1961) at Cockle Creek, N.S.W. with a capacity of 40,000 tons per annum.

47. About half of our total zinc concentrates (all from Tasmania, and some from Broken Hill) are treated at these plants. The remainder of the concentrates from Broken Hill and all of those from Mount Isa are exported. In 1962 production of electrolytic zinc was 168,000 tons. Domestic consumption was 85,000 tons. The total value of the output was some £16 million after treatment.

48. Tin: From being a country with a once considerable export surplus Australia has been partly dependent on imports since about 1947. Recent developments in the revival of several old mining centres have raised hopes that this position may soon be corrected, so that although tin imports may continue for several years to come, Australia may be self sufficient again in the not far distant future.

49. In 1962 production of tin in concentrates was 2714 tons and smelter production of refined tin was 2704 tons. Imports were 1778 tons and apparent consumption 4482 tons. Domestic consumption has risen sharply following the commissioning of the new electrolytic plant at Port Kembla in 1962 and imports have shown a corresponding rise. Consumption is expected to level out at 4,500 and 5,500 tons per annum in the next few years. There is a good chance that the short-fall, expected to be about 2,000 tons in 1963, will be gradually met by new mines coming into production.

50. For some time past the main tin producing centres have been alluvial deposits inland from Cairns and in north-eastern Tasmania. Minor, but useful production, has come from New South Wales and Western Australia. How much of the increased consumption can be met from domestic sources may depend upon three new mining ventures which have been pushed on vigorously in the last year or two - Ardlethan, N.S.W. soon to come into production with an estimated 780 tons per annum from the open cut mining of lode tin; Mount Cleveland, Tas., where drilling following a geophysical survey has revealed extensions of the old sulphide tin lodes; and Greenbushes, W.A., a former alluvial field, where modern equipment is to be introduced. Some recent successes in testing at Renison Bell, Tas., may be the forerunner of increased production from that locality.

* Lake George Mines has now ceased production and closed down in March, 1962.

51. Some of the greatest tin producing countries in the world lie immediately to the north of Australia - Malaya, Thailand and Indonesia. In times of emergency we might try to maintain our supply lines with one or other of these sources; but if this were not possible, and if our own new domestic resources fail to live up to the test, we might have to look further afield, to Bolivia or Nigeria for example, to provide us with vital supplies.

URANIUM, THORIUM ETC.

52. Uranium: Australia has recently passed through a brief though not unspectacular interlude as a producer of uranium. 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 some 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 were erected first at Port Pirie, where some rather high-cost uranium oxide was produced from ores mined at Radium Hill; Rum Jungle, where the large plant is still in operation treating stockpiled ores; Mary Kathleen, now closed down on a care and maintenance basis; and Moline, N.T., which is still operating to fulfil the last part of an overseas contract.

53. 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 arbitarily set. In the event the price secured by Australia in several of her long term contracts turned out to be a good one and long before these contracts were fulfilled alternative sources overseas were able to supply more cheaply. At the same time a dwindling demand for defence and the lack of any comparable requirement for peaceful purposes lead to a situation in which no market was available to Australian production once her contracts were fulfilled.

54. It is believed that a new market will arise some time about 1970 when reactor and power generation programmes in a number of overseas countries reach completion. Until then Australia will have to do the best she can to maintain her uranium industry in a condition of readiness to go into production when the need arises.

55. A shortage of reserves is not apparent. 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 it is believed that testing for extensions had by no means reached its limits. Rum Jungle has mined out both of its known ore bodies but the treatment plant is continuing to operate on stockpiled ore and is stockpiling the uranium oxide produced. Meanwhile further exploration is being carried out. Recently it was announced that a total of 3,250,000 lbs. of oxide had been produced during the life of the Rum Jungle plant and that total revenue over the period of operation had been £21 million.

56. Although production of uranium has been heavily curtailed because of marketing conditions, Australia had the resources to provide for her requirements for a considerable time ahead.

57. Thorium and Cerium: The main commercial source of thorium, which has been of interest recently 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 in the near future, but this situation could be changed as a result of new technology, or beneficiation and refining advances.

58. The principal interest in monazite lies in its rare-earth content, one element of which is cerium. The rare-earth minerals are used in the ceramics industry, in metal alloying and in nodulising cast iron. Lately they have had increased interest because of their developing use in nuclear control rods, light amplification, cryogenic, thermoelectric and electronic devices. Cerium is present in the mineral allanite, large quantities of which are found in the Mary Kathleen uranium deposit.

59. High grade monazite concentrates are recovered from beach sands in Western Australia, Queensland and New South Wales. The monazite recovery in Western Australia is a by-product of ilmenite production but in the other States it is a by-product of rutile and zircon production. In 1962 production was 899 tons, three-quarters of which came from Western Australia. It is expected that 1963 figures will show a considerable increase brought about by the increased output of other beach sand minerals. Installed capacity for the recovery of high grade monazite in Western Australia reached 1500 tons early this year. All sales made were overseas.

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

61. Beryllium: Beryllium is a light-weight metal processed mainly from the mineral beryl which is better known perhaps as a semi-precious stone. The metal has become of great interest since the development of nuclear technology, but its main use is still in alloys of copper, nickel and aluminium.

62. Australian production of beryl began in 1939 and reached a peak in the war years. It has fallen away since and production in 1962 was only 223 tons containing some 26 tons of beryllium oxide. Almost all the production was exported to the United States where a limited stockpiling programme has been in force. Domestic demand is very small if any.

63. Most of the Australian production has come from the north western part of Western Australia. In time of emergency, particularly if production costs were not the principal consideration, the small scattered deposits already known would most likely be able to produce sufficient for our requirements. Overseas sources are Brazil, South Afric, Rhodesia, Uganda, the Congo and the United States.

64. Lithium: There has been an irregular production of lithium ores since 1905. In 1962 amounts totalling 136 tons were produced in N.S.W. and W.A. No detailed information is available on the consumption of lithium products in Australia and except for occasional use of local production all requirements are imported. The main uses are in the glass, ceramics and pharmaceutical industries and in the preparation of greases and welding and brazing fluxes. South Africa dominates the world production scene but Canada and the United States are alternative sources.

65. For several years past a mining company has been drilling a lithium prospect near Kalgoorlie and extensive reserves have now been proved. This deposit would seem to ensure Australia's supplies in any future emergency.

OTHER METALS

66. Aluminium: A little more than a decade ago Australia appeared to have a serious deficiency in bauxite, the ore of aluminium. Although exploration during the war years had shown that there were sufficient domestic reserves to justify the establishment of an aluminium industry with installations at Bell Bay, Tasmania, it was nevertheless believed that the industry would normally be dependant largely upon imported ores.

67. A series of spectacular discoveries was to change this picture completely. In 1949 relatively small deposits of bauxite were found at Marchinbar Island off the coast of Arnhem Land, and this was followed by more substantial deposits on the mainland near Gove. In 1956 very large deposits of bauxite were found at Weipa on the Cape York Peninsula; and in 1958 important new sources were recognised in the Darling Ranges close to Perth. Production of ore from the two latter localities is now in full swing and Australian reserves are known to be very large, perhaps the largest of any country in the world.

68. On the industrial side, developments have been very rapid in the last twelve months. The Bell Bay plant which is jointly operated by a mining company group and the Tasmanian Government has been expanded to produce 52,000tons of metal per year and is now being supplied with ore from Weipa where mining and shipping facilities are complete.

69. An alumina plant with a capacity of some 200,000 tons per annum has begun production at Kwinana, near Fremantle, W.A. and is supplying feed to the newly commissioned smelters at Geelong. These smelters came into productions with an initial capacity of 20,000 tons of metal which is being expanded to 40,000 tons.

70. Meanwhile the C.R.A.-Kaiser group in collaboration with several major overseas companies has announced plans to construct an alumina plant at Gladstone, Qld. with an output of some 600,000 tons of alumina per annum. Part of this may be used for establishment of smelters in New Zealand if current negotiations with the New Zealand Government are successfully concluded. The remainder will form a source of supply to important producers of the metal overseas.

71. Australia is not likely to suffer any future shortage of bauxite ore, alumina or aluminium metal and in the course of a few years is likely to emerge as one of the important producer countries in the international scene.

72. Titanium: Australia's resources of titanium minerals (rutile and ilmenite) are considerable. In 1962 production of rutile concentrates was 119,000 tons which represented a large part of the world production: and of ilmenite concentrates 182,000 tons which rates below that of several of the world's other principal producers.

73. The main uses of rutile have been in the manufacture of welding rods and the production of titanium metal; recently it has come into use in the manufacture of pigment. Ilmenite usage is almost confined to pigment.

74. The principal Australian resources of rutile are sands close to the beaches of the eastern coast, and reserves are large. Production is sustained by long term contracts to supply rutile to the United States. World demand for our rutile appears to be rising and production is capable of being increased to meet the demand. On the eastern coast, ilmenite which accompanies the rutile has too high a chromium content to be saleable for pigment and is usually left as a residue in dumps.

75. An extensive mineral sands industry exists also in the south-western part of Western Australia. The quality of the ilmenite from this source is satisfactory for the manufacture of titanium white, and as ilmenite is a main heavy mineral constituent of the sands its recovery forms the basis of a growing industry. A large new pigment plant has recently been commissioned at Bunbury, W.A., founded on local supplies.

76. Zirconium: The only important source in Australia is the beach sand mineral zircon. Resources on the eastern coast are very large - estimated to be between 2-3 million tons at least. The W.A. sands also have an appreciable zircon content.

77. In 1962 production of zircon concentrates was 134,000 tons - the largest of any country in the world. Exports were 132,000 tons.

78. Australia's extensive reserves of beach sands render her self sufficient in these minerals for many years to come.

79. Antimony: Antimony ores have been produced since the middle of the last century but most deposits have been worked out. At the present time the only significant production is from a mine at Guyra in north-eastern N.S.W. - 1962 production was 53 tons of concentrates.

80. Australian consumption of antimony in 1962, including that obtained from melting scrap antimonial lead, was 1,200 tons. Some 300 tons of this was imported, chiefly from mainland China. Alternative sources of supply are South Africa, Bolivia, and Mexico. Australian production is expected to be increased soon following an extensive development programme at the Guyra mine which was aimed at raising the output to 1250 tons in 1964.

81. 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.

82. In 1962 the production of cobalt oxide at Risdon was 22 tons (metal content 15.3 tons), about one-quarter of Australia's requirement: the rest was imported mainly from the Congo, which is the world's principal producer. Canada, Morocco, and Northern Rhodesia are alternative sources.

83. Production of cadmium in 1962 was about 350 tons of refined metal: three quarters of this came from Risdon and about one-fifth from Cockle Creek. Domestic sales were about 100 tons and the rest was exported along with some 600 tons contained in lead-zinc concentrates. In the event of a breakdown in local supplies the United States, Canada and Japan are alternative sources.

84. Tantalum-Niobium: Tantalum and niobium 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 usually a small annual output as a by-product of tin mining. This amounted to less than 9 tons of combined oxides in 1962, and was all exported. 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 produced in limited amounts at Newcastle during the war. Australian resources for production are more than ample.

86. Gold: Annual production has been steady for a number of years at a little over 1 million ounces, of which 85 percent comes 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 a number of years, the cost of production has crept steadily upward. 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 and a development allowance to reimburse part of the cost of opening up new shoots. Gold's main use is as a dollar earner.

87. Silver: All Australian silver is won as a byproduct from mining other metals, more particularly lead and zinc. Mine production in 1962 was 17.5 million ounces most of which came from the lead-zinc industry. Silver refined in Australia was 7.4 million ounces and the rest of the mine product was exported in concentrates or bullion. Domestic consumption was 6.8 million ounces, an important use being for coinage by the Treasury.

88. Platinum Group Metals: There has been a small eratic production of platinum and osmiridium for almost 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 no production has been recorded from them since 1958. About 100 ounces are recovered annually as a by-product of gold refining at Port Kembla.

89. The main uses are in chemical ware, in jewellery, as alloys for electrical purposes and in the petroleum and glass industries. Canada and South Africa are among the world's leading producers.

90. Selenium and Tellurium: Selenium is used in a small way 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 in the electrolytic copper refineries at Port Kembla but no statistics are available.

91. Tellurium, a byproduct of copper 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 of both metals is small. Annual production is about 3,000 lb.

92. Bismuth: There has usually been a small annual production of this metal as a content of tin and tungsten concentrates from the Northern Territory and Western Australia, but this dwindled to less than 100 lb. in 1962. Its uses are for low melting point alloys and for the production of salts used for the pharmacuetical and chemical industries. About 11 tons of bismuth metal and 6 tons of salts were imported in 1962, almost all from the United Kingdom.

Other sources are Peru, Mexico, Canada and Japan.

93. Mercury: Australian reserves are negligible and there has been no recorded production since 1945. The metal has lately been finding increasing use in the electronic industries and in 1962 some 39 tons were imported from Spain, Mexico, Turkey and Yugoslavia.

94. Vanadium: A metal used in both ferrous and nonferrous 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.

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 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, corundum and emery, and production is negligible. Small amounts of industrial diamonds were once obtained as a byproduct of gold dredging in the Macquarie River, New South Wales, but today the total domestic requirement of some 250,000 carats is imported. The Congo and the Union of South Africa are the world's major producers but in recent years there has been a growing production from off-shore dredging along the West African coast. Some interest has lately been expressed in the possibility of dredging for diamonds off the Australian coast but so far nothing has come of it.

97. Corundum and emery have been mined on a small scale in Western Australia. Part of our requirement of garnet is obtained as a byproduct of mining beach sands along the eastern coast: imports, amounting to several hundred tons in 1962, from the United Kingdom, U.S.A. and Canada, fulfill the remainder of our requirements.

98. Soft abrasives such as diatomite and ground felspar are produced in Australia in the quantities required.

99. Arsenic: Used in insecticides, sheep dips, weed killers, wood preservatives, and in glasses and enamels, is now almost all imported (1800 tons in 1962). Formerly a considerable amount was obtained as a byproduct from goldmining 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) but only minor ones of amosite and of white asbestos (chrysotile). Because of its fineness, strength, flexibility, and its suitability for spinning fibres, white asbestos is the most valuable variety. The only deposit being worked at present is at Baryulgil, N.S.W., where some 800 tons were produced in 1962. The discovery of several deposits in the Pilbara district, north-western Western Australia, has been reported recently and plans are believed to be under way to begin commercial production.

101. Blue asbestos, which lacks many of the desirable properties of the white, but is stronger and more resistant to chemical action, is coming into increasing use in the manufacture of asbestos cement products such as building sheets, pipes, guttering etc. Very large deposits exist near Wittenoon, W.A., and support an industry which in 1962 produced some 17,500 tons of which about half was sold locally and half exported.

102. Canada and South Africa are sources of supply for imported white asbestos (imports in 1962 were 30,000 tons). South Africa is also a source of amosite (imports in 1962 were 7000 tons).

103. Barite: Australia has adequate resources of this mineral the principal use of which is in oil drilling muds, and a lesser one 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 for oil drilling purposes. During 1962 there was a marked increase in the use by secondary industry but this was more than offset by a decline in the demand for drilling and production fell from 19,000 to 12,500 tons.

104. The principal Australian deposits are in South Australia and New South Wales. The United States, Germany, Canada and Mexico are important world producers.

105. Bentonite and Fuller's Earth: An increasing demand for bentonite, mainly for use in oil drilling, occurred in 1962 but was met from imports as Australia's resources are small and generally poor grade. An important use continues to be as a bonding agent for moulding sands. Local production of bentonite in 1962 was 780 tons, and imports 9,200 tons: production of Fuller's earth was 400 tons. Recently there have been reports of the testing of new deposits of bentonite in Queensland and Victoria. The United States and Italy are the main world producers.

106. Diatomite: There are many small deposits of this mineral in Australia and production has been almost continuous since 1896. Figures for 1962 were 7,300 tons. It 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 4,000 tons were imported from U.S.A. in 1962. Resources for other purposes are adequate.

107. Feldspar: Australian resources are large and more than enough for any likely requirement. Present centres of production are Londonderry, W.A., Broken Hill, N.S.W., and Olary, S.A. for the potash varieties; and Bombala, N.S.W., and Gumeracha, S.A., for the soda varieties. 1962 production was 8,500 tons. This could be expanded at will.

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 because of the ready availability of high quality material from overseas at a low price. Imports in 1962 were 4,350 tons mainly from South Africa and the United Kingdom. Mexico, China, France, Italy and the United States are important world producers.

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. Up to date no high-grade deposits have been discovered in Australia though possible resources have not been fully investigated. All our requirement is met by imports, which amounted to 2,000 tons in 1962, mainly from Ceylon and Malagasy. Korea, Austria, Mexico and Germany are 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 much 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 plastering products such as building boards. In 1962 production was 631,000 tons of which 140,000 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 1962 limestone production was 6.4 million tons and dolomite production was 0.2 million tons. Production of both could be increased almost indefinitely.

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 area in central Northern Territory, now support only a few fossickers.

113. While the Commonwealth Government's 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, however, the market disappeared and most of the small recent production has been from scrap from dumps. Imports in 1962 amounted to 1.4 million lb., (620 tons) almost all from India. 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, graphite and slate powder. 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 at Wilgie Mia and Weld Range, W.A.; Rumbalara, N.T.; and Dubbo and Glen Innes, N.S.W. Domestic consumption is very small and production in 1962 amounted to 60 tons all of which came from Tasmania. Some 270 tons were imported.

115. Quartz Crystals: There has always been acute shortage of high-quality quartz crystal which is used in radio, communication and 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. In recent years annual imports have ranged from 25 to 75 tons.

116. Salt and Sodium Compounds: Common salt, sodium chloride, can be produced abundantly 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 was the main contributor to the 535,000 tons produced in 1962, the greater part of the recovery coming from the evaporation of sea-water at alkali works near Adelaide. Construction work has begun on a new salt evaporation project at Shark Bay, W.A., aimed at a target of 250,000 tons p.a. for the export market.

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 on oil-fields abroad. Regional geological mapping has indicated the likely positions of several more. These could provide useful reserves in time of necessity but their geographical isolation is such that there seems little likelihood of commercial development at the present time.

118. Sillimanite and Kyanite: These minerals are used chiefly in the manufacture of high-alumina refractories used in furnaces. Deposits are known in several parts of Australia, mostly in remote localities. Production has been increasing in recent years to meet increasing demands from industry. The figure for 1962 was 2,600 tons, which met most of the local requirement. A few hundred tons of special sorts were imported from India.

119. India, South Africa and the United States are major producers but it is likely that Australia could meet her own requirements in any forseeable emergency.

120. Sulphur-bearing Materials: Commercial deposits of native sulphur are unknown in Australia but there are large resources of sulphur materials such as pyrites, base metal sulphides, and gypsum. When brimstone was in short supply overseas in the early 1950's, the Commonwealth introduced measures 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 felt itself unable to continue the bounty payments and announced that they would not be renewed after June 1965.

121. Sulphuric acid is produced 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., Norseman, W.A.; and as a by-product from treatment plants at Mount Lyell, Mount Morgan and Kalgoorlie. Sulphur is also recovered from oil refinery processes at Altona, Vic. and Adelaide.

122. Production of sulphuric acid rose to 1.23 million tons in 1962, of which 0.6 million came from indigenous raw materials. Imports of elemental sulphur were 0.23 million tons. The greater part of the acid produced was used in the production of superphosphate. Mexico, U.S.A., Canada and France are sources of supply.

123. Talc and Pyrophyllite: The chief consuming industries are cosmetics, rubber, ceramics, foundries, textiles, paper 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 1962 amounted to some 16,000 tons of which 5,000 tons were exported. Imports, mainly of varieties not available domestically, were 2,000 tons. The United States is the world's leading producer but Australian imports have come from China, India and Italy.

124. 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 1954, although several deposits are known to exist in Western Australia. Imports in 1962 amounted to 1800 tons almost all of which came from South Africa.

125. 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.

126. Phosphate Rock: is used in large quantities for the production of superphosphate (1,721,000 tons in 1962 all of which was imported). Local sources are negligible and are generally unsuitable for superphosphate manufacture.

127. 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, rights to which are held by Australia and New Zealand (with the U.K. as a partner in the Pacific). Although the rock from these sources is extremely high grade by world standards, the deposits have a limited life and are expected to be worked out in about thirty years, or perhaps less if the present trend to increased superphosphate consumption continues. Some years ago a widespread search for additional island deposits was made jointly by the Governments concerned, but no discoveries of importance resulted. It can be assumed that the chances of any new deposits of island phosphate supplementing the existing supplies are now remote. However the mainland of Australia offers the prospect of phosphate deposits of a different type, such as are contained in sedimentary basins in some other parts of the world. Concurrently the Bureau of Mineral Resources and one or two private companies have been carrying on investigations in several different localities with this in mind. No commercial discoveries have been made but the search has not been without encouragement and needs to be continued.

128. 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 is the main producer with an output of 4,300 tons in 1962. A discovery, made near Rum Jungle in 1961, of a unique type of phosphate deposit in ancient Pre-cambrian strata has been tested extensively by drilling and pitting. However, the proved reserve is only about 1 million tons and the grade is low. It seems as though this deposit, like the others known in Australia, will be useful only as a direct additive for local use.

129. In a country such as Australia, with a marked lack of natural phosphates in the soils of much of its agricultural land, a shortage of rock phosphate deposits must be regarded as a serious mineral deficiency. However no comprehensive search has so far been made for non-outcropping deposits. Since the possibility exists that some of our sedimentary basins may contain resources of great importance, Government policies designed to stimulate the search became important. Such policies are receiving active consideration at the present time.

130. Potash: Commercial deposits of the stratified type (such as are typical of Stassfurt, Germany) have not been discovered in Australia and there may be these or other types of deposit not yet recognised. In particular evaporite salt deposits are quite likely to 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 so far not revealed anything of importance. Another possibility exists in the salt domes discovered during the course of oil drilling.

131. At Lake Chandler in Western Australia an effort was made some years ago 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. However the operation proved uneconomic and the plant was closed in 1949.

132. In 1962 Australia imported some 75,000 tons of potash fertilizers and 2,500 tons of potassium salts for chemical purposes. The bulk of this came from West Germany and France.

133. Nitrates: No commercial deposits of nitrates are yet known in Australia although the demand for nitrogenous fertilizers has been increasing significantly both for the cane industry in Queensland and for the wheat industry in W.A.

134. The only nitrogenous fertilizer produced in Australia is ammonium sulphate. Production in 1962 was 101,000 tons and an additional 17,500 tons were imported. All other nitrogenous fertilizers including urea, sodium and potassium nitrate and calcium ammonium nitrate, amounting to some 50,000 tons in 1962, were imported. Main sources of supply are Japan, Belgium, Western Germany and Italy.

135. Petroleum: Australia's main mineral deficiency has long been that of indigenous petroleum resources, 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 1962 the figure reached some 110 million barrels and the cost £107 m. The annual rate of increase is from 3½ to 5½ percent.

136. With the beginning of production from Moonie in the early months of 1964 the first step has been achieved in the national effort to become self-sufficient. In the satisfaction aroused by our first commercial field however, it should not be lost sight of that this is so far only a minor contribution to our need. In 1964 production rate from Moonie will be only 2 percent of consumption, somewhat less than the annual rate of increase. Many more discoveries are needed before we can rest easy on the question of petroleum resources.

137. Meanwhile an Australia-wide search has been going on, in recent years with mounting intensity. To the end of 1962 more than £120 m. had been spent on the national search; a further £23 m. is likely to be spent this year. It is hoped that this figure will grow until final success is achieved.

138. Part of the reason for the increasing interest in oil search in Australia derives from the Commonwealth's policy of subsidising private companies' expenditure under a scheme introduced in 1958. Under this scheme selected operations were at first reimbursed by 50 percent, and later on by 30 percent, of the cost. Part is undoubtedly due to the encouraging results met in the last couple of years :-

these include the oil-field at Moonie, important strikes of oil and gas on Richmond near Roma; gas at Rolleston, inland from Gladstone; and, most recently, significant quantities of gas at Gidgealpa, near the Qld.-S.A. corner, which may offer a future supply for industry in Adelaide.

139. At the present time exploration titles are held over the surface areas of most of our known sedimentary basins, and drilling is going on in all States except Tasmania. Of late, interest has turned to some of the offshore localities where extensive basins are believed to exist on the shallow continental shelves. Drilling on the seabed is normally a more expensive operation than drilling on land, but the prospects are considered good enough for plans to have been announced to bring an offshore drilling rig to Australia. It is expected that this rig may be functioning in Bass Strait for the end of 1964.

140. Obviously the Australian economy cannot go on indefinitely becoming more and more dependant on imported petroleum, and if we are unsuccessful in establishing petroleum reserves within our own boundaries it will be necessary to turn our thoughts to other source materials for petroleum and to other fuels such as uranium. Petroleum can be distilled from oil shale but our known deposits are low grade and costly to mine, and the reserves are not large enough to justify a capital outlay that would be required to produce quantities of petroleum products: on the other hand our very extensive resources of coal may provide an alternative source. A great deal of attention has been given, in the last couple of years, to setting up the research facilities necessary to examine all possibilities connected with making full use of our coal.

141. <u>The Role of Government in Assisting Mineral Exploration and Development</u>:

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

142. It is perhaps not generally appreciated how much effort is already going into the mapping programme, or how far it has already advanced. The Department of National Development acts as the co-ordinating body for the various Government agencies engaged in this widespread and important activity. Overall direction of the programmes is provided by the Advisory Committee on Commonwealth Mapping, chaired by the Department and composed of representatives of the Navy, the Army and the Institution of Surveyors. A second body with somewhat different responsibilities in the field is the National Mapping Council consisting of the Director of National Mapping (Chairman) and the Surveyors-General of the States and Commonwealth. This is a high-level technical body which functions also in the co-ordination of State and Commonwealth programmes.

143. The Commonwealth undertakes topographical mapping within its own territories and in some of the States; in other States it subsidises the work of the local agency. In the division of functions the Army Survey Corps is responsible for the work in specified areas and the Division of National Mapping elsewhere. The aim of the topographical programme is to prepare maps at a scale of 1:250,000 to confirm with boundaries established by the international grid. Each of the Commonwealth agencies is geared to produce about 30 maps per year and, at the present rate of advance, some 5 or 6 years is required for completion of the programme.

144. Both Commonwealth and State agencies undertake regional geological mapping. Programmes are worked out on a basis of consultation between the authorities responsible but the work is a good deal slower than that of topographical mapping and the time necessary to complete a similar 1:250,000 coverage will be several times as long.

145. Geophysical surveys are largely a Commonwealth responsibility and a great deal of work has been done by airborne equipment. The ultimate aim is to provide adequate coverage by gravity, magnetic, radiometric and seismic methods. Only one State, South Australia, is equipped to take any real share in this programme but the increasing efforts in oil exploration have brought a number of private contractors who have been responsible for many detailed surveys over parts of the sedimentary basins. Comparable surveys in the field of metalliferous exploration have not often been undertaken.

146. 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 uncommon. One popular arrangement is for Government agencies to undertake geological and geophysical surveys in the understanding that the companies will undertake any subsequent testing suggested by the investigations.

147. Other direct contributions to the search are made by the Commonwealth in the form of subsidies or special allowances. Examples of this are bounties on the production of gold, copper and sulphuric acid; subsidies for the cost of oil exploration; reimbursement of development expenses in certain circumstances in gold mining. Concessions on transport are a form of assistance often given by State Governments.

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

149. On occasions particular minerals have been given specially 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 other times again, sections of the industry have been temporarily protected by licensing imports.

150. Government intervention 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 in recent years, owes its existence to this procedure. Initially our exports consisted of unseparated 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.

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

152. A procedure applied to manganese ores brought beneficial results some years ago. At the time when manganese was in short supply, the export of its ores was prohibited; but the easing of the embargo to allow the export of 1/3 of any new reserves proved touched off an intensive prospecting campaign which brought many new deposits to light.

153. 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. I think it has been shown that the picture is a generally favourable one. With a few notable exceptions we can provide all we need for our own consumption, and in many cases, there is an exportable surplus. One may hope that with the passage of time we will remedy all our deficiencies and that ultimately our continent will yield us everything we require. But this is not going to be without effort on our part - effort that will require the expenditure of large sums of money and the best use of our technical skills. The events of recent years suggests that even when the prospects look least encouraging we may be on the verge of important discoveries.

154. The history of bauxite exploration illustrates the point very well. Before the World War II there was no knowledge of any important bauxite deposits within our shores and we imported our total requirement of aluminium metal. It was not until the stage in the progress of the War when we were experiencing great difficulty in maintaining supplies of ingot aluminium that a decision was made to try to establish our own industry. By the time that the aluminium plant was set up at Bell Bay some minor deposits of bauxite had been examined and tested but they were believed to be either too small or too low grade to be other than a standby in emergency. It was intended in normal times to run the plant on imported ores. The subsequent discoveries at Gove, Weipa and the Darling Range show how seriously our bauxite resources had been undervalued simply through lack of information.

155. What has happened in regard to copper is a story rather similar to that of bauxite. Australia had once been an important copper producer, but the deposits appeared to be largely exhausted and the prospects of regaining self-sufficiency did not seem to be bright. Again it turned out that lack of information was the chief shortcoming. When the Mount Isa company embarked on an ambitious exploration programme it was not long before the copper lodes, which previously had seemed to be of minor importance, were in fact proved to constitute a major deposit by any world standards. The nation's supplies of copper now look secure for many years to come.

156. The story of iron is perhaps even more striking. When in 1939, with the threat of war hanging over us, the Government acted on the best advice available to it and imposed a complete embargo on the export of iron ore, it did so in the generally accepted belief that the surface of the continent had been so thoroughly prospected in the last half century that any worthwhile deposit of a conspicuous mineral like iron would almost certainly have been found. How misleading a judgement of this sort can be, when based on scanty information, has been proved by the events of the last three years.

157. All these events strengthen the conviction that if a policy of vigorous exploration keeps pace with the growing demands on our mineral deposits, many more discoveries will yet be made. It is not over-optimistic to hope that in time all our deficiencies will be made good.

158. For some years the Government has been giving much attention to the formulation of policies which will encourage efforts to search for the minerals we lack. Government action in subsidising oil exploration is generally agreed to have led well along the path towards our first production.

159. However, measures introduced by Government action alone are not the complete solution to our problems. We need, as well, a more widespread understanding among all citizens of the peculiar circumstances associated with the search for minerals. The Government needs the support of the people in shaping the policies and practices which seem appropriate to these circumstances.

160. The situation in regard to supplies of phosphate, wherein the end of our island deposits is already in sight and no alternative sources have yet been developed within our shores, underlines one of the distinctive features of the mineral industry viz., even the largest orebody has its limits and will one day be worked out. The most careful management or the most successful technology cannot avoid this end. It is therefore necessary to maintain a constant and energetic search for new deposits even when the existing ones are most productive and the prospects further afield are less than encouraging.

161. There is good reason for believing too that the expenditure on this long-range search should be fostered by special treatment in taxation and other forms of Government concession.

162. Government action to ensure the proper conservation of our resources is also very necessary. One way in which this is exercised is by insistence on good engineering practices and economic production methods. Another way is to provide an economic climate which will ensure that the maximum tonnage is extracted from the deposit down to the very lowest working grade of ore.

163. The minimum working grade of ore is no doubt controlled largely by the price of the product and the efficiency of the operation. The Government may have little ability to influence the first factor and may frequently leave the second safely in the hands of the operators. It may not therefore be apparent at first sight that many other factors such as public transport charges, royalties, company and personal taxation, import duties, health and safety regulations and wage determinations will exercise a formidable influence on the cut-off grade at which the mine can be worked. To the extent that each or all of these items is higher than it need be, so will the cut-off grade be forced upward and so will there be left behind in the ground, often without hope of recovery, a valuable proportion of our national mineral wealth.

164. An example may illustrate this point: some years ago when one of our largest base metal companies was planning an expanded production rate, a very detailed calculation mas made of the amount of ore from known reserves that would be unmineable if the existing production rate could not be stepped up and production costs reduced to the desired figure. It was an object lesson to find that some £A250 million worth of minerals would be abandoned and lost by the time the mine reached the end of its economic life. Few would argue that such a loss of wealth should be accepted without every means to prevent it being explored.

165. The proper development of our mineral resources, and the fullest exploitation of what is found, requires in us all a sense of national responsibility. It is not a problem for the mining communities alone: our predominantly urban population must be prepared to play its part and accept its share of the cost. We cannot afford to see the vital enterprises, situated mostly near our frontiers, struggle and die for want of assistance from our own prosperity.

166. This will amount to more than mere subsistence. In the twentieth century the people in every part of our continent who contribute to the growth of our civilisation feel that they are entitled to share in some of its benefits. They too want radio and television, streamlined transport services, telephones and communications, fresh foodstuffs, bitumen roads and petrol at reasonable prices. If these needs are to be provided, in many cases the whole of our community must share some part of the cost. It is shallow to think that such problems do not concern us all. The fate of even the most distant mining project may have an impact on our own daily lives whether we realise it or not. In the complex pattern of modern industry no State can live on its own resources. The industrial development of each depends to a considerable degree on minerals won outside its own boundaries. The steel industry of New South Wales, for example, depends upon iron ores from South Australia and Western Australia. The lead industry of South Australia is made possible by ores from N.S.W. The aluminium refinery at Geelong lives on alumina from W.A. Such examples could be continued at length.

167. The history of recent years suggests that the industries of our southern States will become more dependant in the future upon discoveries made in the tropical north. In the last decade or so we can point to Weipa, Rum Jungle, Mary Kathleen, Hamersley Range, Tennant Creek, Groote Eylandt and many other places where important mineral deposits have been revealed. The old belief that such localities cannot become permanent working abodes for predominantly European communities has been exploded. Where it has been possible to improve working and living conditions by providing refrigeration, air conditioning and mechanical labour-saving devices, daily life functions very much the same as elsewhere in Australia. Even in places where these amenities are not to be found the working efficiency is often surprisingly high. Perhaps we are becoming tougher as a people.

168. None of us I am sure doubts the future wonders that our nation may achieve. But they will not be achieved without purpose and effort on the part of us all. We have shown in the past that as a people we carry this purpose in our being. History has shown that when it is lost a people do not long survive. Our destiny lies ahead of us bright with promise. It is up to us to see that the promise is fulfilled.

APPENDIX 1.

SUMMARY STATEMENT ON RESOURCES

The following statement summarizes the reserves and production of the principal metals and minerals in relation to Australian consumption and world demand. It is difficult to give a satisfactory summary of this kind without appending many notes and qualifying phrases. However, the list should prove useful as a summary and the main part of the text can be referred to where amplification of the statement is required.

1. Reserves Adequate

(a) Production sufficient for domestic requirements and export.

Metals - aluminium, cadmium, copper, gold, iron, lead, silver, zinc.

Minerals - barite, bauxite, blue asbestos (long fibre), coal (black), gypsum, ilmenite, monazite, opals, rutile, salt, sapphires, scheelite, wolfram, zircon.

(b) Production sufficient for domestic requirements.

Minerals - blue asbestos (short fibre), clays (except high-grade china clay), coal (brown), dolomite, felspar, limestone, lithium minerals, pyrophyllite.

(e) Production not sufficient for domestic requirements. Imports necessary at present.

Metals - magnesium.

Minerals - manganese ores, muscovite mica, potassium salts (from alunite muds), sodium salts, sulphides (as source of sulphur).

2. Reserve Position Uncertain

(a) Production sufficient for domestic requirements and exports.

Metals - osmiridium.

Minerals - beryl, tantalite, talc, uranium oxide.

(b) Production sufficient for domestic requirements.

Minerals - glass sands, sillimanite.

(c) Production not sufficient - imports necessary.

Metals - antimony, arsenic, cobalt, platinum, selenium, tin.

Minerals - bentonite, china clay, chromite, diamonds, diatomite, emery, fuller's earth, graphite, kyanite, manganese ore (chemical grade), phlogopite, mica, pigments (red oxide and yellow ochre), quartz crystals, garnet fluorite, magnesite, vermiculite.

3. Reserves Negligible

Production negligible - imports necessary.

Metals - bismuth, mercury, molybdenum, nickel, vanadium.

Minerals - borates, chrysotile asbestos, cryolite, iceland spar, nitrates, petroleum, phosphate rock, sulphur (brimstone).