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THE AUSTRALIAN EXPLORATION BOOM 1965-1972-'73

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INTRODUCTION

Before the second World War mineral exploration in Australia was at a low ebb; prospecting was largely restricted to the examination of known deposits by established local mining companies. In 1949 the discovery of small but rich uranium deposits at Rum Jungle in the Northern Territory prompted fresh interest in Australia's mineral potential and resulted in a considerable increase in activity by both local and overseas mining companies.

In the 1950's and early 1960's further major discoveries of bauxite, manganese, lead, zinc, and iron ore resulted in an upsurge in exploration, which reached a peak in 1970-71. This paper attempts to analyse some of the results of this boom, but, because statistics on exploration in Australia are not available for the years before 1965, the analysis is restricted to the search for minerals (exclusive of petroleum) over the period 1965-1972/73, which was in fact the important period. Statistics collected in the annual mineral exploration census conducted by the Australian Bureau of Statistics have been drawn on extensively.

Australia experienced an unprecedented increase in exploration activity from 1965 to 1971. Total expenditure of exploration for minerals other than petroleum rose from $25.6 million in 1965 to a peak of $168.4 million in the fiscal year 1970-71, an increase of $142.8 million. The magnitude of this rise is evident when contrasted with Canadian statistics for the same period. Canada, like Australia and numerous other countries, also witnessed a strong upturn in exploration activity but total expenditure rose by only $84.7 from $C54.0 million in 1965 to $C138.7 million in 1971.

Exploration for minerals declined noticeably in most Free World countries, with the possible exceptions of South Africa, Brazil and the Philippines, between 1970-71 and 1973. In Australia exploration expenditure has dropped sharply from the 1970-71 peak of $168.4 million to $109.1 million in 1972-73.

The boom in exploration activity in Australia was sparked off by the successful development of a series of very large mining projects, including the Groote Eylandt manganese deposit, Gove and Weipa bauxite deposits, the Bowen Basin coalfields, and the Western Australian iron ore province. The success of these early ventures and the political and economic stability of Australia attracted the attention of both Australian and foreign explorers and support for the boom was provided by a series of new discoveries. Prominent among these were the 1966 discoveries of the Kambalda nickel province in Western Australia and the immense phosphate reserves at Duchess and Lady Annie in Queensland. Exploration interest was sustained and heightened by

recent base metal discoveries, including the Lady Loretta silver/lead/zinc deposit in Queensland, the Woodlawn copper/lead/zinc deposit in New South Wales, continued exploration success in the nickel belts of Western Australia, and of late the discovery of important, new, major uranium deposits in the Northern Territory and Western Australia.

Australian public interest in exploration increased rapidly during the boom. In 1964-65 mining stocks constituted 20 percent of the total equity shares traded on The Sydney Stock Exchange; in 1969-70 over 70 percent. In the three years to 1968 a total of 51 new mining and exploration companies were admitted to exchange lists compared with less than 26 industrial companies. Published Australian Bureau of Statistics (ABS) figures show that the total number of enterprises engaged in exploration in Australia increased dramatically from 438 in 1968-69 to 848 in 1970-71 while in the same period the number of enterprises spending more than $1 million annually on exploration increased from 16 to 41. By 1970 virtually all the major world mining companies were actively exploring for metals in Australia.

Data from company reports and other sources indicate that at least 70 percent of the companies spending more than $0.5 million a year on exploration between 1969 and 1972 were directly foreign owned. They were also responsible for 50-60 percent of total expenditure in Australia in these years. The ABS definition of direct foreign company ownership was adopted for the purpose of this paper, namely: companies incorporated in Australia in which 25 percent or more of the ordinary shares are held by one company or group of associated companies incorporated in one foreigh country; or, companies in which 50 or more percent of the ordinary shares are held by individual shareholders resident in one foreign country; or, branches of companies incorporated in foreign countries.

In 1971 the great Australian exploration boom went into reverse and expenditure fell sharply. The sharp downturn in activity indicated by the 1971-72 expenditure figures coincided with a weakness in world metal markets induced by economic recession in most industrialized countries and a fall-off in the discovery rate in Australia. However, the fall in the level of effective exploration between 1970-71 and 1971-72 was undoubtedly much less than the figures suggest, as a significant proportion of the funds expended on exploration in Australia at the height of the boom in 1970-71 was unwisely spent, and in some instances virtually wasted. In the period between 1965 and 1971 the single most important source of exploration funds was undoubtedly re-invested mining profits of the established miners. As metal prices declined and profits were squeezed most mining companies in Australia and elsewhere cut back the areas of corporate activity where no immediate return on funds was being obtained.

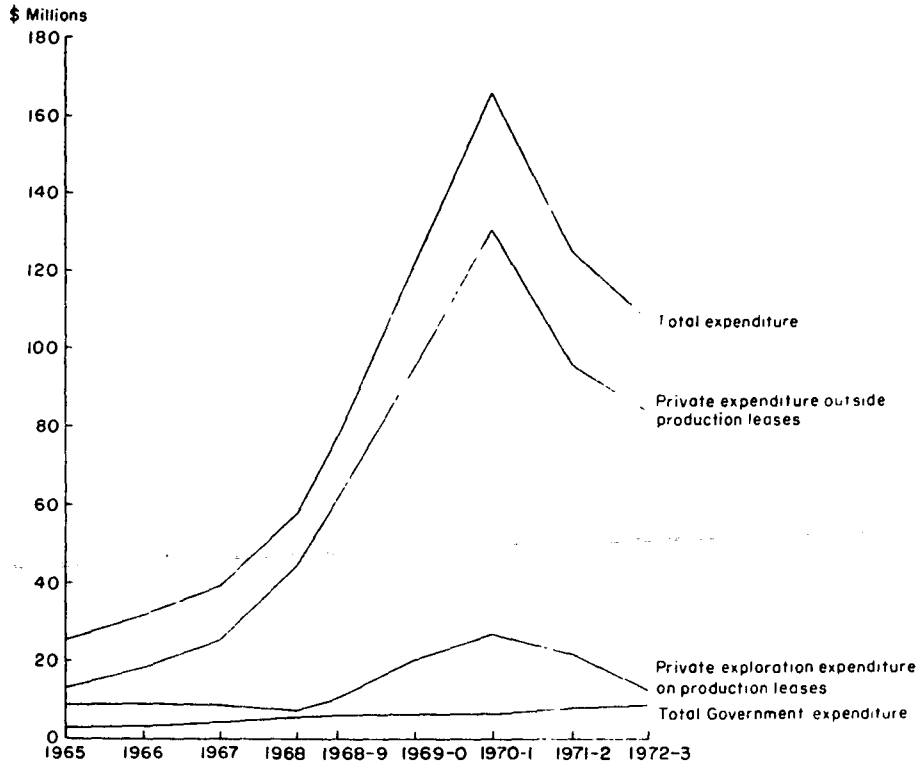

Fig. 1 Mineral exploration expenditure (excluding petroleum).

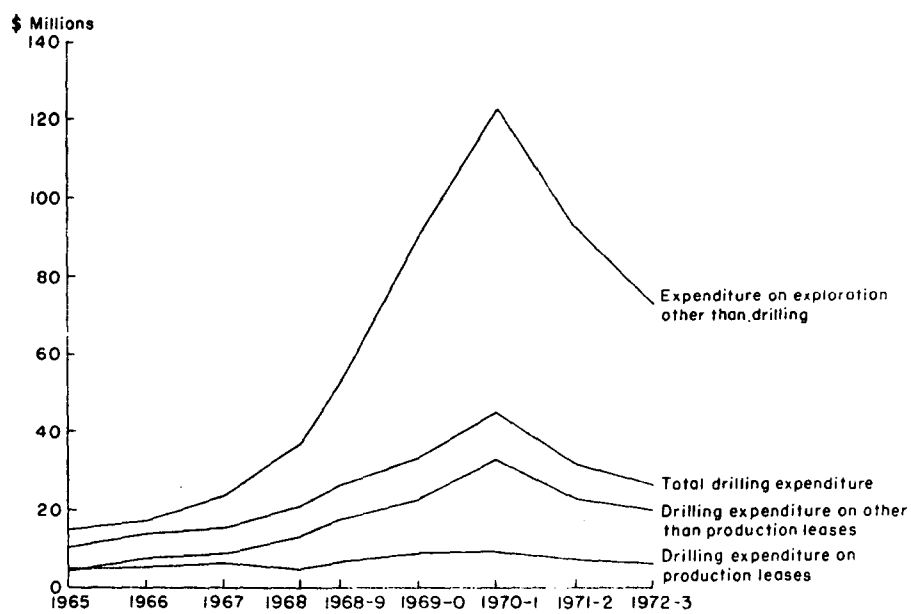

Fig. 2 Mineral exploration expenditure (excluding petroleum)

In nearly all cases this meant reduced exploration budgets.

At the same time the Australian investing public ended their romance with mining and exploration companies. Public confidence was severely damaged in 1971 by: the collapse of the Vam Ltd and Mineral Securities Ltd mining groups; the severe downgrading of uranium reserves at the Nabarlek uranium deposit, which had commanded world attention when first announced; and the Tasminex and Leopold affairs in Western Australia. As a consequence funds for speculative mining ventures were greatly reduced. Published ABS figures show that the number of small explorers (i.e. those spending less than $50 000 a year) declined from 539 at the height of the boom in 1970-71 to 395 in 1971-72 and 337 in 1972-73. The total number of explorers active in Australia also fell sharply from a peak of 848 in 1970-71 to 553 in 1972-73, a decrease of 295.

Available statistics suggest that total exploration expenditure has continued to decline in 1973-74.

EXPENDITURE

Total expenditure

Expenditure in Australia on exploration for minerals other than petroleum is tabulated in Table 1 and graphically presented in Figures 1 and 2. Data presented were obtained from published ABS statistics. Exploration is here defined as the search for and/or appraisal of new ore occurrences and known deposits of minerals, but exploration for water and mine development activities are excluded. Expenditure data also exclude payments, other than to governments, for the purchase of exploration leases, licenses, etc.

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All expenditure data are in unadjusted 'current' dollars. Ideally allowance should be made for erosion in the purchasing power of the dollar when comparing expenditure on a yearly basis over the period examined. However, it appears likely that in this period the introduction of new technology and exploration methods, and scale economies in, for example, laboratories and service company operations, would have considerably modified inflationary effects and helped maintain a 'constant' exploration dollar.

TABLE 1. MINERAL EXPLORATION EXPENDITURE ($'000) 1965-1972-73

	Total	Total Private Expenditure	Total Government Expenditure	Private Expenditure Exclusive of Production Leases (a)
1965	25 582	22 360	3 223	13 971
1966	31 687	28 115	3 572	18 674
1967	39 393	34 822	4 571	25 496
1968	58 321	52 463	5 858	44 818
1968-69(b) (six months only)	39 546	36 281	3 265	31 192
1969-70	124 818	118 115	6 704	97 024
1970-71	168 377	161 063	7 314	133 511
1971-72	125 396	117 061	8 334	95 882
1972-73	109 140	99 738	9 402	86 035
TOTAL	722 260	670 018	52 243	546 603

(a) This figure represents total private expenditure on production leases.

(b) Prior to 1968-69 the annual mineral exploration census covered the year ending 31/12. In 1968-69 the reporting period was changed to the year ended 30/6 thus data for the 6 months ended 31/12/68 are included in both the 1968 and 1968-69 returns. Expenditure for the 6 months ended 30/6/1969 has been estimated here by halving total expenditure for the year ended 30/6/1969 i.e. by halving reported 1968-69 expenditure.

Note: Prior to 1968 the scope of the ABS census was limited to private exploration on lease or license areas, and all Government exploration. From 1968 the scope of private exploration was broadened to take in general exploration work not directly attributable to lease or license areas. To this extent the annual figures for 1965, 1966, 1967 and the total expenditure are understated.

The statistics presented in Table 1 and Figures 1 and 2 illustrate the important private sector contribution to exploration in the period examined. Private expenditure increased from 87 percent of the total expenditure in 1965 to 91 percent in 1972-73.

Government exploration

Government exploration expenditure by the Commonwealth Government (Bureau of Mineral Resources, Joint Coal Board) and State Mines Departments almost trebled in amount but decreased as a percentage of the total from 12.6 percent to 8.6 percent between 1965 and 1972-73.

Private exploration

The most volatile and probably the most important single category of exploration from the viewpoint of national resources has been private expenditure outside production leases. By definition this category includes all work carried out by the private sector on areas covered by licences and authorities issued by the State Governments and Territorial Administrations for exploration for minerals, but excludes exploration on production leases currently producing or under development for production of minerals. It is therefore this category of exploration activity which has been most directly responsible for new mineral discoveries in Australia in recent years. Investigations by Governments have of course been an important contributing factor, principally by providing data basic to the search for minerals, but have also been directly responsible for a number of discoveries in the past, e.g. the Gove bauxite deposit, the Groote Eylandt manganese deposit, and the Woodcutters base metal deposit in the Northern Territory. However, expenditure by Governments amounts to a small proportion of the total and has declined in comparison with private exploration expenditure in the period under review.

Private exploration expenditure outside production leases has become an increasingly important component of total expenditure, rising from about 55 percent in 1965 to 79 percent in 1972-73. In absolute terms this category of private expenditure has declined substantially from the peak level reached in 1970-71, but it has not fallen as rapidly as private exploration on production leases, indicating a shift in emphasis by explorers to more 'grass-roots' exploration. It is suggested that this switch resulted from two factors. First, declining demand for most metals lead to generally falling prices in 1971 and lower company profits, thus reducing the exploration budgets of producing miners in particular, with a consequent effect on the level of exploration on production leases. Second, in the boom years leading up to 1970-71 almost all

explorers were involved in land acquisition programs in prospective areas, in some instances to the detriment of active exploration on areas already held. Nearly all areas acquired were subject to minimum work conditions and as land stocks of individual explorers were built up to satisfactory levels exploration of these areas began, at the expense of work on production leases, to satisfy work requirements and to ensure that areas were thoroughly searched before relinquishment or reduction.

Regional pattern

In Table 2 the total private exploration expenditure is tabulated by region for the 8½ years under review. Clearly the most actively prospected regions, New South Wales, Queensland, and Western Australia, were also the States in which activity declined most sharply in 1971-72 and again in 1972-73. Little real change is evident in Victoria and Tasmania, but exploration has tended to increase in South Australia, although here again a downthurn is clearly evident in 1971-72. In marked contrast to the major States, exploration in the Northern Territory has increased in every year except 1971-72. This apparent anomaly is best explained by the interest and exploration activity sparked off by the 1970 discovery of the very rich Nabarlek uranium deposit. Companies attracted to the Northern Territory included a number of explorers new to Australia and the metal exploration subsidiaries of several major oil companies whose exploration budgets were largely unaffected by the 1971 downturn in world metal prices.

Table 3 provides a measure of the change in relative importance of each region over the 8½-year period under review by expressing yearly expenditures as a proportion of total annual expenditure. The growing recognition and realisation of the mineral potential of Western Australia is clearly shown by the rapid increase in the proportion of total exploration funds expended in this State.

In addition, the total expenditure in each region has been contrasted with their relative land areas. These figures quantify to some extent the exploration potential of each region as assessed by the exploration companies which have operated in Australia between 1965 and June 1973. For example the mineral potential of Tasmania, which represents only 0.9 percent of the total Australian land mass, is highlighted by past exploration expenditure, which represents 4.2 percent of the total. Western Australia and New South Wales statistics show a similar pattern although the contrasts are not nearly as dramatic.

TABLE 2. TOTAL PRIVATE EXPLORATION EXPENDITURE ($'000 000) BY STATE AND TERRITORIES 1965 - 1972-73

	1965	1966	1967	1968	1968-69(a)	1969-70	1970-71	1971-72	1972-73	Total 1965 - 1972-73
New South Wales	4.5	4.9	4.6	5.6	3.6	16.6	21.2	15.1	12.7	88.7
Victoria	1.0	1.2	1.5	1.5	0.8	2.4	1.9	1.3	1.9	13.4
Queensland	4.4	8.3	11.7	13.3	9.0	25.0	32.7	22.1	15.5	142.0
South Australia	1.1	1.4	1.2	2.7	1.5	5.8	6.2	4.1	5.3	29.0
Western Australia	3.9	6.5	10.2	23.1	17.7	59.8	86.1	62.8	51.1	321.4
Tasmania	5.1	2.8	2.2	2.1	1.2	3.3	4.4	3.5	3.4	28.0
Northern Territory	2.4	2.9	3.5	4.2	2.4	5.2	8.6	8.2	9.9	47.4
TOTAL	22.4	28.1	34.8	52.5	36.3	118.1	161.1	117.1	99.7	670.0

(a) Prior to 1968-69 the annual mineral exploration census covered the year ending 13/12. In 1968-69 the reporting period was changed to the year ended 3-/6 thus data for the 6 months ended 31/12/1968 are included in both the 1968 and 1968-69 returns. Expenditure for the 6 months ended 30/6/1969 has been estimated here by halving total expenditure for the year ended 30/6/1969, i.e. by halving reported 1968-69 expenditure.

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

TABLE 3. PERCENT TOTAL PRIVATE EXPLORATION EXPENDITURE BY STATE AND TERRITORIES 1965 - 1972-73

	1965	1966	1967	1968	1968-69	1969-70	1970-71	1971-72	1972-73	Percentage Total Expenditure by State	Percentage Total Australian Land Area
New South Wales	19.9	17.3	13.2	10.7	10.0	14.0	13.2	12.9	12.7	13.2	10.4
Victoria	4.5	4.4	4.2	2.8	2.2	2.0	1.2	1.1	1.9	2.0	3.0
Queensland	19.6	29.7	33.5	25.4	24.8	21.2	20.3	18.9	15.5	21.2	22.5
South Australia	4.7	4.8	3.5	5.1	4.1	4.9	3.9	3.5	5.3	4.3	12.8
Western Australia	17.7	23.2	29.3	44.1	48.8	50.6	53.4	53.7	51.3	48.0	32.9
Tasmania	23.0	10.2	6.3	3.9	3.3	2.8	2.7	3.0	3.4	4.2	0.9
Northern Territory	10.7	10.3	10.1	7.9	6.7	4.4	5.3	7.0	9.9	7.1	17.5

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

On purely statistical considerations contrasting the proportion of total expenditure with the relative land areas for each region may also indicate regions which are relatively unexplored by Australian standards. Obviously the mineral potential for any region depends on the geological environment and the decision to undertake exploration in any one area is predicated on a wide range of variable factors such as type and grade of mineralization expected, location, access, land availability, etc. Nevertheless, comparison of the figures mentioned above is considered valid because of the areas involved would be expected to reduce substantially the variables involved.

On this basis the Northern Territory, South Australia, and Victoria appear to have received less attention from explorers during the exploration boom than they merited on purely statistical considerations.

EMPLOYMENT

Almost all employment trends in Figure 3 closely follow the expenditure patterns. However, the trend for professionals engaged in private exploration diverges significantly and contrasts strongly with that for non-professionals, largely reflecting the change in the direction of exploration after 1971. As companies switched to assessment work on prospective areas they had delineated, their requirement for geoscientists capable of carrying out this type of work would be expected to increase compared with non-professional support staff, who were employed to assist in the early, broad-ranging reconnaissance phases of exploration in Australia between 1965 and 1971.

In part this trend probably also represents reluctance on the part of management to terminate highly qualified professional staff and the early release of non-professional staff; over-reliance on non-professional support staff occurred in the years immediately preceding 1970-71, when a severe shortage of suitably qualified exploration personnel developed in Australia.

DRILLING

Drilling trends in Figure 4 closely parallel expenditure patterns. The rate of increase in non-core drilling footage when compared to core drilling up to 1970-71 is largely a function of the concentration on reconnaissance type exploration up to that date.

The marginal decline in core drilling footage in 1971-72 and again in 1972-73 contrasts strongly with the sharp downturn in non-core drilling and

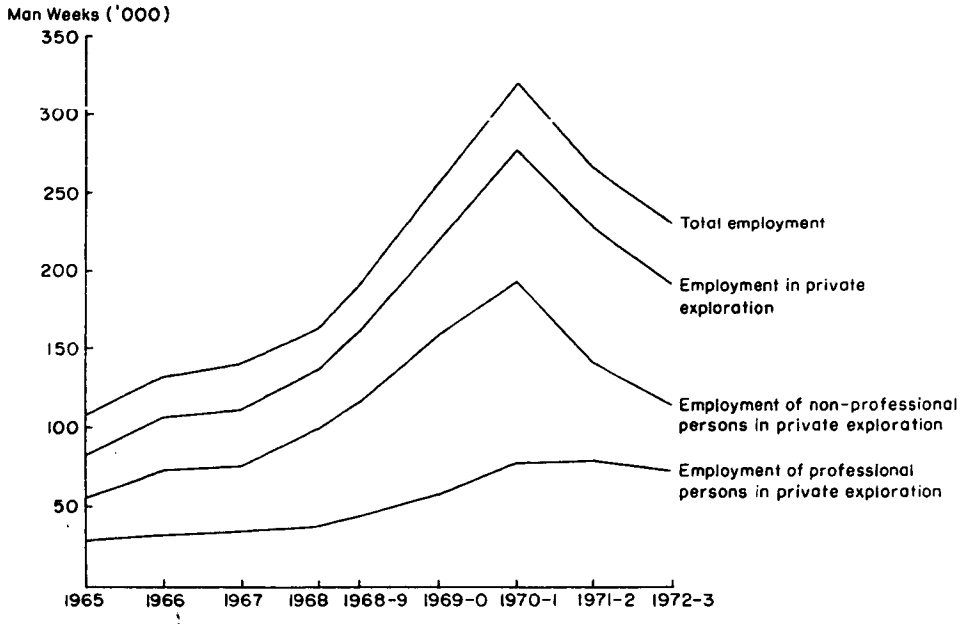

Fig. 3 Employment

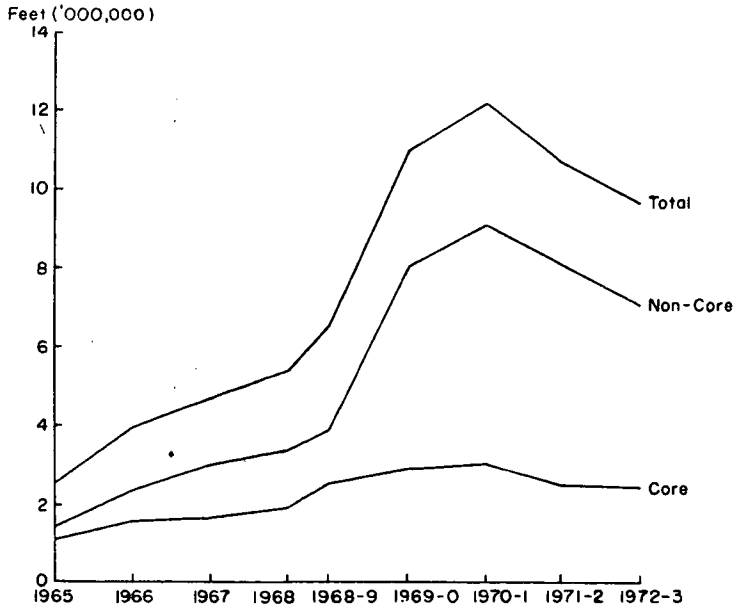

Fig. 4 Drilling

again indicates a switch in emphasis by most explorers to more detailed evaluation of prospective areas outlined in the earlier reconnaissance phase.

However, this interpretation is subject to some reservations. The smaller and more speculative explorers, who proliferated before 1970-71, showed a marked tendency to use non-core drilling methods in their initial property evaluations. Non-core drilling has the twin advantages of speed and relative cheapness, both important factors to companies with a limited budget and no cash flow. Relative costs in Australia are normally in the range of $2-5/foot for non-core and $10-12/foot for core drilling, although costs vary widely depending on location, hole depth, footage drilled, and other variables. Also although no statistics on the number and type of drilling rigs are available for the period under examination it appears probable that the very large increase in drilling activity resulted in a shortage of core drilling capacity, thus forcing some explorers to use second preference non-core drilling methods.

SOURCE OF FUNDS

In the five years commencing 1968-69 for which official statistics are available, the major explorers, here defined as enterprises spending more than $500 000 a year on exploration in Australia, were the most important source of exploration funds. They remained a relatively constant proportion (8 percent) of the total number of explorers but accounted for more than 61 percent of total expenditure in each of the five years. The number of explorers in this category has, however, declined sharply from 68 at the height of the boom to 45 in 1972-73.

Historically prospectors have played an important, and perhaps the major, role in the discovery of new mineral deposits in Australia. However, their importance as ore finders has declined in the past 20-30 years and this trend appears likely to continue as orebodies become progressively more difficult to find and search techniques increase in cost and sophistication. King (1973) estimated that only 10 out of a total of 87 discoveries made in Australia, Papua New Guinea, and the British Solomon Islands between 1955 and 1972 were attributable to the activities of prospectors, including residents and landowners; all the others were found by companies.

The major explorers are regarded as most important principally because they investigate the greatest number of prospects and are thus most likely to discover and/or develop new resources. In addition they are responsible for most of the long-term expenditure, research, and new technology. On the basis of a number of case studies Morgan (1969) has suggested that a

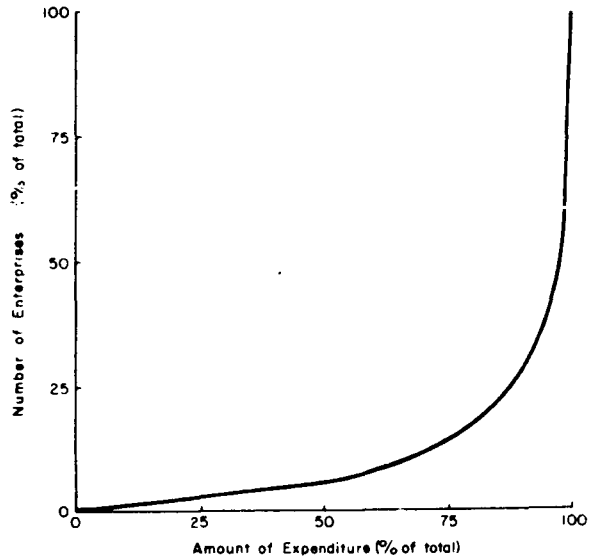

Fig. 5. Distribution of private exploration expenditure 1971-72.

minimum desirable annual rate of spending on exploration by a single explorer is $1-$1.5 million a year, which provides a better than 50 percent chance of finding a medium to large ore deposit within 6-10 years.

Information from company reports and other sources indicates that directly foreign-owned exploration companies were responsible for at least 70 percent of total expenditure by major explorers between 1968-69 and 1972-73. The foreign explorers outnumbered major Australian explorers (companies with majority Australian equity) by 3 to 1 and their average expenditure per company in 1971-72 was about $1.7 million a year compared with about $1.4 million by major Australian explorers.

The great majority of foreign companies directly involved in Australian exploration operate on a large scale with budgets in excess of $500 000; hence on the figures above, it appears probable that they have contributed around 50 percent, or $303 million, of the total exploration funds expended in Australia in the past five years.

DISCOVERY COST

In 1973 the Australian Mining Industry Council estimated that $600 million had been expended on exploration and assessment work in Australia in a ten-year period between 1962 and 1972. Of the 67 significant discoveries made, 29 were either being mined or were under development; development of the remaining deposits awaits changed conditions for viability; hence the

costs of these discoveries will be increased by the appropriate interest charges on the funds involved. These figures are in close accord with unpublished estimates prepared in the Mineral Resources Branch of the Bureau of Mineral Resources, which indicate that in the period 1965 to June 1971 $488 million was spent on mineral exploration and 50 significant orebodies discovered; however, only about half of these discoveries were immediately viable.

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Both sets of figures suggest that the total cost of a significant discovery in recent years has been about $10 million. However, the average cost to explorers of a viable orebody has been closer to $20 million, assuming an average ten-year delay before the remaining discoveries become viable.

More recently Western Mining Corporation Ltd noted that since the Kambalda nickel discovery in 1965 the company had spent $20 million on exploration, mainly in Australia, between 1965 and 1971. In that period the company made only one commercial discovery outside the Kambalda nickel province, the Yeelirrie uranium deposit in Western Australia. By way of contrast the Australian exploration arm of the Belgium-based miner and explorer, Union Miniere S.A., has spent over $9 million in Australia since 1968 and has yet to make a commercial discovery.

Ore discovery costs in Canada were the subject of an important paper by Cranstone & Martin in 1973 and their general findings are considered applicable to Australia with one important proviso. Canada has been the subject of more intensive and extensive exploration than Australia except in very recent years. In general, discovery costs increase with time and the amount of total exploration effort as the more obvious deposits are found. Thus Australian discovery costs could reasonably be expected to lag behind Canada assuming similar geological environments and comparable exploration efficiency.

Cranstone & Martin show that the cost of a discovery in Canada (regardless of size) in constant 1971 Canadian dollars has increased

from about $2 million in 1946-1955
to $6 million in 1956-1965
to $14-15 million in 1966-1970
to $27 million in 1971.

However, in Canada the general size of new discoveries increased significantly between 1946 and 1971, which largely compensated for the increase in the cost of an individual discovery. Thus, while the cost of a single discovery increased by a factor of about 13 between 1946 and 1971, the real cost of discovery per tonne of metal only doubled. It is considered probable that discovery costs per tonne of metal have increased in Australia by a similar order of madnitude.

THE BENEFITS FROM EXPLORATION

In this study the benefits accruing to Australia from recorded exploration expenditure over an 8½-year period between 1965 and 30 June, 1973, have been measured by calculating the proven reserves discovered for a group of eight important minerals; copper, lead, zinc, nickel, uranium, black coal, iron ore and bauxite. This particular group of minerals was chosen because of the amount of published information available and because of their relative importance. In 1972 they represented about 57 percent of the total ex-mine value of Australian mineral production and accounted for 83 percent of the total value of Australian exports of primary mineral products.

Only deposits discovered since January 1965 have been included here, and the reserve figures used were in most cases the published proven reserves at the time of writing. Additional reserves located at deposits known to exist by 1965 have been excluded as they are considered to result largely from normal development activities rather than exploration. Obviously the discovery dates of some reserves are subject to argument, so wherever possible the date of the first significant intersection of ore, which led to the recognition of an orebody within a relatively short time span, was chosen. The new reserve figures are almost certainly understated, as published ore reserves are normally conservative and additional tonnages are usually established after further work.

Several reservations apply to the discoveries included in this report. Firstly a new discovery is normally the result of cumulative exploration effort and expenditure over a long period of time. Thus some deposits included as discoveries may have resulted primarily from expenditure incurred in earlier years. However, total exploration expenditure in Australia in the five years to January 1965 was certainly less than $60 million. Given that discovery is a function of expenditure, the proportion of ore deposits included here as new discoveries which were the result of pre-1965 expenditure would appear to be minimal. The vast increase in funds outlain on exploration in recent years suggests that we can expect a number of new discoveries in the

immediate future which will be largely attributable to expenditure in the 1965-1972/73 period.

The new reserves figures published here can therefore be considered as conservative for three reasons:

1. Published reserves are typically conservative.
2. Not all discoveries made during 1965-1972/73 have been announced.
3. Future discoveries will be made as a direct result of past and present expenditure.

Net reserves are here defined as new reserves minus mine production, and in Table 4 they are compared with the current (1973) rate of mine production.

Obviously exploration for coal and iron ore has been tremendously successful. The results for nickel, uranium, and bauxite are also impressive and suggest that for all five of these commodities Australia is sufficiently well endowed to permit substantial increases in the current production rates.

However, the results for lead, zinc, and particularly copper are in sharp contrast. Between 1965 and June 1973 more copper was mined in Australia than was discovered in new reserves, while net reserves of zinc and lead show only a marginal increase. Although no detailed breakdown is available for expenditure on the search for these particular minerals, company reports, etc., show that all three were high on the priority list of most explorers. The results can only be regarded as disappointing and lead to the conclusion that Australia is not nearly as well endowed with copper, lead, zinc as commonly thought; and statistics on the number of operating mines support this conclusion. For instance in 1973 there were at least 73 Canadian mines producing copper compared with about 21 significant producers in Australia.

Although exploration over the past 8½ years has failed to add significantly to Australia's reserves of copper, lead, and zinc, reserves of these metals in deposits discovered before 1965 are sufficient for about 23, 34 and 40 years respectively at projected production rates. Resource assessments of these three commodities have been instituted by the BMR and are likely to increase total known reserves substantially.

TABLE 4. MINE PRODUCTION AND NET RESERVES OF SELECTED COMMODITIES ('000 tonnes) 1965 - 1972-73

Commodity	Mine Production	New Reserves Discovered(a)	Net Reserves(b)	Current Yearly Production Rate (1973)	Net Reserves: Current Production (c) (years)
Copper	1 273	702	-571	214.3	-2.7
Lead	3 598	3 862	+264	404.1	+0.7
Zinc	3 977	6 298	+2 321	460.9	+5.0
Nickel	169	1 825	+1 656	41.3	+40.0
Uranium	-	198	+198	-	-
Coal	406 590	8 000 000	+7 593 410	60 700	+125
Iron Ore	368 406	11 000 000	+10 631 594	84 000	+127
Bauxite	65 559	1 679 000	+1 613 441	19 000	+85

(a) New reserves are here defined as all those contained in new discoveries since 1 January 1965 plus reserves subsequently proven at deposits located prior to 1 January 1965 but which contained no proven reserves at that date. Reserves arising from extensions to pre-existing orebodies are specifically excluded.

(b) Net reserves are here defined as new reserves minus mine production in the period covered.

(c) The net reserves to production ratio is a measure of the life of the net reserves at the current annual production rate. A negative sign implies a decrease in reserve life.

In Table 5 the ex-mine value (1972) of net reserves discovered in Australia between 1965 and June 1973 is tabulated as an indication of potential value. Though it is realized that ore in the ground has no real value until its economic recovery and sale is assured, reserves are valued in this exercise to provide some measurement of the potential benefits of exploration. The ex-mine value is defined as the value of the mineral at the mine or at the associated treatment works in the locality of the mine. In general it is derived by valuing the quantity produced during the year at the unit selling value less any transport costs from the mine or associated treatment works to the point of sale. Internal BMR studies and work elsewhere has clearly shown that in the long term the selling prices of almost all minerals have remained fairly stable or increased slightly in constant dollar terms with time.

TABLE 5. NET RESERVES VALUATION 1965 - 1972-73

Commodity	Net Reserves(a) '000 tonnes	Ex-Mine Value $/tonne (1972)	Ex-Mine Value of Net Reserves $'000 000
Copper	-571	683.37	-390
Lead(b)	+264	191.33	+51
Zinc	+2 321	134.28	+312
Nickel	+1 656	1 500.00(e)	+2 484
Uranium	+198	13 000.00(e)	+2 574
Coal	+7 593 410	6.42	+48 750
Iron Ore	+10 631 594	5.88	+62 514
Bauxite	+1 613 441	5.00(e)	+8 067
TOTAL			+124 362

(a) Net reserves are here defined as new reserves discovered minus mine production in the period covered.
(b) Note ex-mine value of lead used here for valuation purposes includes silver content.
(e) Estimate.

Table 5 therefore provides a conservative measure of the potential value to Australia of the exploration carried out in the 8½ years to June 1973, assuming that current ex-mine values will apply to the new reserves when developed. Expressed in dollar terms expenditure on exploration for minerals other than petroleum in Australia of slightly over $722 million has resulted in the discovery of new net proven reserves in the ground of lead, zinc,

nickel, uranium, bauxite, iron, and black coal valued on a 1972 ex-mine basis at $124 362 million; or, alternatively, an average of $172 of ore has been found for each $1 spent on the search for minerals other than petroleum. The majority of these reserves can be attributed to private expenditure outside production leases, which totalled $546.6 million.

However, these figures do not represent the total value of exploration carried out. First, only eight minerals have been considered. Important new reserves of phosphate, beach sands, gemstones, and numerous other minerals have also been discovered. Second, mineral deposits have been discovered which, although presently uneconomic, constitute important future resources. Examples include the huge Mt Keith nickel deposit in Western Australia and the low-grade porphyry copper deposits of Queensland. Third, even exploration programs which fail to locate new deposits yield valuable information which can result in later discoveries. Other side benefits include employment provided, etc.

Logically the benefits accruing to Australia should be compared with the returns available in alternative avenues of investment. However, this presupposes that exploration funds would be available for re-direction, and it is pertinent to note here that the search for minerals is international in character. The explorers' decision to invest high-risk capital in any particular region is based on the potential rewards which could reasonably be expected from development of a mineral discovery.

It seems probable that any attempt to re-direct exploration funds would result in withdrawal of this high-risk capital from Australia. Thus the only reasonable conclusion is that Australia has obtained the maximum benefits possible from exploration because the bulk of funds expended to date were only available for this particular avenue of investment.

THE FUTURE OF EXPLORATION IN AUSTRALIA

Any discussion on the future of exploration in Australia would be incomplete without some consideration of Australia's long-term mineral requirements. Noakes in his recent (1974) paper entitled 'Mineral Resources of Australia' has shown that, with the important exception of petroleum, Australia is fairly well endowed with minerals and has a reasonable lead-time in which to discover new reserves.

However, this situation should not allow us to be lulled into a false sense of complacency about the future. Most of the more prospective areas of the continent have now been explored on at least a 'first pass' basis and probably nearly all the outcropping and easily recognized deposits have been found. The next phase of exploration must concentrate on locating deposits for which surface evidence is either subtle or entirely lacking. The discovery of these orebodies will require the use of increasingly sophisticated search techniques and and will involve greater risks and expenditure than was incurred in the past. The task ahead is as formidable as it is important. In 1971-72 the value of mineral production represented 3.1 percent* of the gross domestic product at factor cost but mineral exports constituted 24 percent of the total value of all exports.

It is instructive to re-examine the source of funds over the period reviewed in this paper and the levels of equity ownership in new reserves discovered. As presiously stated, directly foreign-owned explorers were responsible for about 50 percent of total exploration expenditure in Australia between 1968-69 and 1972-73 and accounted for at least 70 percent of the total expenditure by major explorers.

The level of Australian equity in new reserves discovered between 1965 and 1972-73 is calculated as:

59.3 percent in copper,
36.6 percent in lead,
32.9 percent in zinc,
52.4 percent in nickel,
75.4 percent in uranium,
58.0 percent in coal,
40.1 percent in iron ore,
and 26.8 percent in bauxite.

Overall Australian equity in new reserves adjusted on a weighted ex-mine value basis is 47.2 percent, which compares favourably with the estimated proportion of total exploration expenditure by Australian companies during the same period. It should be noted that inclusion of other new reserves such as the immense phosphate rock discovery of BH South in Northern Queensland would raise the Australian equity share in new reserves to well over 50 percent.

* This figure refers only to mining and quarrying and does not include value added by smelting and refining.
ture for the year ended 30/6/1969 i.e. by halving reported 1968-69 expenditure.

Thus a good correlation is apparent between the amounts expended on exploration and the equity ownership in new reserves discovered. In fact, this result is somewhat surprising when it is recognized that at least 20 percent of the total Australian company expenditure was attributable to a very large number of small companies who were unable to enjoy the economies of scale or technical and research facilities available to most of the overseas explorers operating in Australia.

The discovery rate of significant new deposits has decreased markedly since 1970; this is well illustrated in Kings (1973) paper on exploration. In it King presented a detailed list of 'exploratory discoveries' of which 2 were made in 1964, 6 in 1966, 12 in 1968, 15 in 1970, and only 2 in 1972. This trend closely parallels the trend in total exploration expenditure and serves to emphasize the fact that orebodies are becoming both more difficult and more costly to find. Although the criteria used by King to define a discovery differ from those detailed elsewhere in this paper the downturn in discovery rate is clearly evident whichever criteria are used.

It is not possible to predict accurately the level of exploration expenditure required in the future to replenish known reserves now being mined. However, the sharp decrease in the rate of discovery since 1970 should be viewed with concern if it persists at what is still, currently, an historically high annual rate of expenditure.

It has been clearly shown that the discovery rate of new orebodies is a function of total exploration expenditure. The downturn in discovery rate may well signify the end of an extremely successful period of exploration in Australia and herald the advent of a new and more costly phase characterized by concept-orientated programs with an emphasis on the search for partially obscured or blind orebodies and totally new deposits in new environments.

CONCLUSIONS

Throughout this paper no attempt has been made to measure the effects of changes in Australian government policies, which may have affected explorers investment decisions, for two main reasons. First, policy changes affecting exploration are extremely difficult to quantify; and second, they cannot be considered in isolation, given the international character of the search for minerals. Changing political and investment climates in other countries and recognition of the mineral potential in newly developing regions exert considerable influences on investment decisions which may outweigh or counteract change in domestic policies.

The boom in exploration in Australia which culminated in peak expenditure of $168 377 000 in 1970-71 resulted primarily from international recognition of the mineral potential of Australia, and an encouraging political and economic climate following successful development of a number of major mineral developments in Australia in the early 1960's. A series of significant new discoveries in the 1965-71 period promoted increasing interest and expenditure on exploration.

The downturn in activity which began in 1971-72 was partly attributable to a substantial fall in world metal prices and industrial activity and growing disillusionment with the exploration results being obtained by local explorers.

The main measurable benefits to the nation stemming from exploration expenditure in Australia between 1965 and 1972-73 are the substantial new reserves of coal, iron ore, bauxite, nickel, and uranium discovered in this period. Current Government policies are designed to improve Australian ownership in the mineral industry, which was assessed at 52.2 percent in mining and quarrying by ABS and at about 61 percent in mining and processing by BMR in 1971-72. However, it is vitally important that this be dome in such a way as to maintain exploration for minerals at an adequate level to ensure the discovery of additional mineral deposits which will certainly be needed to maintain and further Australia's development in the future.

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