SUBMISSION BY GEOSCIENCE AUSTRALIA

to the

HOUSE OF REPRESENTATIVES STANDING COMMITTEE INQUIRY INTO RESOURCES EXPLORATION IMPEDIMENTS

July 2002

Contact officers:

Minerals: Dr Ian Lambert: Tel. 62499556; Email: Ian.Lambert@ga.gov.au

Petroleum: Dr Trevor Powell: Tel. 62499471; Email Trevor.Powell@ga.gov.au

HOUSE OF REPRESENTATIVES STANDING COMMITTEE INQUIRY INTO RESOURCES EXPLORATION IMPEDIMENTS:

SUBMISSION BY GEOSCIENCE AUSTRALIA

July 2002

INTRODUCTION

The agency

Geoscience Australia[1] is a prescribed agency within the Commonwealth Industry, Tourism and Resources portfolio.

As Australia's national geoscience research and information agency, Geoscience Australia undertakes activities covering onshore and offshore Australia and spatial information. It serves the government and helps the community make appropriate and informed decisions about mineral and petroleum resources, the management of the environment and the safety and wellbeing of its citizens. To this end, it maintains a range of regional to national scale fundamental geoscience datasets, which are available free online or at the marginal cost of transfer.

Minerals and petroleum overview

Over the past 18 years, Australia's exports of minerals and petroleum have earned ~$565 billion, around 50 percent higher than exports of the agricultural sector (see Figure 1). As the nation's largest export earner, minerals and petroleum contributed

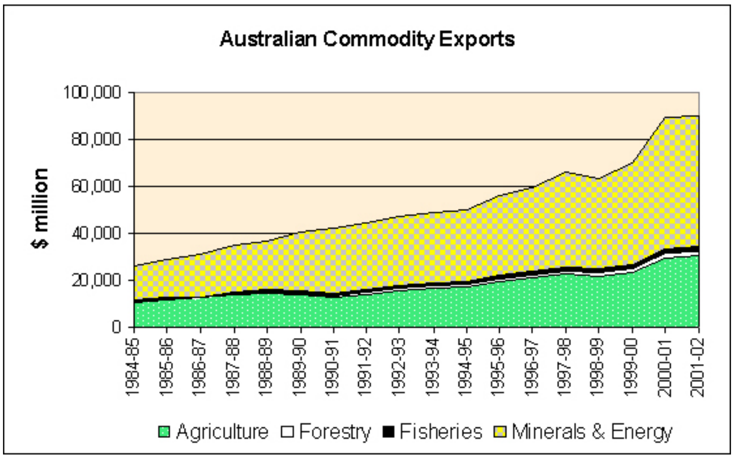


Figure 1: Australian commodity exports 1984-85 to 2001-02. (Source: ABARE)

[1] Geoscience Australia grew out of the Bureau of Mineral Resources (BMR) and the Division of National Mapping, both of which were founded soon after World War 2. BMR became the Australian Geological Survey Organisation in 1992, several years after Division of National Mapping had become the Australian Surveying and Land Information Group (AUSLIG). AGSO and AUSLIG merged to become Geoscience Australia in 2001. Further information is available at www.ga.gov.au.

$55.3 billion to Australia's economy in 2001–02 alone, accounting for 46% of merchandise exports and 36% of total goods and services exports (ABARE). Mineral and energy exports are forecast by ABARE to rise by 4.4% in 2003 (ABARE, 2002).

Australia's endowment of minerals, including solid fuels, is very large in global terms and more than 80 percent of production is exported to world markets. Reserves of bauxite, iron ore coal and uranium will not be depleted in the foreseeable future, but gold and base metal reserves are less secure.

The situation is different for petroleum. Australia has only a fraction of a percent of the world's known oil reserves and a couple of percent of gas reserves. But the high level of oil self sufficiency it has enjoyed over the past 30 years, mainly from offshore production, has meant that Australia has been isolated from concern about security of oil supplies. Australian oil production is set to decline in the medium term unless new commercial reserves are found.

The submission

This submission by Geoscience Australia provides background and factual information in two self-contained parts, one dealing with minerals[2] and the other with petroleum[3].

Each part is introduced by a section dealing with the importance of the sector, followed by material relating to selected Terms of Reference:

- An assessment of Australia's resource endowment and the rates at which it is being drawn down;
- The structure of the industry and role of small companies in resource exploration in Australia;
- Impediments to accessing capital, particularly by small companies;
- Public provision of geoscientific data; and
- Contributions to regional development.

---

[2] Authors in alphabetical order: Mike Huleatt, Lynton Jaques, Ian Lambert and Chris Pigram.

[3] Authors in alphabetical order: Steve Cadman, Clinton Foster, Eugene Petrie, Trevor Powell, Heike Struckmeyer, Denis Wright.

TABLE OF CONTENTS

PART 1: MINERALS

SUMMARY

The minerals industry is very important to the nation's economy. Australia owes its pre-eminent position as a mining and mineral exporting nation to several factors:

1) A world class mineral endowment and good record of discovery of major deposits;
2) An active and innovative private sector that employs the latest exploration tools and geological concepts in exploration;
3) Government policies that have encouraged private sector investment in the resources sector and provided a world-competitive fiscal, administrative and legal regime for the effective discovery and development of resources; and
4) Government programs that have provided the geoscientific knowledge base to reduce the risks associated with area selection and early stage exploration.

That said, Australia's mineral endowment is not unique: globalisation and fiscal and legislative reforms over the past decade have made other nations increasingly competitive in mineral exploration and mining. This international competition for risk capital for exploration comes at a time when Australia is being seen increasingly as having been relatively well explored, with remaining potential largely in areas under cover.

Provision of regional-scale (pre-competitive) geoscientific information has been shown to be a highly cost-effective means of encouraging exploration investment in Australia, with consequent opportunities for regional economic stimulus. Some other countries encourage exploration through direct subsidies, which lead to market distortions. The quality of the geoscientific information base that has provided a competitive advantage for Australia is being challenged by implementation of modern geoscientific programs by other jurisdictions.

If it is to attract sufficient exploration to maintain its gold and base metal resource base, in particular, Australia needs to commit to surveys using new technologies that provide additional insights into materials and processes beneath the surface. The same new generation geoscience information is also important for effective natural resources management.

1. IMPORTANCE OF AUSTRALIA'S MINERAL SECTOR

1.1 Role in the Australian economy

Australia's economy is more dependent on the minerals sector than is the case for other developed nations. It provides almost 240,000 jobs directly and indirectly, many of them in remote and regional Australia. Over the past 18 years, minerals have been the nation's largest export earner, earning around $483 billion (PMSEIC, 2001). Figure 2 shows trends in export earnings for selected mineral commodities from 1983-84 – the main commodity exports, in general order of decreasing value, were coal, gold, iron ore, bauxite/alumina, and nickel. In 2000–01, mineral exports contributed $43 billion to Australia's economy, with minerals accounting for 36 percent of merchandise exports and 28 percent of total goods and services exports (ABARE, 2002).

Australia's mineral wealth has spawned some of Australia's major companies (such as BHP Billiton) and contributed directly to new industries such as ore smelting and refining, steel making and manufacturing (PMSEIC, 2001). It has led to some smaller Australian companies becoming significant exporters of mining equipment, technology and services to more than 50 countries. In 2000-2001, such exports exceeded $1.5 billion, with some 60% of software used in mining operations world-wide exported from Australia (Mining Technology Services Action Agenda, 2002).

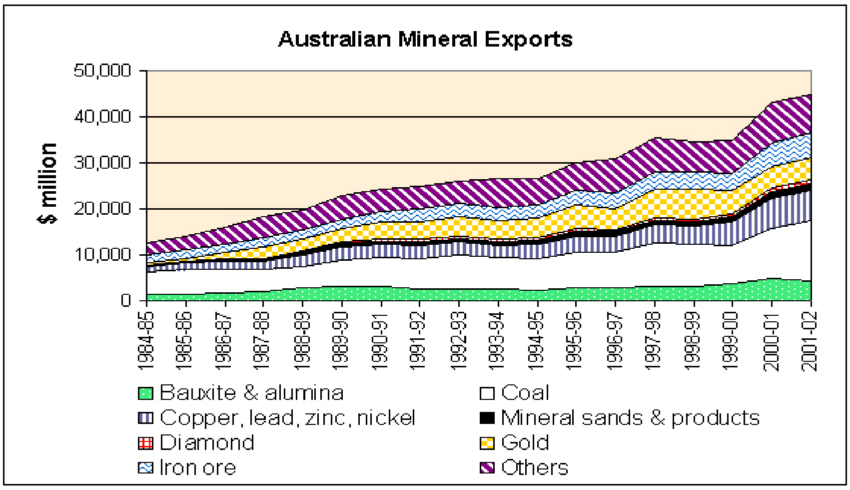


Figure 2: Australian mineral exports 1980-2001 (Source: ABARE)

1.2 Historical background

Australia's mining industry was well established in the second half of the 19th century, following the gold rushes around the continent and discoveries of major deposits such as Broken Hill, Kalgoorlie, Mount Lyell and Mount Morgan. However, the mining industry played a relatively minor role in the Australian economy in the first half of the 20th century. The need for new ore reserves of many minerals was the major concern of the industry in the late 1930s and early 1940s. Indeed, there was a widely held view there were few new resources to be found, and that the industry would gradually run down.

A series of discoveries of major new base metal, iron, and uranium resources from the 1950s to the 1970s completely changed the structure of the industry and elevated Australia to a major mining and mineral exporting country.

An important factor behind this surge of discoveries was the greatly increased knowledge of the geology and resource potential of Australia resulting from systematic geological and geophysical surveys across the continent. This followed the establishment of the Bureau of Mineral Resources in 1946, and the increasing focus of State and Northern Territory Geological Surveys on mineral and petroleum resources.

2. ASSESSMENT OF AUSTRALIA'S MINERAL RESOURCE ENDOWMENT AND RATES AT WHICH IT IS BEING DRAWN DOWN

Australia has to date sustained a sound inventory of many mineral commodities despite high production rates. However, there is no room for complacency – replenishing stocks has become more difficult, and known economic resources of gold and base metals are not sufficient to support current production levels in the longer term.

2.1 "Non-renewable" resources

While mineral resources are not "renewable" in the same sense as agricultural and fisheries resources, they will not be exhausted in the foreseeable future. This is because:

- there is still very considerable potential for more discoveries, particularly beneath cover;
- technical and economic changes can allow formerly sub-economic deposits to be mined;
- husbandry of resources is improving, involving increased recycling and substitution of abundant metals (eg. aluminium) for less common (eg. copper) and/or heavier (iron) metals.

2.2 National mineral resources

Geoscience Australia and its predecessors have systematically reported on the nation's stocks of identified resources of all major and several minor mineral commodities since the mid 1970s[4].

National resource stocks are classified in various categories based on the degree of geological assurance of occurrence and the degree of economic feasibility of exploitation. **Economic demonstrated resources (EDR)**[5] have the highest geological and economic assurance. EDR includes what is considered to be currently commercial – that is, ore reserves reported by companies under the Australasian Code for Reporting Mineral Resources and Ore Reserves (the JORC Code) – plus portions of reported mineral resources that are considered by Geoscience Australia's

[4] Geoscience Australia collates and analyses information from company reports, and seeks clarification or additional information as required, including through site visits. So national resources reporting is based on and consistent with the JORC Code, which is used by companies listed on the Australian Stock Exchange to report reserves and resources in individual deposits. (Codes based on JORC have now been implemented in Canada, South Africa and Europe). In the national inventory, resources are classified in accordance with circumstances at the time of classification. Mineral resources that are not available for development at the time because of legal and/or land-use factors are classified without regard to such factors; however, the resources thus affected are, wherever possible, stated for each classification category.

[5] The classification category 'economic demonstrated resources' is used instead of 'reserves' for the national inventory because the term 'ore (mineral) reserve' has specific meanings for individual mineral deposits under the criteria of the JORC Code. EDR provide a basis for meaningful international comparisons with the economic resources of other nations, in particular those reported by the United States Geological Survey in their annual "Mineral Commodity Summaries" publication.

commodity specialists to be economic[6] in the longer term. Ore is usually mined from resources in the EDR category.

2.3 Australia's mineral endowment

Australia owes its mineral endowment to its diverse geology with over 70 types of mineral deposits of economic significance occurring in rocks ranging in age from very old (Archaean, ~ 3 billion years) to very young (< 5 million years), and over a wide range of geological settings. There are currently approximately 300 operating mines in Australia.

Most of these are concentrated in particular provinces where a range of geological processes acted in concert to permit the concentration of ore. The McArthur - Mount Isa region – commonly referred to as the 'Carpentaria Zinc belt' – is one of the most endowed zinc and lead provinces in the world (containing more than 61 Mt zinc and 31 Mt lead). The Eastern Goldfields of Western Australia are one of the world's great gold and nickel provinces. The Hamersley iron province and Bowen Basin coal measures are other major mineral provinces that support a number of operating mines.

Australia's mineral production is underpinned by a small number of major deposits that have sustained the bulk of production and contain most of the known resources. Commonly referred to as 'world-class deposits', these include the Olympic Dam copper-uranium-gold, Mount Isa copper and lead-zinc, Broken Hill silver-lead-zinc (which is nearing the end of production), the Kalgoorlie gold mines, the Weipa, Gove and Darling Range bauxite deposits, as well as the Hamersley Province iron ore mines, and the Bowen Basin coal mines.

2.4 Long term trends in Australia's resource base

Over the three decades of systematic assessment, EDR for all major mineral commodities have, on average, either increased or been maintained despite substantial levels of production; none have decreased significantly.

Much of the success in maintaining EDR can be attributed to the sustained exploration activity that Australia has enjoyed until recently, and to the highly prospective nature of the continent. The depletion of EDR by mining has also been offset by technical and economic changes that have allowed formerly subeconomic deposits to be reclassified as economic. For example, the increases in gold price from the early 1970s and the development of low-cost carbon-based technologies in the late 1970s made it economically viable to recover gold from many low-grade deposits, vastly increasing gold exploration and, ultimately, economic gold resources.

2.5 Current known resources

Australia continues to rank as one of the world's leading mineral resource nations. It has the world's largest EDR of cadmium, lead, mineral sands, nickel, tantalum, uranium and zinc. In addition, its EDR is in the top six worldwide for bauxite, bismuth, black coal, brown coal, cobalt, copper, gold, iron ore, lithium, manganese ore, rare earth oxides, silver and gem/near gem diamond. In contrast, Australia's EDR of platinum group metals is extremely small and Australia lacks substantial resources of chromium.

---

[6] Economic = can be profitably mined over life of mine, where profitable means income exceeds total costs, and there are no commercial constraints.

Table 1 shows Australian and world resources and production for a range of mineral commodities. This table is from Geoscience Australia's publication, *Australia's Identified Mineral Resources* (http://www.ga.gov.au/pdf/RR0019.pdf), which provides information to the end of 2000. The next version of this annual publication, providing information to the end of 2001, is currently in preparation.

Table 1: Australia's resources of major minerals and fuels, and world figures for 2000 Simplified from Geoscience Australia (2001). Inferred resources excluded.

		AUSTRALIA				WORLD	
		Economic Demonstrated Resources	Subeconomic Demonstrated Resources		Mine production	Economic Demonstrated Resources	Mine production
Commodity	Units		Para-marginal	Sub-marginal			
Bauxite	Gt	4.4	2.6	1.7	0.05	25	0.1
Black coal *	Gt	42.6	1	8.3	0.301	770	3.5
Brown coal*	Gt	37.7	39	16.3	0.066	189	0.9
Copper	Mt Cu	24.1	14.4	1.2	0.83	340	12.9
Diamond							
Gem/near**	Mc	92.6	225	0.1	26.6	-	56.5
industrial	Mc	96.1	233	0.3		580	58.6
Gold	t Au	4959	1021	117	296.4	48959	2445
Iron ore	Gt	13.6	2.1	1.4	0.168	135.6	1.01
Lead	Mt Pb	14.6	3.4	9.6	0.7	64	2.98
Magnesite	Mt $MgCO_3$	267	27	35	0.35	8900	10.9
Manganese ore	Mt	128	23.1	167	1.6	1871	21.7
Mineral sands							
Ilmenite	Mt	196	51	0.1	2.2	671	7.16
Rutile	Mt	22	12	0.1	0.2	49.3	0.43
Zircon	Mt	28	19	0.2	0.4	69.3	0.90
Nickel	Mt Ni	20	3.1	1.6	0.17	58.2	1.23
Phosphate rock	Mt	77	981	-	0.806	12000	139
Rare earths***	Mt	0.9	2.8	10.1	-	100	0.08
Shale oil	GL	4.6	197.5	3719	0.006	16,373	na
Silver	kt Ag	32.1	11.1	11.5	2.1	280	17.9
Tantalum	kt Ta	29.3	30	0.23	0.6(q)	32.3	0.62
Uranium (I)	kt U	654	13	30	7.612	1570	34.8
Zinc	Mt Zn	33	8	17	1.42	190	8

Abbreviations: t = tonne; m^3 = cubic metre; kt = 10^3t; Mc = 10^6 carat; Mt = 10^6t; Gt = 10^9t.

* Recoverable. ** High proportion of near gem quality. ***Rare earth oxides plus Y_2O_3

In 2000:

- Australia's EDR of bauxite, diamond, magnesite, nickel and tantalum increased by over 15% following evaluation of resources information that became available during the year;
- brown coal, copper, mineral sands (ilmenite, rutile, and zircon), nickel, phosphate, uranium and vanadium also increased, but by smaller amounts;
- EDR of zinc, lead and silver were maintained at levels similar to those reported in 1999;
- resources of black coal, gold, iron ore, manganese ore and lithium decreased, due mainly to ongoing high levels of production and, to a lesser extent, commodity prices.

2.6 Production

Australia is a major producer and exporter of over 20 mineral commodities to world markets. Australia is among the top three producers of ten of the most valued mineral commodities, including gold, diamond, zinc, tantalum and nickel (Table 2).

Table 2: Australia's ranking in global production of selected mineral commodities, based on estimates of 2001 production by the United States Geological Survey.

2001	Largest producer	2nd largest producer	3rd largest producer
Bauxite	AUSTRALIA	Guinea	Brazil
Diamond*	AUSTRALIA	Botswana	Congo
Gold	South Africa	USA	AUSTRALIA
Iron Ore	China	Brazil	AUSTRALIA
Lithium	Chile	China	AUSTRALIA
Mineral Sands	AUSTRALIA	South Africa	Canada
Nickel	Russia	AUSTRALIA	Canada
Tantalum	AUSTRALIA	Brazil	Congo
Lead	AUSTRALIA	China	USA
Zinc	China	AUSTRALIA	Peru

* Gem + near gem + industrial, by weight

Production of many mineral commodities reached record levels in 1999–2000, and overall mine production is projected by ABARE to rise by around 8% over the five years to 2005–06. Significant growth in mine output over this period is expected for nickel (55%), copper (7%), zinc (9%), bauxite and alumina (6% and 9%) and iron ore (15%).

2.7 Australia's mineral potential

New deposits continue to be found both in proven mineral provinces and in new provinces containing no mining districts (greenfields provinces). For example, despite nearly 100 years of exploration economic gold and nickel deposits continue to be found around Kalgoorlie. The future of Australia as a major mining nation depends on the discovery of major deposits to sustain large, low cost mining operations.

Significant parts of Australia remain under-explored, especially those remote regions under cover. Two recent significant discoveries highlight the high prospectivity of such areas. Both were underpinned by geoscience information provided by governments, supplemented by company surveys and concepts. One is the nickel–copper sulphide mineralisation discovered by WMC Ltd in 2000 in the Giles Complex of the remote Musgrave Ranges (WA). The other is the copper–gold–uranium mineralisation reported by Minotaur Resources – a junior company working in joint venture with BHP-Billiton – in 2001 from the Prominent Hill prospect in the the northern Gawler Craton (SA), which has features similar to the giant Olympic Dam[7] deposit some 150 km to the southeast. Exploration is continuing at both prospects and no resource figures are yet available.

The high prospectivity of such areas, the record of past success with very attractive discovery rates, the diversity of commodities and mineral deposit types, and recent advances in exploration technology (such as new airborne electromagnetic and airborne gravity gradiometer systems) provide a good basis for continued exploration and discovery of minerals in Australia.

2.8 The future

The EDR to production ratios provide an indication of the time until economically recoverable resources are exhausted. It is an imprecise and dynamic indicator because it can be changed by:

- further discoveries of economic mineralisation;
- upgrading of resources through ongoing evaluation of lower category resources, commodity price increases, cost decreases or technology advances;
- downgrading of resources from EDR through ongoing evaluation of resources, commodity price decreases or cost increases;
- downgrading of resources as a result of commodity price decreases; and
- changes in production rates.

The EDR/production ratio is a national level parameter that is based on an overall assessment rather than the current commercial objectives of the companies holding the resource. Commercial decisions are made on the basis of the JORC code ore reserves rather than national EDR. The reserves/production ratio is always lower than the EDR/production ratio, which is a **maximum average resource** life for a commodity under current conditions.

Table 3 provides rounded EDR/production ratios as assessed at 5-yearly intervals since 1975. Even with the above qualifications, it is clear from these figures that Australia has major resources of the bulk commodities: coal, bauxite, and iron ore. And there are other substantial known resources for the bulk commodities that could become EDR given impetus to bring new mines on stream. However, the markedly lower EDR/production figure for iron ore in 2000 indicates how rapid changes can result from major increases in production, coupled with reassessment of resources.

---

[7] Olympic Dam itself was discovered in 1974 beneath several hundred metres of cover, in a remote area which had no known mineral deposits at the time (see Section 5.3.3)

Table 3: Years of economic demonstrated resources[8] at the production level for the year (rounded to nearest 5 years)

Commodity	1975	1980	1985	1990	1995	2000
Coal	255	270	210	250	205	140
Bauxite	145	100	90	135	60	80
Iron Ore	180	155	175	135	125	80
Nickel	25	30	20	45	35	120
Copper	30	25	60	20	65	30
Zinc	40	45	30	20	40	25
Gold	10	20	15	10	15	15

The situation for gold and some base metals (particularly zinc) is less secure. Australia needs major new discoveries of gold to maintain current rates of production, for which relatively low EDR/production ratios have been maintained through the recorded period. While new EDR have more or less been replenishing production of gold over the last quarter of a century, this situation could obviously change rapidly depending on rates of discovery and production. In the case of zinc there is uncertainty about future supply in that less than a third of national EDR are currently classified by companies as ore reserves.

There is always a significant period between discovery and commencement of mining. An indicative lag period for a major base metal mine is 10 years, but the figure is commonly less for gold deposits.

While commodity prices vary up and down, the long-term trend has been consistently down – metal prices have shown a long-term average decline of 2-4 percent per annum in real terms. The current low prices and cost/price squeeze is a consequence of over supply of most commodities. The last decade has seen a lot of effort put into reducing costs. Unless the overall downward price trend reverses in the short to medium term, defying most predictions, the existing EDR base will contract. Mining will become even more focussed globally on world-class deposits that have the most favourable cost/price ratios. Australia has considerable potential for further discoveries of such major deposits, and its generally benign climatic and topographic conditions and low population densities are important in keeping costs of mining down while meeting environmental and social expectations. Realising this potential requires ongoing exploration, based on a progressively improving geoscience information base.

---

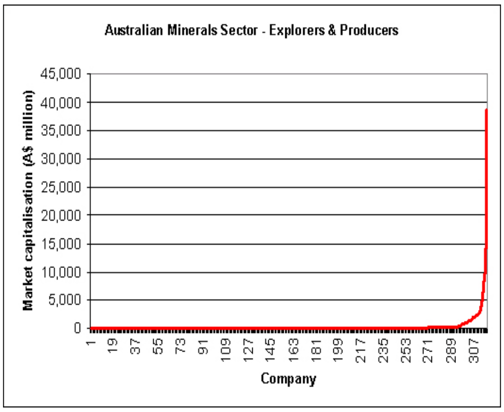
[8] Taking account of commercial objectives, the ore reserves/production ratio is generally less than the EDR/production ratio. For example, in 2000 the ore reserve/production ratio for gold as less than 10, compared with the EDR/production ratio of 15.

3. THE STRUCTURE OF THE INDUSTRY AND ROLE OF SMALL COMPANIES IN RESOURCE EXPLORATION IN AUSTRALIA

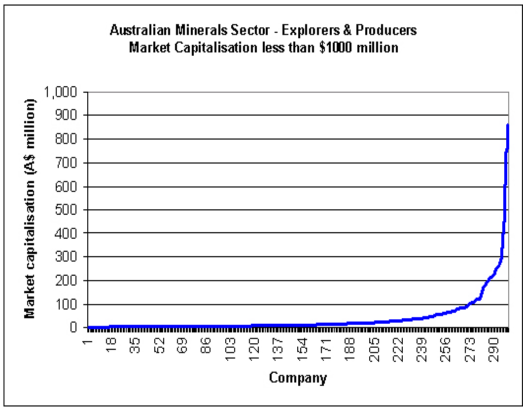
3.1 Industry consolidation

Internationally, the minerals industry has been undergoing major change — rationalisation and restructuring have accelerated in the past five years. It is following the lead of the petroleum industry, with takeovers and mergers leading to its domination by a relatively small number of major companies. The top 5 producers now control between 40-70% of global copper, diamond, gold, iron ore, lead, nickel, and zinc production.

The range in market capitalisation of the Australian minerals industry is shown in Figure 3 (a) and (b). Nearly 80% of companies have a market capitalisation of less than $50 million and about 65% have a market capitalisation of less than $20 million.



(a)



(b)

Figure 3: Market capitalisation (at 26th June 2002) of companies listed on the ASX that undertake mineral exploration and mining. (a) is all companies, and (b) is a subset showing more detail for juniors and medium sized companies. (Source: Minmet Ozmine database)

Historically the gold industry has been the most diversified in the Australian minerals sector. But recent consolidation means that two-thirds of Australian production is now controlled by 5 companies, and nearly half of production comes from 12 mines.

Many successful medium-sized exploration and mining companies have been, or are likely to be, caught up in the takeovers and mergers. This is a particular issue for Australian companies while the dollar is depressed, but is likely to be an ongoing factor as globalisation intensifies.

The junior[9] companies that survive will be those that can take advantage of opportunities for provision of specialist exploration, mining and environmental services. Increasingly, large companies are looking at supporting selected smaller companies to help their investment strategies. This is an acknowledgment of the important roles that juniors can continue to play, through their skills, experience and flexibility.

[9] As it is not feasible to define them on the basis of clear discontinuities in market capitalisation (Figure 3), juniors are here equated with non-producers.

3.2 Exploration – the lifeblood of the mining industry

Exploration is an essential part of the mining cycle, necessary to replace mined out resources. The industry would be unsustainable were it not for the new deposits discovered through successful exploration. Modern successful exploration involves high levels of skill, advanced technology, and innovation as well as the traditional elements of commitment and perseverance (PMSEIC, 2001). It also requires considerable capital and involves major risk taking by the company — very few exploration programs lead to discovery of economic mineralisation. To illustrate this point, Rio Tinto has reported (Rio Tinto, 2001, p.2) that "… an average of only one in 350 prospects drilled will yield a mine…".

Exploration expenditure varies considerably with economic cycles (Figure 4). Australia has maintained its position as the world's leading country for mineral exploration with 17-20% of global expenditure over the past decade (Figure 5). It has an investment climate that is stable and financially competitive and an enviable record in successful discovery of new resources, due in no small part to a strong collaborative research and development effort between industry and government (PMSEIC, 2001). This model, where the private-sector invests in and undertakes exploration using the knowledge framework supported by government, is widely regarded as 'world's best practice'.

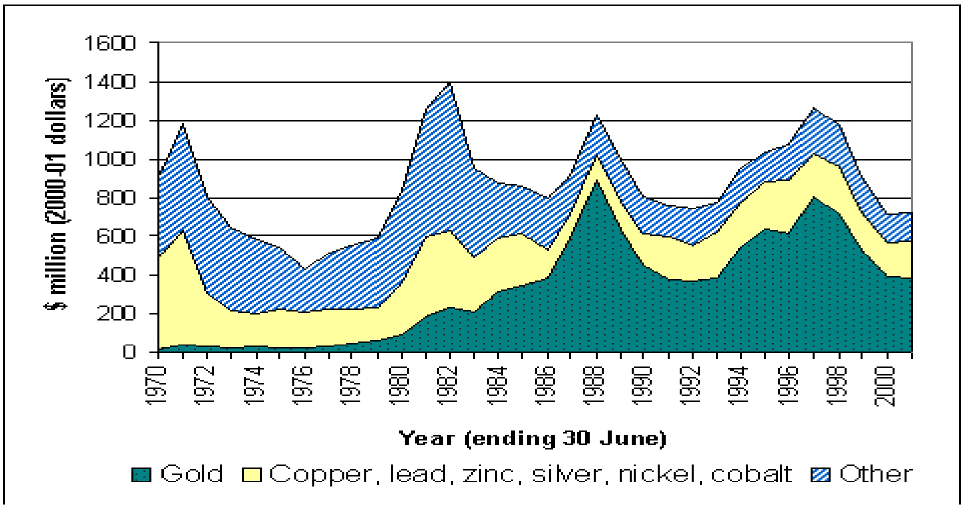


Figure 4: Australian mineral exploration expenditure from 1970 to 2000 (in 2000–2001 dollars). Derived from ABS quarterly survey of mineral and petroleum exploration expenditure.

Surveys of investment risk in the minerals sector consistently rank Australia highly as a country in which to operate[10].

[10] The Canadian based Fraser Institute undertakes an annual survey of companies to determine the relative attractiveness of various regions for investment. The Annual Survey of Mining Companies 2001/2002 ranked Australia as the most attractive country for investment, although it was behind the Canadian provinces of Quebec and Ontario. In the survey, Australia was the top ranked nation in terms of factors influencing its mineral potential but performed less well in policy related factors where it rated after Chile and Brazil. Australia's poorer performance in policy related matters was due largely to respondent's uncertainty about native land claims. On that particular issue, Australia achieved the second worst rating (British Columbia was rated worst).

The Australian industry publication Resource Stocks undertakes an annual survey of investment risk. In the 2002 survey, Australia was considered to be the country with the lowest risk overall. Canada and the USA closely followed Australia. The major areas of concern in relation to Australia for respondents to this survey were land access, green tape and land claims — similar concerns were also expressed for these factors in relation to Canada and the USA.

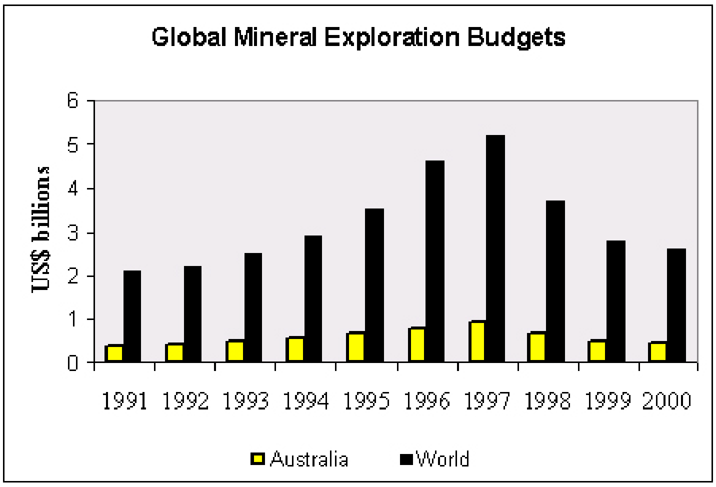


Figure 5: Global exploration budgets for the period 1991-2001 (MEG, 2001).

Mineral exploration expenditure in Australia (Figure 4) has followed the global pattern, falling sharply to a 20 year low in real terms since peaking in 1996/97. The fall reflects the major structural changes that are taking place in the mineral industry and a number of related factors (Lambert, 2001; Jaques & Huleatt, 2002):

- abundant supply and consequent low metal prices have squeezed profitability and resulted in poor returns on capital invested in mining. In recent years returns from mining have commonly been less than the cost of capital resulting in a loss of shareholder wealth (Cusack, 2001)[11];

- significantly increased costs of discovery (Doggett, 2000), a reflection of poor discovery rates through the 1990s, particularly for the giant or world-class deposits on which the industry is built (Haynes, 2000; Parry, 2001). Generally speaking, the more obvious deposits in the more accessible places have been found, and the overall declines in commodity prices make it increasingly difficult to find mineralisation that is economic;

- risk capital for exploration has had unprecedented competition for capital from new sources in recent years (such as the IT and biotechnology sectors).

3.3 Mineral exploration by size of company

Exploration is conducted by individual prospectors, small publicly-listed and unlisted companies engaged exclusively in exploration, mid-size miners and explorers, and the global miners and explorers.

While the Australian minerals sector is dominated numerically by junior companies (Figure 6 (a)), about 80% of exploration spending has traditionally been by major

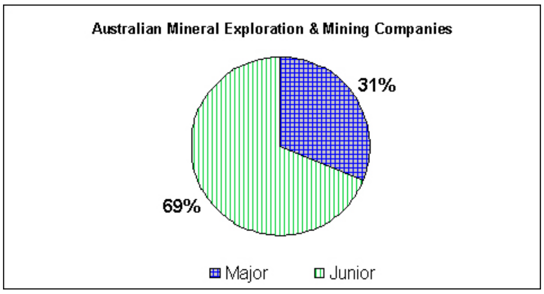
---

[11] The Minerals Council of Australia Minerals Industry Survey Report (MCA, 2001) showed a substantial improvement in 2001 with net profit returns on average shareholder funds of 13.9% compared with a 10 year average of 6.9%, although this was due in significant part to the depressed Australian dollar.

companies (Figure 6 (b)). However, varying proportions of the exploration expenditure of major companies is spent through juniors under joint venture arrangements.

Australian juniors have been particularly successful in discovery of gold deposits, and significant players in discovery of base metals, mineral sands and diamond deposits. For example, juniors discovered major gold deposits at Plutonic, Bronzewing, Granny Smith and Big Bell, the base metal deposits at Woodlawn, Nimbus, Windarra and Cawse, and various mineral sands deposits of the Murray Basin.

Exploration for the bulk commodities — coal, iron ore and bauxite — is to a greater degree the province of larger companies, although smaller companies have played and are playing roles, particularly in iron ore and coal.



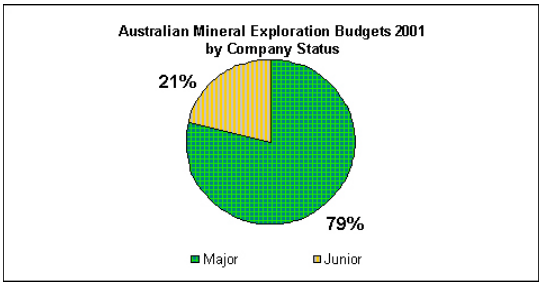


Figure 6: (a) Percentage of Australian mineral exploration and mining companies by category. (b) Estimated proportion of Australian mineral exploration budgets by company status. Juniors = non-producers. (Source: MEG, 2001 and Minmet Ozmine database)

4. ACCESSING CAPITAL

The minerals industry is now more global than ever and countries, companies and projects compete for increasingly scarce and 'foot-loose' venture capital.

4.1 Foreign investment

Foreign investment has played an important role in Australian mineral exploration and development. The Australian capital base has been too small to finance the vast expansion of the mining activities and associated infrastructure and processing developments that have occurred over the past 40 years.

In the case of exploration, foreign-owned exploration companies outnumbered major Australian explorers 3:1 and were responsible for at least 70% of total mineral exploration by majors in the period 1968-69 and 1972-73 (Roberts, 1977). However, in the past 25 years a greatly increased proportion of Australian exploration funds have been raised domestically. In 2001, some 74% of Australian exploration budgets was from Australian-based companies, with the next largest contributors being from companies with head offices in Europe, South Africa and Canada (Figure 7).

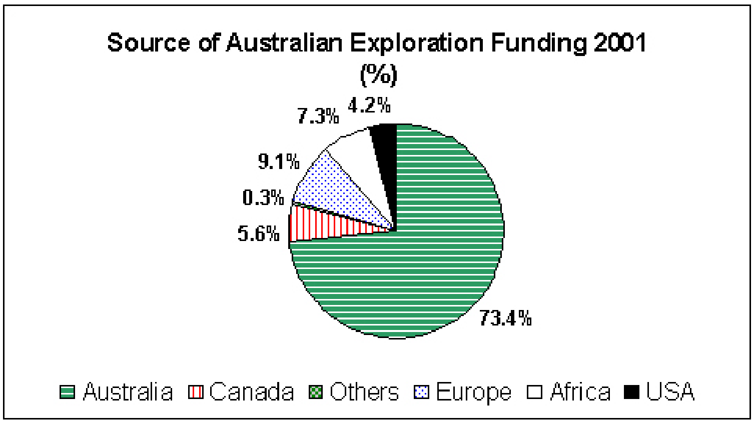


Figure 7: Sources of Australian mineral exploration funding 2001 (MEG, 2001)

As a result of ongoing rationalisation, especially within the Australian gold sector during the past 12 months, the proportion of exploration by major North American and South African companies is expected to increase significantly. The globalisation of the industry means that investment decisions are increasingly being made in overseas head offices and that Australian projects are ranked against competing projects in other countries.

The size of exploration budgets of individual companies has fallen since the peak exploration year of 1996-97 to the point where only 7 companies had budgets of more than $25 million in 2001 (Figure 8). The bulk (nearly 80%) of Australian mineral exploration budgets in 2001 were less than US$2 million (MEG, 2001).

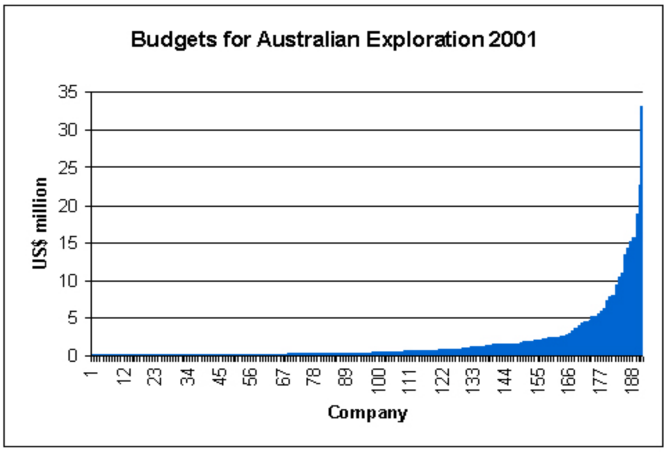


Figure 8: Budgets for Australian mineral exploration by companies 2001 (MEG, 2001).

4.2 Raising capital in Australia

The ability of Australian junior minerals companies to raise capital on stock markets suffered during the "high-tech" boom, both as a consequence of unprecedented competition for risk capital and poor returns. New floats of juniors appear to be starting to pick up, although they are still widely viewed as a high-risk and the growing "ethical" investment sector has shown little interest to date.

Information in KPMG's (KPMG 2002) review of the performance of Australian capital markets in 2001-02 highlights the magnitude of the problem facing junior companies. They report that the average size of an initial public offering (IPO) in 2001-02 was $28 million and the total amount raised was $1.6 billion. Of the total $1.2 billion was raised by 10 companies and the average size of the remaining IPO was just $7 million. KPMG note (page 4) that *"Many of these small IPOs were too small to attract support from institutional investors and found it difficult to generate interest from small investors, who have been flooded with initial public offerings in recent years".* For the resources sector which includes gold, other metals and energy, although there were 27 floats the total amount raised was only $134 million or an average of just under $5 million per float – well under the $7 million considered above to be too small to attract institutional investors. KPMG did however note that the number of successful floats reflected increasing interest in juniors.

Opportunities for juniors to raise capital through the stock exchange are likely to remain largely in gold, other precious metals and diamond exploration, and will increase if there is a sustained upturn in commodity prices.

5. PUBLIC PROVISION OF GEOSCIENTIFIC DATA

It is government policy to 'enhance Australia's international investment attractiveness for mineral and petroleum explorers through public investment in precompetitive [essentially regional-scale] geoscientific surveys and research where the market does not yet provide such information and where community benefits outweigh public costs' (Minerals and Petroleum Resources Policy Statement, 1998, p. 12).

There are a number of reasons why governments, rather than the private sector, should provide pre-competitive regional geoscientific datasets (Lambert, 1999; Powell, 1997). The primary reason why industry does not provide such data is that individual companies can not directly internalise the benefits. Moreover, the costs of such large scale regional geoscientific surveys are beyond the capacity of all but the largest companies.

Other compelling reasons for government involvement include the public good value of such data for a range of public policy decision-making (see later), the need for harmonisation of the data at province and continent scales, equality of access to the data, and the efficiency of data distribution. In essence, the coverage has to be broad enough to satisfy the needs of the whole minerals industry, and the purposes of a range of other users, including land managers[12]. As an island continent Australia must provide the entire geoscientific knowledge base for the continent unlike many other countries that share land borders.

5.1 Importance of precompetitive geoscientific information

Investment in mineral exploration is high-risk. Successful discovery of mineral resources requires knowledge of what to look for and where to look, access to the area of interest, and appropriate technology to make the discovery (Herriman 1989). Explorers, from the smallest to the largest, use precompetitive geoscience information to reduce that risk – for assessment of mineral potential and identifying new opportunities (Williams & Huleatt, 1996). Regardless of their size, explorers use the government provided information to select broad areas to take out exploration licences, and they augment the government coverage with more detailed geoscientific surveys over their tenements to locate specific targets.

If a country wishes to actively develop and maintain its competitiveness for exploration investment, relevant and up-to-date information on prospectivity is essential (eg Lowder 1994). All major mining nations provide regional scale geoscience datasets and policy settings to maintain or stimulate exploration

[12] An important new application of the same geoscience information and technologies traditionally used for minerals exploration is in the assessment of dryland salinity. High resolution airborne geophysical surveys (magnetic, radiometric and electromagnetic data) supplemented by ground studies and innovative image processing and interpretation are providing essential information on materials and processes for effective management of salinity through the identification of salt stores and salt migration pathways within the regolith.

The collaborative, Geoscience Australia-led GILMORE project (Lawrie et al., 2000) demonstrated the systems approach to identifying salt distribution, zones of likely preferential groundwater migration, and potential mineralisation (being tested by companies). This work gave impetus to the push for a national salinity initiative, which led to the National Action Plan for Salinity and Water Quality, announced by the Prime Minister in late 2000.

expenditure. The United States provides an example of what can happen when such government inputs are reduced. Over the last decade or so, major cuts in the provision of geoscience data and services, and increasing community concerns about mining, have seen marked downturns in the US share of world exploration and greater emphasis by US companies on exploration in other countries (Wilburn, 1998). In contrast with Australia, the US economy is large, diverse and not particularly reliant on its minerals sector.

The importance of a knowledge base in successful mineral exploration was also acknowledged by Roy Woodall, former exploration manager for WMC (Woodall, 1984, p.41) who stated that 'the ability to conceive useful conceptual models during the generative stage of exploration is limited only by the density of available, reliable geological, geochemical and geophysical data and our understanding of the physics and chemistry of earth processes … The source of much of the data is … the valuable national geoscience database assembled by the government geological surveys and universities'.

Perceptions of prospectivity held by mineral exploration companies therefore depend on available geological knowledge, technical capability, geological ingenuity and climate of opinion. Mineral potential assessment is very much in the eye of the beholder and forms the basis of competitive advantage in exploration – the company that makes the correct assessment first is most likely to discover the new deposit (Large 1992). All prospectivity assessments, however, depend fundamentally on geoscience data, concepts and knowledge which provide the framework for successful exploration and mineral and petroleum discovery. The absence of this framework reduces perceptions of prospectivity and increases the risk in exploration.

Increasingly sophisticated exploration techniques and concepts are required to discover deposits under surficial cover or in complex geological environments and this means that the information base and geological framework for mineral exploration need to be progressively updated and refined.

Precompetitive geoscience information is provided for the minerals exploration sector by the States and NT both in their own right and in collaboration with Geoscience Australia. The collaboration between Geoscience Australia and the States and NT to provide precompetitive geoscience information is carried out under the National Geoscience Agreement (NGA). The NGA is managed by the Chief Government Geologists Conference which is a working group under the Ministerial Council for Petroleum and Mineral Resources. The agreement ensures that work programs are complementary and avoid duplication so that scarce resources are used wisely to reduce risk and promote exploration in Australia.

Under the NGA the role of the Commonwealth, through Geoscience Australia, is focussed on the provision of specialist services in support of State/NT geological survey activities. The nature and form of Geoscience Australia's specialist services may vary with time as new techniques and skills become available and are required. NGA projects are covered by MOU's with outcomes, outputs, timeframes and contributions defined in project schedules which are updated annually.

In addition to the precompetitive information delivered by the States/NT and Geoscience Australia, Australia has an immense competitive advantage in that the States and NT hold extensive datasets and technical reports on exploration activities provided by companies as a consequence of legislative requirements. These are confidential as long as exploration continues, but they become publicly available after relinquishment of leases. Such open file data and reports represent an immense resource that is readily available to all explorers and is highly regarded by industry.

5.2 Quantifying the importance of pre-competitive geoscience in attracting investment

Provision of new generation geoscientific data has been shown to be a highly effective mechanism for increasing mineral exploration, both in terms of the area under licence and expenditure on exploration. Published and unpublished information from Australia and overseas indicate that each $1 of government expenditure on new pre-competitive data generates, on average, $5 (range $2.5-10) of exploration expenditure by the private sector and over time results in discovery on average of in-ground resources worth $100-150 (Lambert, 1999).

Published figures show that over the period 1987-1996 government (federal and State/NT) investment in geoscience was about $2 billion, industry expenditure on exploration was $10 billion and the total in-ground value of economic resources added to Australia's resource inventory was of the order of $360 billion (Lambert, 1999).

In another example, detailed cost benefit studies from the US have estimated the benefits of provision of new geological map information to be 2 – 11 times the cost of provision of the data for highly conservative estimates, and up to 27 times for realistic scenarios - with a general cost benefit average ratio of 3 times (Bhagwat & Berg, 1991; Bernkopf et al., 1993).

These figures are supported by a recent study (Scott, 1999), which found a cost benefit ratio of 4.7 for provision of new "second generation" geoscientific data. This study showed that new higher resolution data dramatically increased the number of targets (up 2.8 times) and estimated that the new data are likely to generate a three-fold increase in the number of discovered deposits over the pre-existing coarser datasets.

5.3 Case studies

5.3.1. Broken Hill Exploration Initiative

The Broken Hill Exploration Initiative (BHEI, 1994-2000), was a joint initiative of the Commonwealth (Geoscience Australia), New South Wales and South Australian governments to secure the long term economic prosperity of Broken Hill and Port Pirie, both of which faced an uncertain future following industry predictions that the Broken Hill ore body would be exhausted within 12 years. The governments undertook an integrated multi-disciplinary geoscience program key components of which were the provision of nearly 500, 000 line km of new high resolution airborne magnetic and gamma-ray data, new gravity stations and deep seismic reflection surveys. Data were released immediately to industry. Expenditure on the BHEI by the three governments totalled approximately $16 million.

The BHEI had an immediate and major impact on exploration in the Broken Hill and surrounding region. The decline in exploration in the province prior to the BHEI was immediately turned around, exploration activity more than doubled, and Broken Hill became an exploration "hotspot" following the release of the first new high-resolution airborne geophysical data (Figure 9). Companies that had ongoing exploration in the Broken Hill region showed renewed commitment to the province, commonly with new exploration strategies based on new data and ideas generated by the BHEI. Companies that had previously ceased exploration in the Broken Hill area and left, returned. New companies were induced to explore in the region, including a number of small companies that have levered involvement by majors. Several international exploration companies commenced exploration in the BHEI region in joint venture with smaller companies.

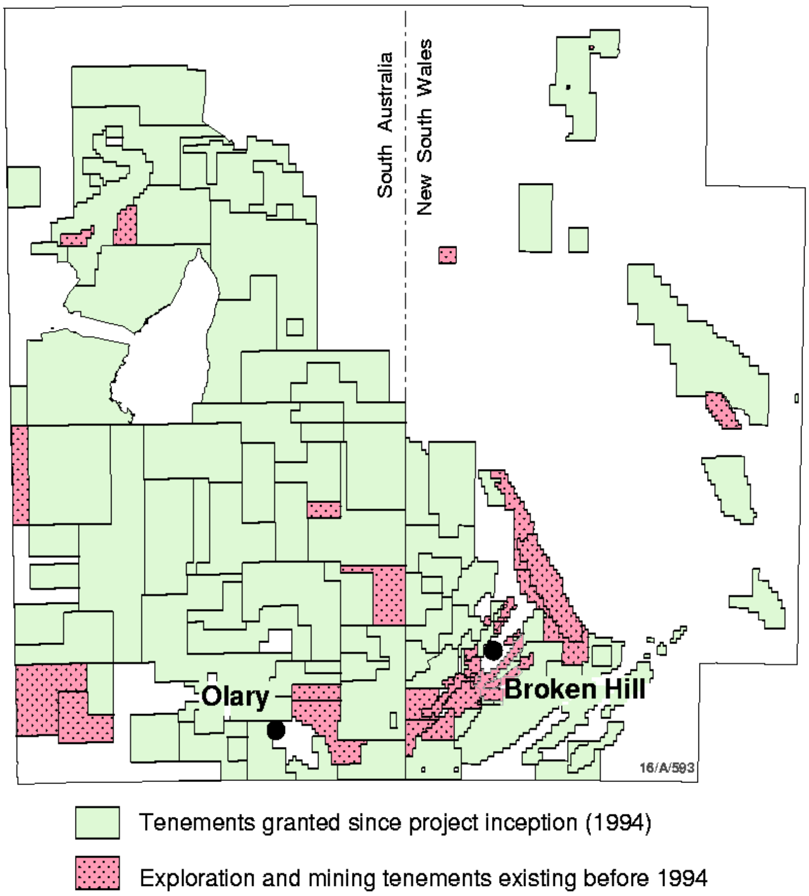


Figure 9: Exploration leases before and after BHEI

The datasets, especially the new high-resolution aeromagnetic data acquired under the BHEI, have proved particularly useful in defining new exploration targets under cover. The new datasets acquired under the BHEI have led directly to the discovery of a number of new Cu-Au and Pb-Zn prospects, including Portia, Mundi Mundi, Kalkaroo, White Dam and Thunderdome. Exploration is continuing.

5.3.2 Lachlan Fold Belt National Geoscience Mapping Accord (NGMA) Project

The Lachlan Fold Belt National Geoscience Mapping Accord (Lachlan NGMA project, 1992-98) in central western New South Wales was a project involving Geoscience Australia and the NSW Department of Mineral Resources. The project involved the geophysical and geological mapping of four 1:250 000 scale map sheets in an area known to have mineral potential but where the existing maps and information were 20-30 years old and inadequate for modern exploration. New high-resolution airborne magnetic and gamma-ray data were released immediately after acquisition and the geological maps were progressively released, together with an accompanying report, on compilation. The release of the geological maps were usually associated with field conferences conducted by the project to outline for industry (and other) clients the new findings and revisions to the existing regional maps. Figure 10 indicates the close relationship between the release of data and the uptake of exploration licences.

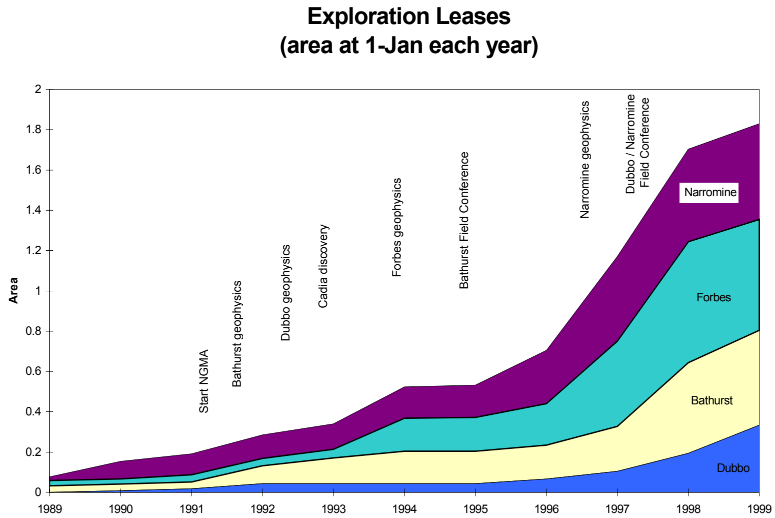


Figure 10: Lachlan Fold Belt National Geoscience Mapping Accord (NGMA) Project 1992-1998
Unit of area = square degrees (1 square degree is roughly 10,000 square kilometres)

5.3.3. Olympic Dam: Salt bush cover conceals mineral riches in greenfields region

In 1975 WMC Ltd drilled an area of salt bush and native pines 200 kilometres north of Adelaide because company geologists noted an anomaly on Geoscience Australia's magnetic and gravity survey maps that fitted an exploration model they were testing. It was risky because the company was drilling where there was no surface evidence for minerals. But WMC’s borehole intersected a giant lode some 300 metres below the surface. At this depth, copper, uranium, gold and silver ore-bodies had formed a mineralised zone more than five kilometres long and three kilometres wide. It is now known as Olympic Dam is and one of Australia's major mines with huge reserves.

Olympic Dam a truly world-class deposit, which

- exports copper and uranium and is a major producer of gold and silver;
- produced its one-millionth tonne of copper on 31 March 2001;
- produced 4500 tonnes of uranium in 2000, making it the second largest single production centre in the world, and the energy supplier for nine countries with its uranium;
- employs 1200 people directly and sustains more than 5000 additional jobs in support industries;
- pays more than $20 million a year in state royalties and much more in payroll and other taxes;
- will provide benefits to Australians for more than 50 years.

5.4 Future discoveries - Potential constrained by the tyranny of depth

Mineral deposits are becoming harder to find. The vast majority of these deposits exploited to date, have a surface or near surface expression. The industry has been exploring a thin rind of the Earth where the geology is exposed on the surface. The thickness of this rind varies, as it is determined by the size and economics of the orebody, mining conditions and location. In practice, the rind is limited mostly to a few hundred metres thick, although in exceptional cases it may extend to a few kilometres below the surface.

This thin rind has been exploited because it is the zone amenable to the available geological understanding and technologies used to both discover and exploit the deposits. This approach has necessarily left vast tracks of Australia either under or unexplored, many of which have geology similar to that of the areas exposed and explored.

Australia's is an old continent which escaped the major glaciations that scraped most of the northern continents clean. Hence Australia is distinguished by extensive deposits of material ranging from sand dunes and flood plain sediments to highly weathered rock – collectively known as regolith. More giant orebodies undoubtedly exist in Australia, but they are likely to be buried and hard to locate. Regolith and bedrock cover therefore represent the single greatest impediment to successful mineral exploration in Australia (PMSEIC, 2001).

As a consequence, developing the capacity to collect, analyse and display information about the geology of the subsurface and its mineral potential is the greatest challenge for the providers of precompetitive information[13].

Historically geologists have extrapolated the surface geology from 2D maps in attempts to develop an understanding of the subsurface. In mine areas where drilling provides a good subsurface control this approach can be quite successful. To attempt the same exercise as part of an area selection process in the absence of information on subsurface materials, is fraught with difficulty – and hence high risk – because of the complexities of the earth.

The 21st Century challenge for the providers of precompetitive information is to provide remotely sensed geological and geophysical data sets that allow the industry to construct well-constrained three-dimensional images and maps of the subsurface to reduce the risk in area selection.

New tools are being developed to allow the collection of appropriate physical properties about the subsurface. Developments in obtaining and processing aeromagnetic data are providing major boosts to exploration through better information on prospective rocks beneath cover. The Cannington and Ernest Henry deposits east of Mount Isa are examples of buried deposits discovered as a result of such advances. Recently, the integration of other technologies − particularly airborne electromagnetics (AEM) (Lawrie et al., 2000) and gravity gradiometry − has been shown to provide additional insights into materials and processes at depth.

---

[13] To use a medical analogy, geologists need the equivalent capability of x-ray, MRI and ultrasound equipment to develop three dimensional images of the earth to reduce risk and allow informed exploration decisions to be made. CSIRO have coined the wonderfully descriptive term the 'the glass Earth' to encapsulate this concept.

5.4.1 New mapping and exploration technologies: Project FALCON case study

FALCON is an airborne mineral exploration tool recently developed by BHP Billiton as a result of a 5 year, US$30 million research program. For the first time, FALCON has enabled high-resolution gravity gradiometer surveys from the air. The radical new airborne exploration system is based on technology designed for use in the US Navy's Trident submarines and developed by Lockheed-Martin. BHP Billiton has three fully operational airborne gravity gradiometer systems in use world-wide including one recently deployed in Australia.

This new tool significantly reduces the time and cost of identifying mineral resource targets and improves the efficiency of exploration programs, providing a significant competitive edge. The benefits of FALCON for mineral exploration are provided by -

- access to new terrains;
- faster target identification;
- better target screening and;
- new regional perspective.

From an environmental perspective, FALCON minimises environmental impacts associated with mineral exploration activities by reducing the need for ground surveys, which may involve constructing access tracks, and drilling or digging trenches to extract rock samples. There are also potential applications in the discovery of oil and gas.

5.5 Summary

The provision of precompetitive data is part of Australia’s competitive edge and gives the country the opportunity to compete globally by providing essential information about Australia's natural endowment that allows companies to make informed decisions in relation to area selection.

New exploration and mapping tools are now available that will enable the "glass Earth" concept to become a reality. However, deployment of these new generation tools requires a commitment to a new generation of geoscientific surveys. There is potential to prioritise such surveys to cater for both exploration and land management needs.

In summary, the challenge for Australia’s’ providers of precompetitive geoscience information is to find the way to use these new tools to collect and provide the data necessary to allow explorers to move confidently into unexplored regions to seek the undiscovered giant orebodies that will contribute to Australia’s wealth throughout this century.

6. CONTRIBUTION TO REGIONAL DEVELOPMENT

The minerals industry has contributed enormously to building national and regional infrastructure, including towns, railways, ports, pipelines and roads (PMSEIC, 2001). Mining operations were the impetus for opening up outback areas that otherwise would have remained isolated and unproductive. With a view to minimising costs and environmental footprints, many modern mines in remote areas are fly-in-fly-out operations. These still bring significant regional infrastructure, employment and services.

The minerals industry accounted for around 20 percent of private new investment in Australia over the past decade, much of this in regional and remote areas. According to ABARE and ABS forecasts, this high level of investment has peaked and is expected to continue falling in coming years. The minerals industry is also the highest value adder to the Australian gross domestic product per person employed. It continues to result in significant benefits flowing to other major Australian industries such as transport, construction, manufacturing and IT.

In regional and rural areas, particularly those of marginal agricultural value and limited tourism potential, exploration and mining offer the main opportunities for economic activity. This requires a commitment to producing new generation geoscience information to stimulate minerals industry interest. Although discovery of mineable deposits is the goal of exploration, major exploration programs in their own right can stimulate regional economies for more limited periods.

Most minerals companies now accept the primary importance of environmental protection and community consultation and involvement. A heightened awareness that companies need to operate more as partners with the communities in which they operate has been to the fore in the Global Mining Initiative, implemented by a group of global miners.

PART 2: PETROLEUM

7 THE PETROLEUM SECTOR, THE ECONOMY AND REGIONAL DEVELOPMENT

Australia has a relatively small onshore oil industry, with significant gas production from the Cooper Basin, and a large offshore industry which provides approximately ninety percent of Australian oil production and seventy per cent of Australian gas production. The petroleum industry is recent in origin with initial major discoveries made in the 1960s and early 1970s in the Gippsland Basin offshore Victoria, in the onshore Cooper Basin of South Australia, on the offshore North West Shelf and in the onshore Bowen and Surat Basins of Queensland. Australia produces approximately \$10.5 billion of oil and gas (petroleum[14]) annually and to date is broadly self sufficient in petroleum.

ABARE figures for 2000/01 show that imports of crude oil and condensate with a value of approximately \$8.7 billion are balanced by crude oil and condensate exports of \$8.1 billion, LNG exports of \$2.7 billion and LPG exports of \$0.8 billion, totalling \$11.6 billion (ABARE, 2001). These values are at an all time high, partly because of the high oil prices that have been sustained in the recent past. The petroleum exploration and production (upstream) industry is thus important to Australia because it protects Australia from substantial balance of payments impacts that would result from importing the oil and gas that is used domestically. Oil and natural gas account for over 68% of Australia's final energy consumption (Dickson, 2001).

Petroleum production by region currently is as follows:

State/Territory	**Oil and Condensate**	**Gas**
Western Australia	44%	50%
Victoria	36%	21%
Northern Territory (including Ashmore Cartier Territory) and Zone of Cooperation	13%	2%
South Australia and Queensland	7%	27%

A main contributor to regional development from the petroleum industry is related to access to petroleum via the high pressure, large diameter (>100 mm) natural gas and crude oil pipelines that have been constructed since the mid 1960s (Figure 11).

[14] Petroleum products comprise the following:
Crude oil – hydrocarbons that exist in liquid phase in the underground reservoir and is produced as a liquid at the well head
Condensate – pentane (C_5H_{12}) and heavier hydrocarbons that exist in the gas-phase in the underground reservoir and are produced as condensate from a separation system at the well head as the gas phase is produced.
LNG – liquefied natural gas, gaseous at normal temperature and pressures, but held in a liquid state at very low temperatures to facilitate storage and transport.
LPG - Liquefied petroleum gas, a liquid mixture of all the propane and butane that are recoverable from a well through a separating facility.
Sales Gas – gas supplied to the pipeline network after removal liquids and non-hydrocarbon contaminants.

Detailed information on the pipelines is to be found in Oil and Gas Resources of Australia (Petrie, 2001).

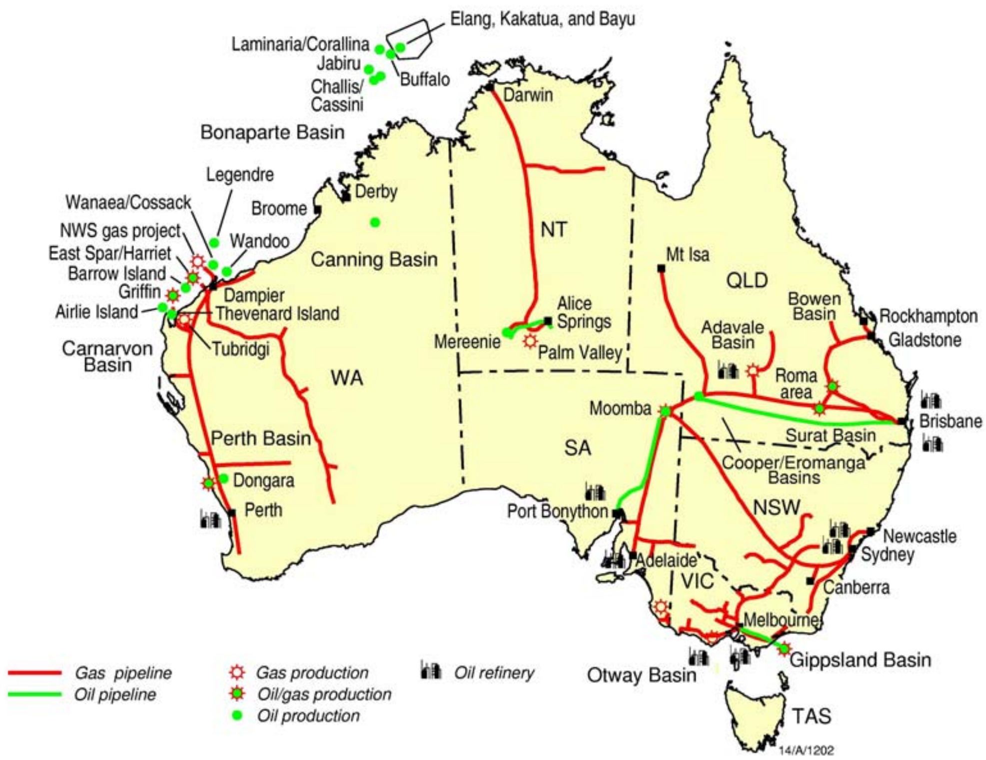


Figure 11: Australian oil and gas pipelines and facilities

The pipelines transport crude oil from onshore and offshore fields to stabilisation plants, refineries and export terminals; transport natural gas from onshore and offshore fields to processing plants, distribution centres or consumers; and carry refined products from refineries or tanker terminals to local distribution centres or consumers. Significant discoveries of oil and gas made in Queensland, offshore Victoria, onshore South Australia, and offshore Western Australia and Northern Territory have led to the supply of oil and natural gas to refineries and consumers in the capital cities, industrial centres and some country areas. The pipelines have the secondary benefit of facilitating the development of onshore oil and gas fields discovered near pipelines.

8 AUSTRALIA'S GLOBAL POSITION IN TERMS OF PETROLEUM RESOURCES

8.1 Introduction

The vast majority of the world's oil supplies lie in areas of relative political instability and as a result, there remains an on-going concern by many nations about the long-term security of supplies. By world standards, Australia is a modest consumer of oil and has been largely isolated from the concerns because over the last 30 years Australia has enjoyed a high level of oil self-sufficiency, with both production and consumption being between 400 and 700 thousand barrels per day. This has been due to the large oil fields discovered in the Gippsland Basin (Bass Strait) in the 1960's, followed by the discovery of numerous smaller fields in the Carnarvon Basin (North West Shelf) and in the Bonaparte Basin (Timor Sea), in the 1980's and 1990's. At the same time Australia has discovered large gas resources with considerable amounts of associated liquid hydrocarbons. To date, the smaller fields and the production of the associated liquids from the gas fields that have been developed have compensated for the decline in production in Bass Strait. A vital question for Australia is: will this trend continue?

Australia's oil production comes from two types of fields

- Crude oil fields where the hydrocarbons exist in liquid phase in the underground reservoir and are produced as a liquid at the well head;
- Gas-condensate fields where pentane and heavier hydrocarbons that exist in the gas-phase in the underground reservoir are recovered as condensate liquid from a separation system at the well head as the gas is produced.

The difference is important because the economics, logistics and investment criteria for the two types of fields are quite different. In particular, condensate production is limited by either the need to have markets and infrastructure for production and delivery of the associated gas, or the ability to re-inject gas into the reservoir for future use.

8.2 Australian commercial and non-commercial petroleum reserves

Australia's reserves can be divided into commercial and non-commercial[15] reserves, as is traditional in the petroleum industry. Most of the reserves occur in offshore basins, with the Carnarvon, Bonaparte and Browse Basins off northwestern Australia and the Gippsland Basin in Bass Strait being the most significant (Table 4).

Current commercial reserves of oil comprise 1212 million barrels of crude oil and 757 million barrels of condensate to give total reserves of 1969 million barrels. Currently, there are additional non-commercial reserves of 452 million barrels of crude oil and 1407 million barrels of condensate to give total reserves of commercial and non-commercial reserves of oil and condensate of 3828 million barrels - the highest ever. However, condensate in gas fields now represents 56% of Australia's liquid reserves. Commercial reserves of sales gas comprise 30.42 trillion cubic feet and non-

[15] Commercial reserves comprise current reserves of those fields which have been declared commercial. It includes both proved and probable reserves. Non –commercial reserves comprise estimates of recoverable reserves which have not yet been declared commercially viable; they may be either geologically proved or are awaiting further appraisal.

commercial reserves comprise 84.21 trillion cubic feet to give total reserves of sales gas of 114.62 trillion cubic feet - a very substantial resource compared to annual production of about 1.3 trillion cubic feet.

Production of the reserves of non-commercial condensate depends on the development of markets for the host gas. Much of these condensate reserves will remain commercially stranded until such time as further large-scale gas production can be achieved. Despite the large total liquid reserves, production in the medium term will be constrained because of the increasingly limited crude oil reserves.

Table 4: Petroleum reserves as at 1 January 2000

Category 1: comprises current reserves of those fields which have been declared commercial. It includes both proved and probable reserves.
Category 2: comprises estimates of recoverable reserves which have not yet been declared commercially viable; they may be either geologically proved or are awaiting further appraisal.

Category 1 (Commercial)	**Oil**	**Condensate**	**LPG**	**Sales gas**
Basin – Location	**million barrels**			**trillion cubic feet**
Adavale – Onshore Queensland	0.00	0.00	0.00	0.01
Amadeus – Onshore Northern Territory	7.20	3.68	2.88	0.40
Bonaparte – Offshore Western Australia and Northern Territory	260.06	0.00	0.00	0.00
Bowen – Onshore Queensland	0.32	0.73	0.96	0.09
Canning – Onshore Western Australia	0.13	0.00	0.00	0.00
Carnarvon – Onshore and Offshore Western Australia	486.67	592.12	577.49	21.92
Cooper – Onshore South Australia and Queensland	7.48	46.05	58.70	3.07
Eromanga – Onshore South Australia and Queensland	39.72	1.10	0.40	0.05
Gippsland – Offshore Victoria	408.21	113.22	206.93	4.70
Otway – Onshore and Offshore Victoria and South Australia	0.00	0.65	0.00	0.04
Perth – Onshore Western Australia	1.20	0.06	0.00	0.10
Surat - Onshore Queensland	1.47	0.13	0.20	0.02
TOTAL	1212.46	757.75	847.55	30.42

Category 2 **(Non-commercial)**	**Oil**	**Condensate**	**LPG**	**Sales gas**
Basin – Location	**million barrels**			**trillion cubic feet**
Amadeus – Onshore Northern Territory	0.00	0.00	0.00	0.02
Bass – Offshore Tasmania	15.41	34.66	51.20	0.34
Bonaparte – Offshore Western Australia and Northern Territory	73.37	579.31	407.82	21.71
Bowen – Onshore Queensland	0.01	0.06	0.12	0.09
Browse – Offshore Western Australia	3.00	222.97	407.27	18.67
Carnarvon – Onshore and Offshore Western Australia	215.20	524.40	469.68	38.70
Cooper – Onshore South Australia and Queensland	0.20	18.56	12.66	1.28
Eromanga – Onshore South Australia and Queensland	0.42	0.40	0.50	0.04
Gippsland – Offshore Victoria	144.35	24.62	3.77	2.92
Otway – Onshore and Offshore Victoria and South Australia	0.00	2.04	0.00	0.44
Perth – Onshore Western Australia	0.00	0.00	0.00	0.00
Surat – Onshore Queensland	0.00	0.02	0.04	0.00
TOTAL	451.96	1407.04	1353.07	84.21
GRAND TOTAL	1664.42	2164.79	2200.63	114.62

Table 5 summarises Australia's crude oil reserves over the last decade as published by Geoscience Australia and its predecessors in the Oil and Gas Resources of Australia series. Crude oil reserves peaked in 1994 and declined by 19% by the year 2000. They now stand at levels not encountered since the 1980's. It is clear that the rate of discovery of new oil reserves has not kept up with production. In the period 1990-1994, 869 million barrels of crude oil was produced and 751 million barrels found whilst in the period 1995-1999 769 million barrels of crude oil was produced and 317 million barrels found.

However, Table 5 shows that commercial reserves of crude oil have stayed constant or grown slightly over the last decade whilst Total Reserves have declined. The decline is clearly due to a decrease in non-commercial reserves (Category 2) which have been declared commercial. However, Category 2 reserves have not been replenished through exploration. This indicates that the new reserves, which can be brought into production in the near term, are limited. Further, a proportion of these Category 2 reserves can be considered to be non-economic at present (Category 2A, Table 5) and are unlikely to be produced in a reasonable time frame, further exacerbating the situation.

Gas resources have grown continuously over the period since 1965, and continue to grow rapidly. In recent years many super-giant gas fields (each greater than 3.5 trillion cubic feet) have been discovered. However, because of the remote offshore location of many of the largest discoveries, the growth in commercial reserves has been much less than the growth in non-commercial reserves.

Table 5: Crude oil reserves in Australia through time (millions of barrels)

Year*	1993	1994	1995	1996	1997	1999	2000
TOTAL RESERVES	1785	1764	2045	1897	1702	1724	1660
Category 1 – Commercial	918	998	1125	1198	1161	1017	1212
Category 2 – Not yet commercial	867	768	830	699	541	707	452
Category 2A – Sub-economic	244	199	180	152	190	196	226

*As at January 1

See Table 4 for definitions of Categories.
Category 2A comprises the 'Sub-economic demonstrated'[16] resources under the McKelvey classification of resources and can be considered a sub-set of Category 2 'Not yet commercial' reserves.
Source: (Petrie, 2001), (Australian Geological Survey Organisation, 1998), (Bureau of Resource Sciences, 1997).

8.3 **Coalbed methane resources**

In 1993 an estimate of Australian coalbed methane resources was published (Miyazaki, 1993). Two eastern Australian basins— the Bowen (Southern Queensland) and Sydney (New South Wales) Basins— currently represent the significant potential provinces of coalbed methane in Australia. The inferred coalbed methane resources are 1760 billion cubic metres (62 Tcf). The low permeability of the coal seams hinders current attempts to use this vast energy resource. Coal rank, gas content, depth, gas composition and ash content affect the estimate. The economic and uneconomic demonstrated resources of coalbed methane are yet to be estimated on a project-by-project basis. The inferred coalbed methane resources should not be compared with the remaining commercial and non-commercial gas resources (3246 billion cubic metres or 115 Tcf), because the degree of certainty is substantially different.

Commercial production of coalbed methane gas has now commenced in Queensland (near Moura, Wandoan and Roma) and there is a pilot project at Camden in New South Wales. Reassessment of coalbed methane resources may be possible when the production performance of commercial ventures has been assessed.

8.4 **Australia's global position**

Australia's oil and gas reserves and production are compared to the Asia Pacific Region and the World in Tables 6 and 7. Whereas Australia accounts for 0.4% of world oil reserves it accounts for 0.8% of world oil production indicating a problem of long term sustainability in oil production. It is also noteworthy that the ratio of oil to gas resources is lower in Australia than in the world as a whole. Note that while Australia is insignificant in terms of global reserves, it is significant in comparison to the nearby Asia-Pacific area.

[16] Under the McKelvey system of classification of resources, Economic Demonstrated Resources are resources judged to be economically extractable and for which the quantity and quality are computed partly from specific measurements, and partly from extrapolation for a reasonable distance on geological evidence. Subeconomic Demonstrated Resources are similar to Economic Demonstrated Resources in terms of certainty of occurrence and, although considered to be potentially economic in the foreseeable future, these resources are judged to be subeconomic at present.

Australia currently provides about 1.6% of world gas production from reserves representing 2.2% of the world's total.

Table 6: Oil and Gas Reserves (Oil equivalent billion barrels) in Australia (Petrie, 2001) and the World (International Petroleum Encyclopedia (2001).

	Reserves			Percent of World		
REGION	Oil	Gas	Oil+Gas	Oil	Gas	Oil+Gas
AUSTRALIA	**3.83**	**19.10**	**22.93**	**0.4%**	**2.2%**	**1.2%**
Asia Pacific	43.96	60.86	104.81	4.3%	6.9%	5.5%
TOTAL WORLD	1028.46	879.75	1908.21	100.0%	100.0%	100.0%

Oil equivalent barrels: In energy terms, 6000 cubic feet of gas is equivalent to one barrel of oil.

Table 7: Oil and Gas Production in 1999 (Oil equivalent million barrels) in Australia and the World

	Production			Percent of World		
REGION	Oil	Gas	Oil + Gas	Oil	Gas	Oil+Gas
AUSTRALIA	**185**	**225**	**410**	**0.8%**	**1.6%**	**1.1%**
Asia Pacific	2616	1502	4118	11.1%	0.2%	10.9%
TOTAL WORLD	23619	14099	37718	100.0%	100.0%	100.0%

8.5 **Forecast production**

8.5.1 Crude oil and condensate

Future production rates of crude oil and condensate, as estimated by Geoscience Australia, are shown in Table 8. As few new discoveries of oil are replenishing reserves, it is inevitable that oil production will decline in the medium term as the presently commercial reserves are depleted. The magnitude of the anticipated decline is partly due to the fact that the current ratio of production to Category 1 reserves is very high (1: 4.6 in 2000 compared to 1: 7.3 in the previous 5 years). Given the static nature of the Category 1 reserves this represents production brought forward compared with historical trends. As mentioned above, production of condensate is constrained by the timetable for development of the host gas resources. As a result, the rate at which condensate resources can be brought into production is limited.

Table 8: Forecast for 2002-2015 of crude oil and condensate production from Australia's identified accumulations, and crude oil production from undiscovered accumulations, in the Bonaparte, Carnarvon, Eromanga, Cooper, Gippsland, Browse, Bass, offshore Otway and offshore Perth Basins, as at March 2001

Year	P90	P50	P10	P90	P50	P10
	Thousand barrels per day			Million barrels per year		
2002	487	554	666	178	202	243
2003	385	450	561	141	164	205
2004	312	378	471	114	138	172
2005	296	372	465	108	136	170
2006	277	358	446	101	131	163
2007	258	341	429	94	124	157
2008	243	338	445	89	123	162
2009	218	316	441	80	115	161
2010	209	313	453	76	114	165
2011	182	283	412	66	103	150
2012	181	276	406	66	101	148
2013	170	260	380	62	95	139
2014	165	250	367	60	91	134
2015	159	239	351	58	87	128

P90 means there is a 90% probability that production will exceed the amount shown

On average, production is expected to exceed 341 thousand barrels per day in 5 years time compared with over 720 thousand barrels per day currently and around 550 thousand barrels per day in the late nineties. There is a 10% probability that production will exceed 429 thousand barrels per day in 5 years time. In other words, production is expected to decline by the order of 40-50% in the medium term and then decline steadily even further. This scenario depends on current trends of discovery being maintained into the future.

There are two ways in which this scenario could change. Either substantial new sources of oil must be found and developed relatively quickly, or the rate of development of the identified but as yet non-commercial resources of gas condensate must increase substantially. The latter is unlikely to occur, but condensate production will provide the underpinning for Australia's long term oil supply into the future. Condensate production is expected to represent around 50% of Australian production by 2005.

Clearly, there remains considerable potential to find petroleum accumulations off north western Australia. However, it appears that the chance of finding large crude oil fields, rather than gas-condensate fields, sufficient to arrest the projected decline in oil production, is limited. If Australia is to maximise the opportunity to maintain its indigenous liquid hydrocarbon supply, there is a need to extend the area in which Australian exploration occurs, to maximise the opportunity of discovering a new hydrocarbon province whilst fully exploring the north western basins and their deep water fringes. Australia has some 40 offshore basins that display signs of petroleum potential. About half of these basins are unexplored.

8.5.2 Gas

Forecasts of gas production are dependent on gas markets, and are produced by ABARE. The most recent ABARE forecast, including gas sold as LNG, is given in Table 9. Due to expanding LNG exports, production is forecast to rapidly increase.

Table 9: ABARE forecast of Australian gas production

	Trillion cubic feet	Billion cubic feet per day
1998-99	1.14	3.14
1999-00	1.18	3.23
2000-01	1.21	3.32
2001-02	1.25	3.42
2002-03	1.28	3.51
2003-04	1.30	3.57
2004-05	1.45	3.98
2005-06	1.58	4.33
2006-07	1.64	4.49
2007-08	1.71	4.70
2008-09	1.84	5.05
2009-10	1.98	5.43
2010-11	2.13	5.84
2011-12	2.17	5.95
2012-13	2.21	6.06
2013-14	2.25	6.18
2014-15	2.40	6.58
2015-16	2.55	6.98
2016-17	2.59	7.09
2017-18	2.74	7.50
2018-19	2.78	7.60
2019-20	2.81	7.71

8.6 Rate of drawdown and remaining years of production

The ratio of economic demonstrated resources to production (R/P) indicates how many years of production the resource would support assuming that present production rates could be maintained. For example, the R/P ratio for crude oil has remained fairly steady at about ten years since 1982, but is currently eight years. Natural gas has a current 'life' estimated at 54 years, but past estimates have ranged between about 38 and 65 years.

However this is somewhat unrealistic since production rates decline as fields become depleted. A better indicator of sufficiency of future supplies is the ratio of predicted actual crude oil and condensate production to consumption. On this measure, the capability of domestic oil and condensate production to sustain consumption decreases dramatically from 89% in 2001 to 45% in 2006.

The consumption of crude oil and condensate in 1999 could be sustained by remaining economic demonstrated resources in 1999 for only 11.8 years.

9 THE STRUCTURE OF THE INDUSTRY AND ROLE OF SMALL COMPANIES IN RESOURCE EXPLORATION IN AUSTRALIA

9.1 Changing structure of the industry

Exploration is an essential part of the petroleum production cycle to replace produced resources. In the petroleum industry, exploration is extremely expensive with a single offshore exploration well typically costing around $8-10 million. The industry would be unsustainable were it not for the fields discovered through successful exploration. It is therefore a matter of concern that the rate of new oil discovery has not kept up with production over the last decade. This is true both in Australia and on a world-wide basis. At the same time there has been extensive volatility in oil prices.

As a result and because of the declining overall profitability of the petroleum industry over the eighties and early nineties, there has been a significant rationalisation of the international industry. Major companies have merged to form super majors and medium sized companies have taken over smaller companies and equity capital has been hard to raise. The aim of the larger companies is to concentrate on world class projects, typically “super-giant” fields with over 500 million barrels of oil reserves, that are profitable at even relatively low oil prices. These companies need to be large enough to deploy the large amounts of capital required to explore the frontier deepwater areas of the world, where most of the remaining frontier potential is thought to lie, and to access the oil-rich areas of the Middle East and the former Soviet Union.

In total about 3760 new field wildcat[17] wells have been drilled within Australia with 26 per cent of these located offshore. This exploration effort has discovered 14 productive hydrocarbon basins, which contained an estimated 6.35 billion barrels of crude oil reserves, 2.64 billion barrels of condensate and 133.0 trillion cubic feet of gas (Figure 12). Australia attracts less than 1% of world-wide investment capital which is somewhat less than its share of petroleum reserves (Table 6) whilst significant areas of potentially prospective basins remain to be explored (Figure 12).

[17] A new field wildcat well is a petroleum exploration well drilled on a structural or stratigraphic trap that has not previously been shown to contain petroleum.

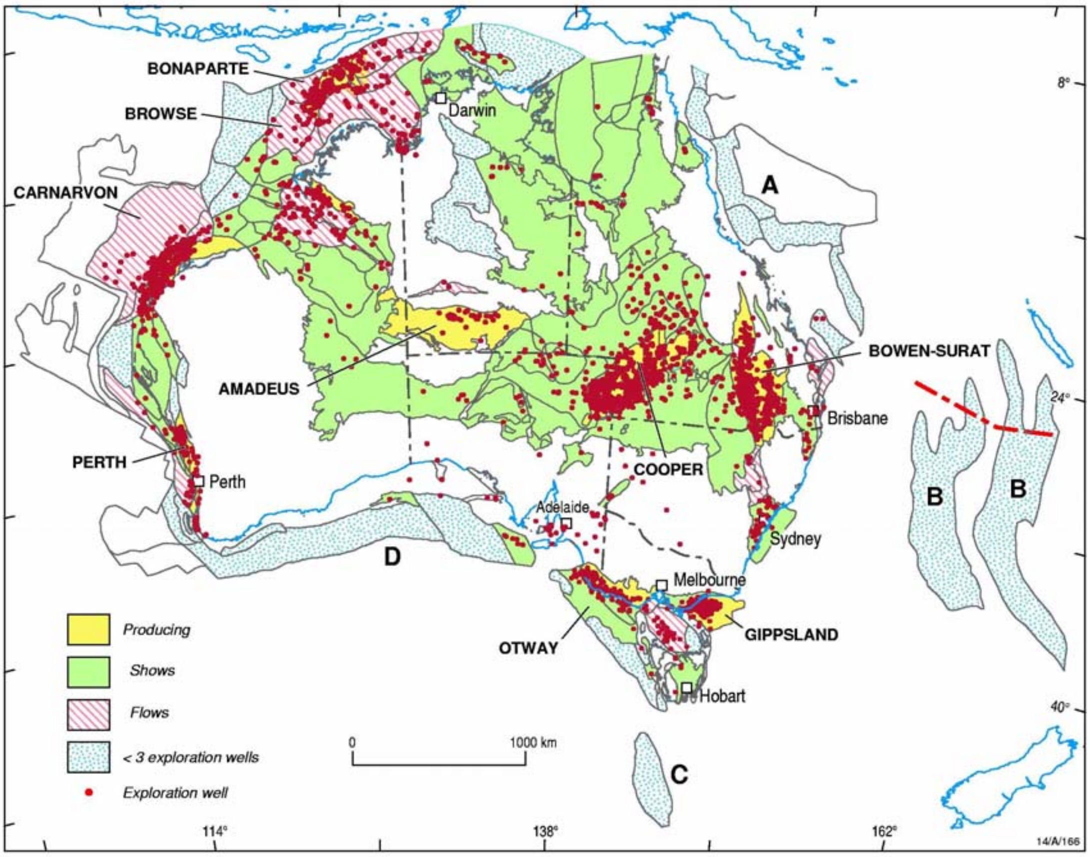


Figure 12: Map of the exploration maturity of Australian Basins showing producing basins, those with hydrocarbon flows and shows and unexplored areas A Northeast Queensland Basins; B Lord Howe Rise and adjacent areas, C South Tasman Rise and D Southern Margin Basins

Junior explorers[18] have traditionally played a significant role in Australian offshore exploration (Figure 13). Over the last decade, while the number of major companies exploring in Commonwealth waters has remained relatively constant, the participation rate of the junior explorers has been sensitive to market conditions and has been more variable (Figure 13). Currently, approximately 60% of companies holding equity in offshore exploration permits are classed as junior explorers.

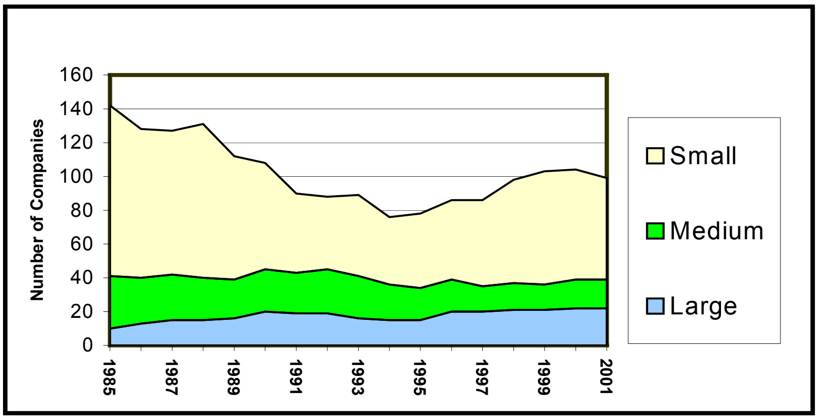


Figure 13: Companies holding equity[19] in Exploration Permits in Commonwealth waters, classified by size, 1985 to 2001

[18] A broad concept, but typically those with market capitalisation of less than $250 million
[19] Includes any interest in any permit (Figures 13,14 and 15)

Around 50% of the companies currently participating in offshore (excluding State and Territory Waters) Australian petroleum exploration are Australian (Figure 14). During the period 1985 to 2001, however, American, British and Canadian explorers have maintained a consistent presence in offshore Australia (Figure 14) and in 2001 these foreign companies comprised around 30% of the total number of companies exploring offshore Australia. Japanese explorers first began acquiring significant equity in offshore Australian acreage in the late 1980's (Figure 14). Since that time, they have steadily increased their equity position and in 2001, represented around 10% of the total number of companies with interests in offshore exploration permits. Figure 15 shows the size of these companies.

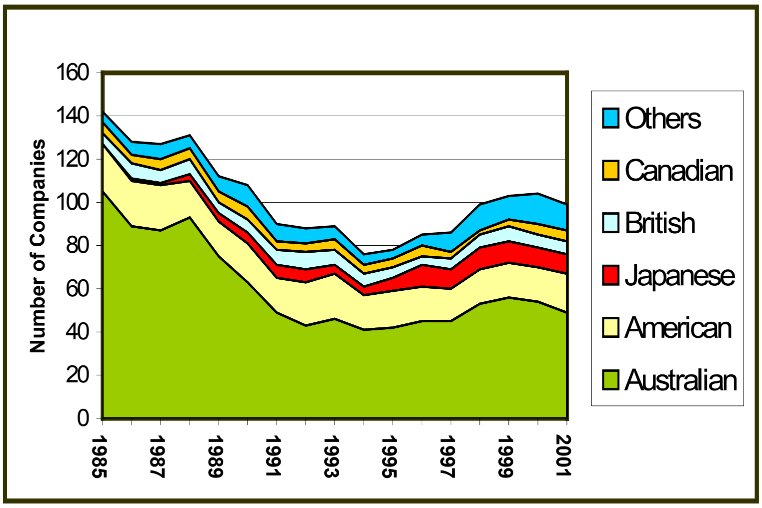


Figure 14: Nationality of companies holding equity in Exploration Permits in Commonwealth Waters, 1985 to 2001.

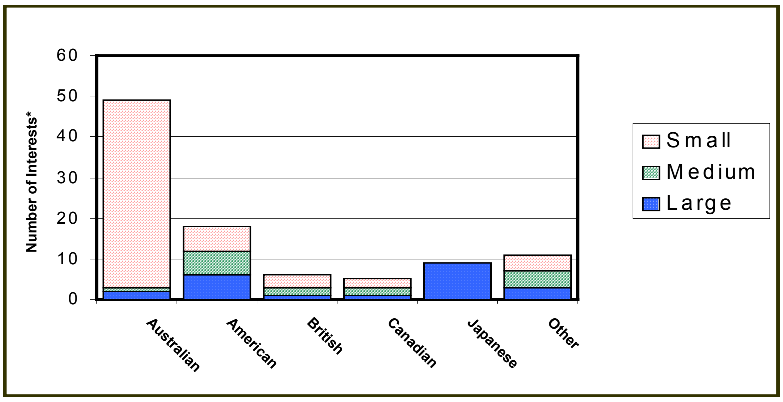


Figure 15: Size of companies holding equity in Exploration Permits in Commonwealth Waters, as at mid-2001

9.2 Trends in exploration investment

Exploration investment in Australia has varied between $800 million and $1070 million annually over the last 3 years. This expenditure is largely a reflection of commitments made in the bidding rounds which may be several years earlier. A more sensitive measure of exploration intentions is the value of the work program bids made each year by the industry in response to the Commonwealth's release of offshore acreage. Figures 16 and 17 show the indicative value of work program bids received on new offshore exploration acreage (excluding acreage in State and Territory Waters and in the former Zone of Cooperation) awarded from Offshore Acreage Release Programs between 1995 and 2000. Indicative expenditure committed to guaranteed (first 3 years) work programs is an indicator of current company perceptions regarding prospectivity and a partial predictor of exploration activity in the immediate future. It should be noted, however, that while the work program elements in the primary work program are 'guaranteed', this analysis does not take into account defaults by companies or changes to equities in permits subsequent to award.

Although Japanese explorers have built a significant equity position in existing offshore exploration permits during the 1990's (Figure 14), between 1998 and 2000 Japanese companies ceased bidding on new acreage offered by the Commonwealth (Figure 17). This reluctance by some Japanese companies to acquire new acreage in Australia in part reflected changed priorities associated with the reorganisation of the 'parent' national oil company (JNOC). With the exception of the American explorers, however, a similar trend to minor involvement in bidding is also observed with other foreign companies (Figure 17).

Although figures 16 and 17 show a steady decline in new indicative expenditure committed to new permits awarded between 1996 and 2000, it should be noted that the A$ 600 million dollars committed in 1996 represents an historical maximum. Since that time, new indicative expenditures have fallen to more average levels. Significantly, however, although new indicative expenditures attributed to junior Australian explorers show a similar decline through this period, the fall is less pronounced than for the major companies (Figure 16). Consequently, while in 1996 only 13% of the new indicative expenditures were attributed to junior Australian explorers, after a nadir in 1999, by 2000 this figure had increased to around 38%.

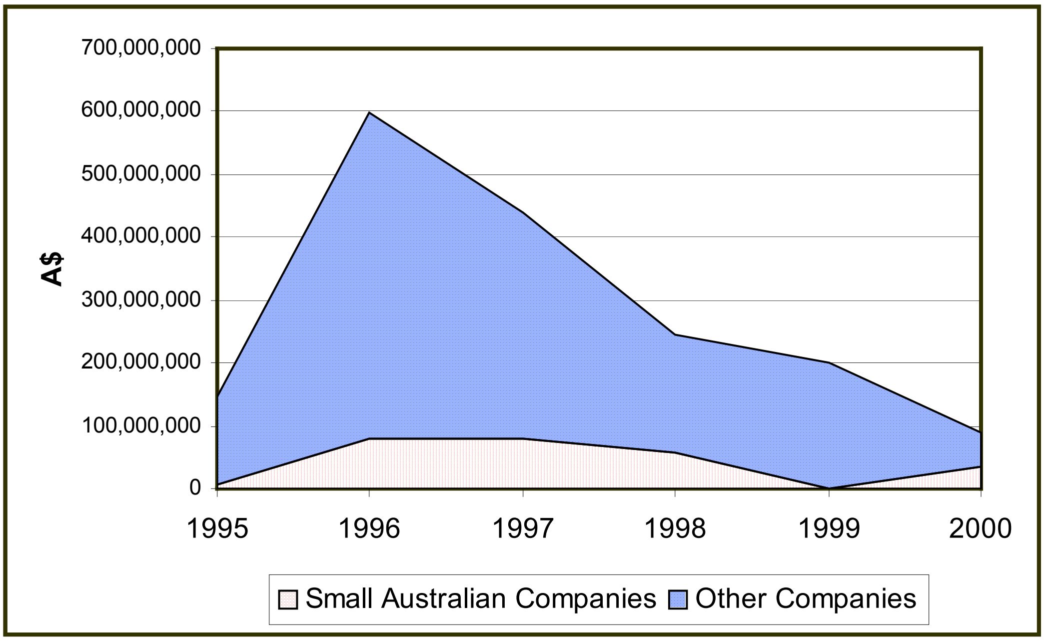


Figure 16: Contribution of small Australian companies to New Indicative Expenditure committed to Guaranteed (Initial 3 Year) Work Programs, Commonwealth Waters, 1995 to 2000

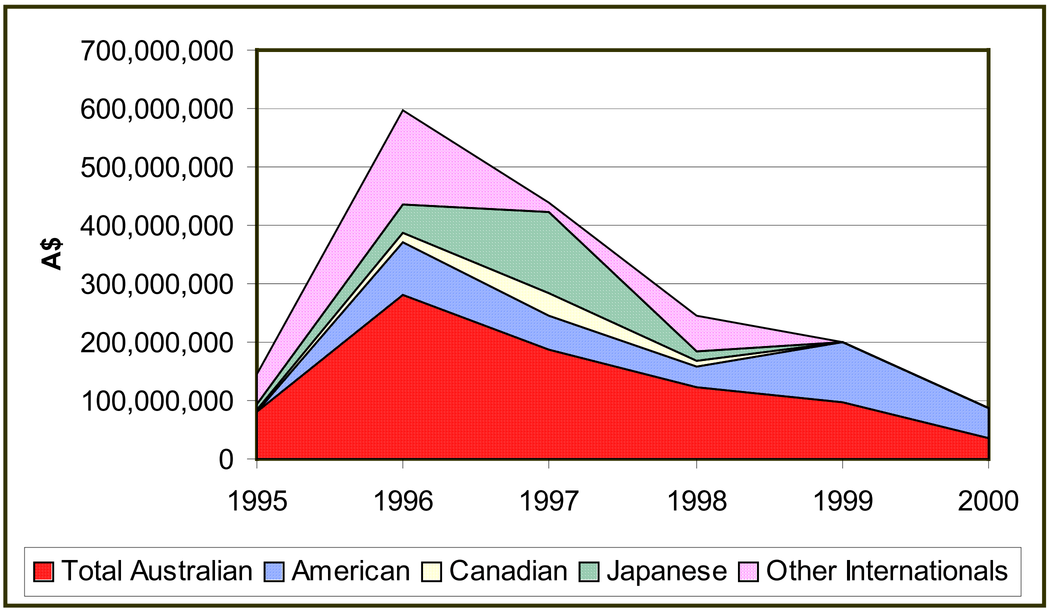


Figure 17: New Indicative Expenditure committed to Guaranteed (Initial 3 Year) Work Programs, Commonwealth waters 1995 to 2000

In recent years, junior explorers have been increasingly represented in exploration permits located in a variety of sedimentary basins (Figures 12 and 13). Acreage awarded to junior explorers has ranged from mature to immature and is generally located in shallow to mid-range water depths. High exploration costs and risks associated with frontier acreage militates against the involvement of junior companies in these areas.

This increased reliance on junior Australian companies to commit funding to offshore Australian exploration is a reflection of the global nature of the oil industry. With an international portfolio of acreage, the major companies have a greater ability to move exploration expenditures overseas in response to changing perceptions of prospectivity, while junior explorers frequently, but not exclusively, focus on exploration within Australia.

9.3 **Exploration success and company size**

Figures 18 and 19 show the number of companies involved in making petroleum discoveries (commercial and non-commercial), both offshore and onshore Australia. Between 1991 and 2001, both offshore and onshore, significant numbers of junior explorers had equities in permits when a petroleum discovery was made. The total share of the reserves discovered attributable to the junior explorers is relatively small (Figures 20 and 21), because the equity of the juniors in each permits is generally small. Of the 6905 million oil equivalent barrels discovered in Australia (both onshore and offshore) between 1991 and 2001, 6% can be attributed to junior explorers who participated in permits at the time of discoveries. Further, although the smaller companies are predominant in the onshore discoveries (Figure 19) the bulk of the reserves found onshore can be attributed to larger companies, reflecting the fact that the most prospective acreage onshore is held by larger companies.

Historically, the larger offshore petroleum discoveries have been made by the major explorers without the involvement of junior companies. The general absence of junior explorers from these deeper water, more frontier regions reflects the high exploration costs associated with these areas.

In spite of this, junior explorers play an important role in assessing or re-assessing acreage not viewed as attractive by the major companies due to the perception that the size of undiscovered fields may be small. Award of exploration acreage to junior explorers may facilitate the promotion and exploration of offshore acreage in that, after the award of a permit and initial appraisal work, many of these companies actively seek and acquire farm-in partners to undertake the more expensive elements of work programs.

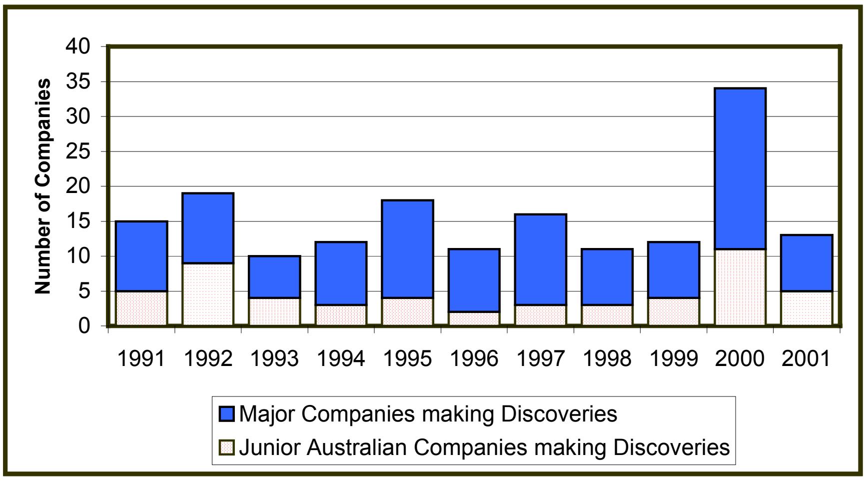


Figure 18: Companies making discoveries, offshore Australia, 1991 to 2001

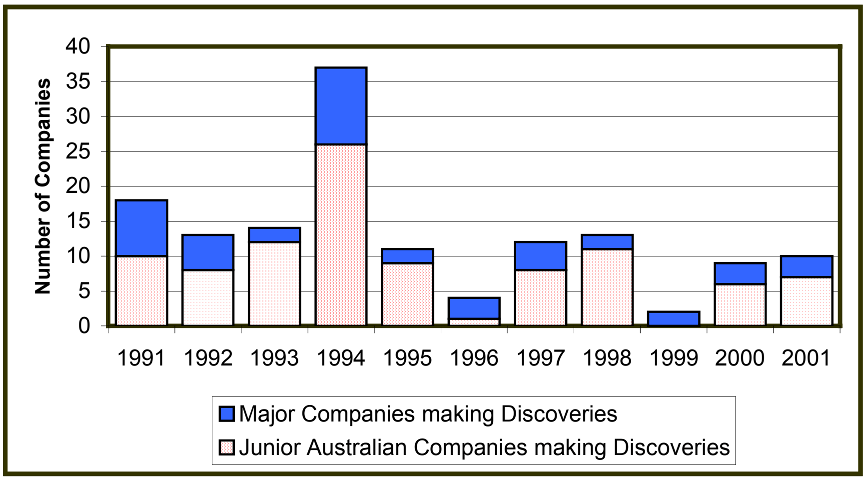


Figure 19: Companies making discoveries, onshore Australia, 1991 to 2001

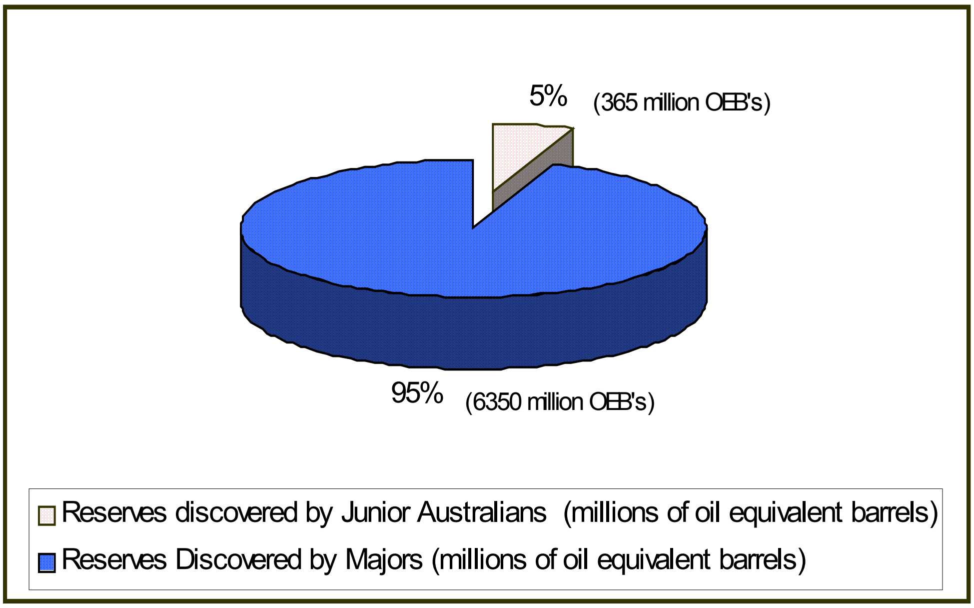


Figure 20: Reserves discovered, offshore Australia, 1991 to 2001

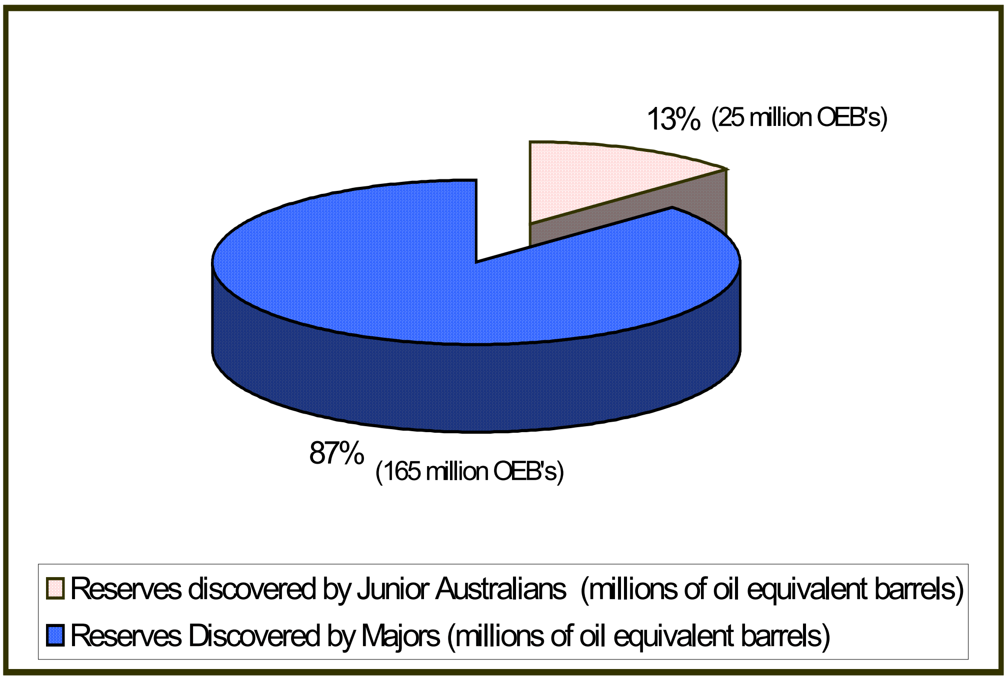


Figure 21: Reserves Discovered onshore Australia, 1991 to 2001

10 PUBLIC PROVISION OF GEOSCIENTIFIC DATA

10.1 Geoscience information and risk reduction

As noted earlier (Section 4.1 above) it is government policy to 'enhance Australia's international investment attractiveness for mineral and petroleum explorers through public investment in pre-competitive geoscientific surveys and analysis where the market does not yet provide such information and where community benefits outweigh public costs'.

International petroleum investment decisions are made on the basis of geological prospectivity, sovereign risk and the appropriateness of the fiscal terms. Geological prospectivity is "the number one priority consideration – what is the perceived risk of not making a commercial discovery, and what is the perceived likelihood that a comparatively significant commercial discovery may be made" (Alexander, 2002).

Investment in petroleum exploration is high risk, and in geologic areas where there has been no previous discovery, exploration success is usually less than 20%, rising to 30-50 percent and occasionally higher in established areas. Commercial success will be much less common, as many discoveries both onshore and offshore do not prove to be commercially viable. Successful discovery of petroleum resources requires knowledge of what to look for and where to look, access to the area of interest and appropriate technology to make the discovery. Particularly in under-explored areas the industry uses publicly available pre-competitive information to select potentially prospective licenses such as from the annual round of release of exploration acreage by the Commonwealth. The absence of this framework of geological information reduces perceptions of prospectivity and increases the risk in exploration.

If a country wishes to actively develop and maintain its competitiveness for exploration investment, relevant and up to date information on prospectivity is essential (Australian Offshore Petroleum Strategy, 1999).

10.2 International competitiveness

To maintain Australia's competitive position as a location for investment in petroleum exploration it is necessary to convince potential explorers that although Australia is a relatively small producer in a global sense, there is good potential for large discoveries of both oil and gas. Australia possesses extensive areas of potential petroleum-bearing sedimentary basins, including a continental shelf of 12 million square kilometres, or more than twice the land area of the continent itself. Because of this huge area, many parts of Australia remain under-explored (Figure 12).

To help convince explorers to invest in Australia explorers must have easy access to major geoscientific datasets. These include government-generated geoscientific maps and datasets, company reports of previous exploration, and other information. These typically include petroleum occurrences, resources, geological features and tenement boundaries. An increasing amount of this data is available in digital formats to facilitate assessment by potential explorers.

Geoscience Australia undertakes major studies designed to reduce exploration risk and promote the petroleum prospectivity of Australia's under-explored sedimentary basins through the provision of pre-competitive geoscience information. It has been carrying out this work since the early 1980s and has extensive databases, data sets and reports from many areas, particularly offshore. Government databases are readily available to explorers, normally at a nominal fee to cover handling and administration costs. In measures almost unique worldwide, petroleum legislation in Australia requires companies to submit data and technical reports on their exploration activities as part of their obligations following the granting of exploration titles. Usually the basic data is made publicly available within a few years of submission and interpretative data may be made available after a further few years. By way of example, under Australia's offshore petroleum legislation (Petroleum (Submerged Lands) Act 1967) basic data is available two years after submission and interpretative data may be made available five years after submission (see Section 10.5 for details).

The amount of data available in and from Australia is highly regarded by industry and puts Australia in a strong position relative to its competitors (AMR, 1995). Of all the factors that influence investment decisions, prospectivity is the principal determinant for defining areas of interest. "Although there are other places in the world which may be more prospective than Australia, a key finding of the evaluation is that perceptions of petroleum prospectivity are driven principally by access to data and in this regard Australia has a competitive advantage" (DPIE, 1997).

10.3 **World risk ranking**

Australian acreage is regarded as gas prone, and it is considered high risk for large oil discoveries. It is low risk for gas discoveries, but much of the gas in the offshore Carnarvon, Browse and Bonaparte Basins is seen as a stranded asset. Geological risking and yet to be discovered field sizes are based on current exploration knowledge and known play types. Perceptions change with new knowledge.

Protocols for determining risk factors affecting exploration success and commercialisation are determined either by individual exploration companies or by international consulting groups, such as Wood McKenzie, Robertson Research, IHS Energy Group, and PennWell, for the explorers. Agreed protocols allow comparisons of acreage across the globe. In any assessment key factors include: political stability ranking; fiscal ranking (government take); estimates of undiscovered reserves, probable field size (mean economic field size); historical discovery and commercial success ratios, and commercial drivers (can the product be sold?).

Wood McKenzie, at a presentation to the American Association of Petroleum Geologists Annual meeting (2002), rank Australia's North West Shelf (NWS) within the top 4 areas in the world to find gas. But there is a perception that the NWS gas market is saturated, and exploration companies with discoveries on the NWS are referring to 'stranded assets'. Australia did not rank in the first 50 countries for oil.

BHP-Billiton, at the Australian Petroleum Production & Exploration Association (APPEA) in Adelaide 2002, showed IHS Energy Group rankings for 103 countries in which Australia is ranked 53rd for fiscal regime, and 17th for political risk. The overall ranking of Australia, that includes all risk elements, referred to by BHPBilliton as 'Global Materiality', shows that " Australia… not a place to rush to for oil".

If for strategic and economic reasons (balance of payments, taxation revenue), Australia wishes to sustain its current levels of liquids production, it must remain competitive in the global exploration market place. Because Australia is so under-explored, at about levels of the US in the 1890's, access to data (under the Petroleum

Submerged Land Act for offshore and State agencies onshore) and to pre-competitive regional or specialist studies is essential to maintain focus on Australia. The pre-competitive information must be relevant to explorers, and this is achieved through consultation with existing groups and with potential players, both Australian and overseas. Consultation includes the majors (eg ExxonMobil, ChevronTexaco) through to the single entrepreneur, with outputs relevant to the whole exploration spectrum. Over the past 10 years, 154 companies have either commenced or recommenced exploration in Australia: but over the same period 163 companies have left. The external perceptions of Australia's potential reserves, and of its fiscal regime need to be understood, so that negative outcomes can be examined and corrected.

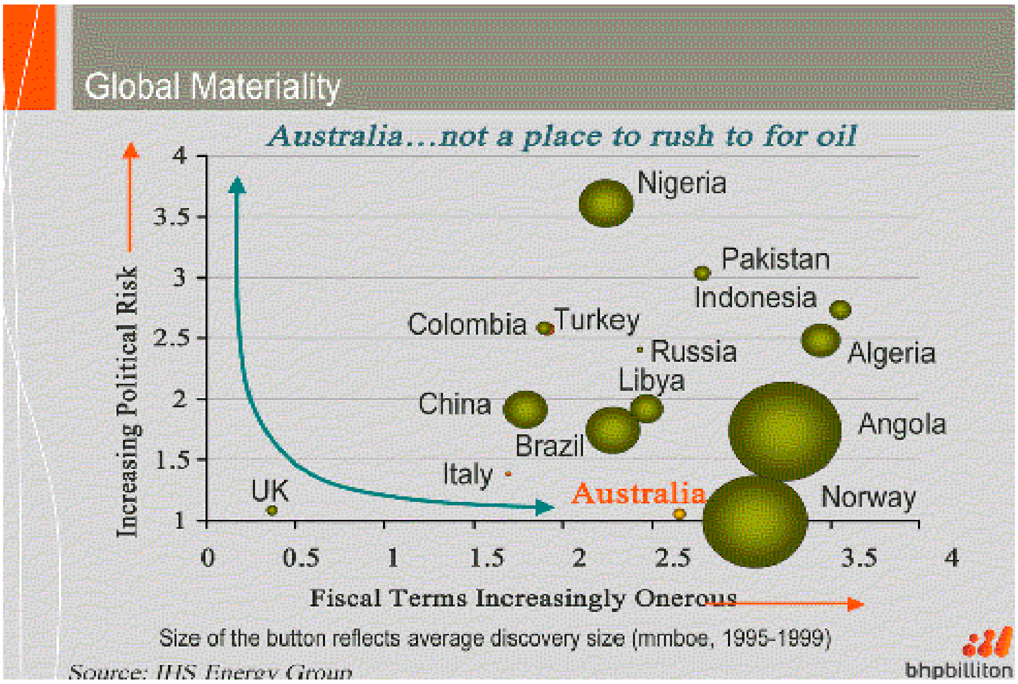


Figure 22: BHP-Billiton assement of Australia's relative attractiveness for oil exploration (http://www.bhpbilliton.com/bbContentRepository/Presentations/APPEAConference2002.pdf)

Without continuing promotion, Australia will be seen largely as a source of gas, and with industry perceptions that the NWS market is currently saturated, expenditure on exploration will not increase significantly.

As indicated in Figure 12, there remain many Australian basins for which exploration has been very limited to date in which there could well be another oil province. The challenge lies in generating enough confidence in the industry to initiate a modern exploration program in these frontier provinces.

Australia is competing in an international market place for exploration budgets and it is essential in these frontier areas that there be basic infrastructure of pre-competitive information to allow companies to evaluate the risk of exploration in these areas. The absence of information on the geology means exploration is inherently high risk. The task for government in setting the scene for exploration investment is to promote the opportunities on offer, emphasising the upside potential based on a realistic assessment on the range of possibilities and to provide as much evidence as possible to mitigate the risk that petroleum exists in an area. Explorers need to know that hydrocarbons have been generated and trapped. In particular, this entails demonstrating an active petroleum system through, for example, seepage studies and indirect indicators of petroleum occurrence.

Current perceptions are based on existing exploration wisdom (paradigms); new play types must be developed from research that is able to be tested, and applied, using conventional industry tools, such as seismic and well logging.

10.4 Case histories

Surveys and studies have been carried out by Geoscience Australia (and its predecessors) and States' Geological Surveys and equivalents over much of the last century and up until now, to provide data and information to reduce the geological risk in petroleum exploration. A key to providing pertinent geoscience information to reduce risk and encourage exploration lies in consultation with industry and the wider geoscientific community to define the major risks to exploration in a given area, and then to design a relevant geoscientific research program that addresses these impediments. This approach is indicated by a number of recent examples (Figure 23) showing how research undertaken by Geoscience Australia has contributed to reducing the risk for exploration.

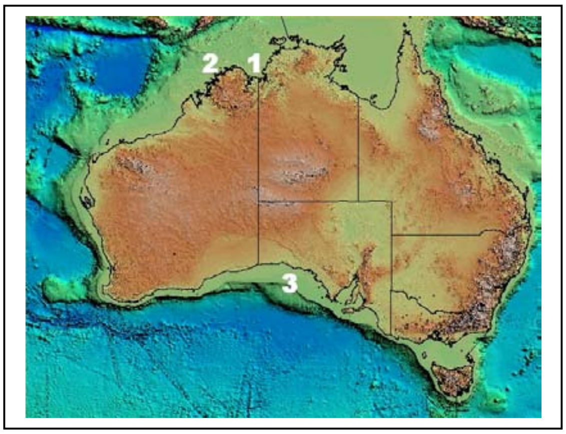


Figure 23: Location of case studies

10.4.1 Bonaparte Gulf: $96 million exploration investment plus future revenue and national benefit from major new discovery

In 1995-96, Geoscience Australia conducted a regional study costing less than $1.5 million of the Petrel Sub-basin offshore northwestern Australia. A new potential petroleum system in the basin was identified; this was actively promoted during the1997 and 1998 releases of offshore permit areas. In 1998-99, Woodside was awarded three permits based on a total exploration program of $83 million. Subsequently, the company made a gas discovery at Blacktip-1 with estimated reserves of 1 trillion cubic feet.

Woodside is currently evaluating rapid commercial development of this field. A further investment of $13 million is forecast in a nearby exploration permit which was subsequently awarded. Woodside acknowledged Geoscience Australia's role in contributing to their initial interest and their subsequent exploration program.

10.4.2 Timor Sea: more than $140 million exploration investment, plus future revenue from newly discovered giant gas/condensate field

In the early 1990's, Geoscience Australia began to systematically market petroleum exploration opportunities to the Japan National Oil Company (JNOC) and associated private companies including INPEX. Off a very low base, Japanese exploration investment in Australia has gradually increased (Figure 14). In the period 1996-2000, Japanese companies represented the largest source of new exploration funds through the up-take of new leases in Australia.

INPEX has been particularly successful and has discovered a gas-condensate resource off northwest Australia representing around 10-15% of Australia's currently defined reserves of petroleum. In 2000 alone, the cost of the exploration effort was $130 million. Current estimates of reserves in the Dinichthys–Gorgonichthys–Titanichthys field are around 10 TCF gas and 300 million barrels of condensate, representing a very substantial petroleum resource and significant levels of future revenue from production.

Geoscience Australia's study of the Browse basin was acknowledged by Inpex as being instrumental in attracting their interest and their bid for Browse Basin acreage. Based on a cost to Geoscience Australia of less than $2 million over the two *years* of the study, this constitutes an exceptionally high return on investment.

10.4.3 Great Australian Bight: expected exploration investment of $90 million in frontier region targeting a new petroleum province

Geoscience Australia study of the frontier region of the Great Australian Bight (1998-2000) was at a cost of $5.5 million over two years. It addressed critical perceptions of risk to the exploration industry. Although the presence of a major sedimentary basin in the region was known prior to the study, the basin had only two wells drilled in 1975 and 1980. Large areas of the basin had not been under exploration permit since the 1970s to early 1980s. Geoscience Australia designed a program to address the key scientific questions to support the release of new acreage in the area. The study provided new data sets and interpretations of the age, thickness and nature of the sediments contained in the basin, models for oil source rock distribution, and evidence for oil having been generated in the basin. In July 2000, three new exploration permits were awarded to a consortium of three companies (Woodside Energy, Anadarko and Encana) with an expected investment of $90 million over 6 years, including the commitment to drill one well. Geoscience Australia's role in attracting new industry investors to the area and country was acknowledged by the consortium.

10.5 Current status of petroleum geoscience data in Australia

Australian State and Commonwealth governments have had a long-standing policy requiring lodgement of all exploration and production data and its public release after a confidentiality period to encourage further exploration.

The Petroleum Search Subsidy Act 1957 (PSSA) was enacted at a time when Australia was considered to be poorly prospective for oil and gas. Exploration distant from existing discoveries was subsidised under the PSSA on condition that data were made available to assist future exploration. During the term of the PSSA from 1957 to 1974, significant discoveries were made in the Gippsland, Perth, Cooper, Bowen, Surat, Adavale and Amadeus Basins, and in the Carnarvon, Browse and Bonaparte Basins on the North West Shelf.

As Australia's petroleum exploration and production industry became established, the subsidy was removed with the introduction of the Petroleum (Submerged Lands) Act 1967 (P(SL)A). The P(SL)A, which governs petroleum exploration and production in Commonwealth waters (Australia's offshore area beyond three nautical miles from the coast), retained the requirement to lodge exploration data and to make that data available for subsequent exploration. The P(SL)A is administered in each State on behalf of the Commonwealth by a Designated Authority (DA) in each State. The arrangement continues to this day.

Petroleum Acts in each State/Territory govern exploration and development in the territorial seas (those closer than three miles from the coast) and onshore Australia. These Acts similarly require that petroleum exploration data from these areas be lodged and made available for subsequent exploration. Storage of this data is the sole responsibility of the relevant State/ Territory mines/resources department.

The Commonwealth and the appropriate State/Territory agencies make these exploration data available to industry to promote and facilitate oil and gas exploration. The data are also used by government agencies, including Geoscience Australia, to support technical advice to government and to promote acreage releases in both offshore and onshore Australia.

10.5.1 Data

All lodgements and access to data from Commonwealth waters formally involve the office of the DA in each State, but direct access to the Geoscience Australia repositories is also possible.

Under the P(SL)A, petroleum exploration and production data obtained in exploration permits, production licence areas and retention leases are made publicly available after specified times. Basic (or "documentary") data are normally available after two years and most interpretative (or "derivative") data are available after five years. Basic data comprise the field and processed data normally available to the explorationist for interpretation (eg, seismic reflection and other geophysical data in both field and processed form; well stratigraphy; well logs; well test data and cores and cuttings). Interpretative data refer to professional assessments in terms of potential for discovery and production of hydrocarbons, and may arise from studies of basic data.

Similar provisions apply in each State/Territory with respect to data from permit and licence areas onshore and in the territorial seas.

Geoscience Australia is custodian of Australia's largest collection of petroleum data, including data lodged with the Government under the PSSA and the P(SL)A. The collection also includes data collected by Geoscience Australia's Continental Margins Program and other research programs. It contains seismic data, well log data, cores and cuttings from exploration wells, well completion reports, seismic survey reports, and reports from analyses of core samples.

Geoscience Australia's collection is made up of over 550,000 digital magnetic tapes, some analogue magnetic data, and associated paper data from over 700 seismic surveys. The digital magnetic tapes contain field seismic survey data and well log, processed seismic and navigation data. The total digital holdings represent 230 Terabytes of data. Geoscience Australia's repository also houses more than 3500 drilling reports, geophysical reports and support data. While most of the reports are printed documents, some recent reports are submitted on CD, with processed seismic data being lodged on tapes. Also available are samples from petroleum wells and stratigraphic holes; down-hole core samples; down-hole drill cuttings; onshore sidewall cores; thin sections and reservoir plugs; and open file destructive analyses reports.

Data on open file can be viewed at the Geoscience Australia Symonston repository in the ACT and at relevant repositories in the State/Territory agencies.

10.5.2 Metadata databases

In addition, the Commonwealth and each state/Territory have a range of highly developed datasets which are publicly available. They typically include petroleum occurrences, resources, geological features and tenement boundaries.

Geoscience Australia's Petroleum Exploration Data Index (PEDIN) contains data for over 10,000 wells and 4,500 geophysical surveys. Basic drilling data are recorded for all wells drilled in Australia. More detailed data, such as formation tops, down-hole temperature and seismic horizon intersections, are recorded for PSSA and P(SL)A wells. Index data is recorded for onshore and offshore geophysical surveys including operator, titles, basins and survey specifications. Surveys conducted under the PSSA and P(SL)A have more details such as summaries from data acquisition, navigation and interpretation reports, line numbers and other line information. PEDIN interfaces with other Geoscience Australia databases. Similar systems operate in each state/Territory.

The Petroleum Information System (PIMS) contains all relevant digital information about data held in Geoscience Australia's data repository in Canberra. This database is accessible through the Geoscience Australia website.

PART 3: REFERENCES

ABARE 2001, Australian Commodity Statistics 2001, Australian Bureau of Agricultural and Resource Economics, Canberra

ABARE 2002. Australian Commodities, vol 9 no 2, June Quarter 2002, Australian Bureau of Agricultural and Resource Economics, Canberra.

Alexander, F.C. and Jones, B., A Proposal for Annotated Upstream Petroleum Regime Model Form Provisions, Organisation of American States' SLA/OAS-CIDA Project White Paper. February 26, 2002, 11.

AMR:Quantum Harris: DPIE Offshore Petroleum Information Review Report, 1995

Australian Geological Survey Organisation. 1998. Oil and Gas Resources of Australia 1998. Australian Geological Survey Organisation, Canberra.

Australian Offshore Petroleum Strategy - a strategy to promote petroleum exploration and development in Australian offshore areas. Department of Industry, Science and Resources April 1999.

Bernkopf RL. Brookshire DS. Soller DR. McKee MJ. Sutter JF. Matti JC. & Campbell RH. 1993. Societal value of geologic maps. US Geological Survey Circular 1111, pp. 53.

Bhagwat S. & Berg RC. 1991. Benefits and costs of geologic mapping programs in Illinois: A case study of Boone and Winnebago Counties and its statewide applicability. Circular 549, Dept of Energy and National Resources, Illinois State Geological Survey, pp. 37.

Bureau of Resource Sciences (1997) Oil and Gas Resources of Australia 1996. Bureau of Resource Sciences, Canberra.

Cusack B. 2001. Address at 2001 Minerals Industry Survey Report launch, Canberra

Dickson, A., Thorpe, S., Harman, J., Donaldson, K., and Tedesco, L. 2001, Australian Energy: Projections to 2019-20, ABARE Research Report 01.11, Canberra

Doggett MD, 2000. Exploration in the new millennium: will it be profitable? Mining Millennium 2000

DPIE 1997 Department of Primary Industries and Energy Portfolio Evaluation of the Role of the Commonwealth in Offshore Petroleum Exploration and Development, October 1997, 2.

Geoscience Australia, 2001. Australia's Identified Mineral Resources, 2001. http://www.ga.gov.au/pdf/RR0019.pdf.

Haynes DW. 2000. Area selection in mineral exploration: a global perspective. Geological Society of Australia, Abstracts No 59, 214.

Herriman N. 1989. Successfiul ore discovery: the need for goals, good science and geologic maps. BMR Research Symposium – Geoscience Mapping Towards the 21st Century. Bureau of Mineral Resources, Canberra.

International Petroleum Encyclopedia 2001 Vol 34. PennWell Publishing Co. Tulsa, Oklahoma, 2001.

Jaques AL. & Huleatt MB. 2002. Australian mineral exploration: analysis and implications. The AusIMM Bulletin No 1, January/February 2002, pp45-52.

KPMG 2002. Survey of the Australian Capital Markets 2001-02. http://www.kpmg.com.au/content/Services/Services/Financial_Advisory_Services/Corporate_Finance_Overview/docs/2002capmarketsurvey.pdf

Lambert IB. 1999. Sustaining economic benefits from mineral resources: Government investment in geoscience. The AusIMM Bulletin No 3, April/May 1999, 82-87.

Lambert IB. 2001. Mining and sustainable development: considerations for minerals supply. Natural Resources Forum, 25, 275-284.

Large RR. 1992. Mineral Symposium, National Agricultural and Resources Outlook Conference, ABARE Canberra.

Lawrie KC. Munday TJ. Dent DL. Brodie RC. Wilford J. Reilly NS. Chan RA. & Baker P. 2000. A geological systems approach to understanding the processes involved in land and water salinisation: the Gilmore Project area, central west New South Wales. AGSO Research Newsletter, Australian Geological Survey Organisation, Canberra.

Lowder G. 1994. Discovery 2000 – a beginning. Minfo New South Wales Mining and Exploration Quarterly, 45, 1.

MCA 2001. Minerals Industry Survey Report 2001. Minerals Council of Australia, Canberra.

MEG 2001. Corporate Exploration Strategies, 2001. Metals Economic Group, Canada.

Minerals and Petroleum Resources Policy Statement, 1998. Commonwealth Government.

Mining Technology Services Action Agenda 2002. Background Paper, February 2002: www.industry.gov.au/agendas/sectors/Mining Technology

Miyazaki, S. and Korsch R.J. (1993) Coalbed methane resources in the Permian of eastern Australia and their tectonic setting. The APEA Journal, 33(1), 161–175.

Parry JR. 2001. The future of mineral exploration in Australia. http://www.wmc.com.au/pubpres/index.htm#explore.

Petrie, E. & others. Australian Geological Survey Organisation. 2001. Oil and Gas Resources of Australia 2000. Canberra: Australian Geological Survey Organisation.

PMSEIC. 2001. Australia's mineral exploration. Paper presented to the Prime Ministers Science, Engineering and Innovation Council. http://www.agso.gov.au/minerals/TOC.html#pmseic.

Powell TG. 1997. BMR's legacy and AGSO's mission: strategic influences on the future direction of Australia's national survey. AGSO Journal, 17(1), 1-11. Australian Geological Survey Organisation, Canberra.

Rio Tinto 2001. Fact Sheet Series: Exploration. www.riotinto.com/library/reports_PDFs/corpPub_FactSheet_Exploration.pdf

Roberts PJ. 1977. Mineral exploration in Australia 1965 to 1973. Australian Mineral Industry Quarterly Review, Vol 29 No 2 pp 48-60. Bureau of Mineral Resources, Geology and Geophysics, Canberra, 51-59.

Scott M. 1999. Valuing Australian State Geological Surveys: Quantitative analysis for strategic planning. PhD thesis, WH Bryan Mining Geology Research Centre, University of Queensland, pp. 260.

Wilburn D. 1998. Exploration. Annual Review: Mining Engineering, May 1998, 51-60.

Williams N. & Huleatt M. 1996. The importance of regional geologic mapping in minerals exploration. Proceedings, National Agricultural and Resources Outlook Conference, ABARE, Canberra.

Woodall R. 1984. Success in mineral exploration: a matter of confidence. Geoscience Canada, 11(1), 41-46.