Mineral exploration in Australia: trends, economic impacts and policy issues

ABARE report to the Chamber of Minerals and Energy of Western Australia, the Minerals Council of Australia, and the Western Australian Department of Mineral and Petroleum Resources

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foreword

Mineral exploration activity in Australia has fallen significantly in recent years. In 2001-02, mineral exploration expenditure (excluding petroleum) was 49 per cent lower in real terms than in 1996-97, and at its lowest level since 1978-79. The downturn is largely associated with reduced spending on exploration for gold and base metals, although exploration expenditure has also declined in recent years for coal and uranium, diamonds and iron ore.

While Australia is relatively abundant in mineral resources, exploration is an ongoing activity that is required for the continued discovery and extraction of those mineral resources over the longer term. Exploration is particularly important for resources such as gold and base metals where the level of economic demonstrated resources relative to production is substantially below that of other major resources such as iron ore and coal.

The key objectives in this study are to examine the economic implications of the recent exploration downturn, to demonstrate linkages between exploration, subsequent production and flow-on benefits to the national, state and territory economies, and to examine policy measures that may facilitate future mineral exploration activity in Australia.

This study was commissioned by the Chamber of Minerals and Energy of Western Australia, the Minerals Council of Australia, and the Western Australian Department of Mineral and Petroleum Resources and draws on policy assessments undertaken on behalf of the Commonwealth Department of Industry, Tourism and Resources.

BRIAN S. FISHER
Executive Director
December 2002
This study was undertaken on behalf of the Chamber of Minerals and Energy of Western Australia, the Minerals Council of Australia and the Western Australian Department of Mineral and Petroleum Resources. The report also draws on economic and policy assessments relating to mineral exploration in Australia that have been undertaken on behalf of the Commonwealth Department of Industry, Tourism and Resources.

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The objectives in this study are to examine trends, economic impacts and policy issues associated with the major downturn in mineral exploration activity that has occurred in Australia since 1996-97:

- **trends** — the recent exploration downturn in Australia is examined in an international and historical context;
- **economic impacts** — the economic implications of the recent exploration downturn in Australia are examined, with particular attention given to linkages between gold exploration, production and flow-on benefits to the national, state and territory economies; and
- **policy issues** — policy measures that may facilitate future mineral exploration activity in Australia are examined, with particular attention paid to land access and taxation.

**Trends**

Mineral exploration expenditure is an investment in knowledge about the location, size and quality of mineral deposits. Discovery of mineral deposits is required before mining may proceed.

As a consequence of historical exploration activity, Australia is a major world producer of several mineral resources including bauxite, base metals (copper, lead and zinc), coal, gold, iron ore and nickel. However, exploration is an ongoing activity that is required for the continued discovery and extraction of mineral resources, and is particularly important for resources such as gold and base metals.

Mineral exploration activity in Australia demonstrates significant medium term or cyclical fluctuations. There were four distinct peaks in mineral exploration expenditure over the past three decades. The change in economic conditions that initiated each of these expansionary phases varied widely. Important drivers were the discovery of a newly prospective mineral provinces, actual and anticipated world commodity price increases, and the adoption of new technologies.

- **Nickel boom** — this peaked in 1970-71 and was associated with higher nickel prices and the discovery of a new type of nickel deposit in Western Australia that increased the prospectivity of the region.
Resources boom — this broadly based event peaked in 1981-82 and was associated with increased commodity prices following the second oil shock in the late 1970s.

Gold boom — this peaked in 1987-88 and was associated with the adoption since the early 1980s of a new gold ore processing technology that substantially lowered economic cutoff grades.

Boom in gold and other resources — this peaked in 1996-97 and was associated with such factors as cyclical increases in key commodity prices in the mid-1990s, the release of new government aeromagnetic data in prospective areas, several major gold and base metal discoveries in the early 1990s that encouraged further exploration activity, and the adoption of a new nickel ore processing technology.

There is currently a substantial downturn in mineral exploration in Australia and overseas. Between 1996-97 and 2001-02, Australia’s mineral exploration expenditure (excluding petroleum, and in 2000-01 Australian dollars) declined by 49 per cent, to A$623 million, the lowest level since 1978-79. The downturn is largely the result of reduced spending on exploration for gold, base metals and nickel, although exploration expenditure has also declined in recent years for coal and uranium, diamonds and iron ore (figure 1).

Based on survey data published by the Metals Economics Group, global nonferrous exploration expenditure declined markedly between 1997 and 2001 (a fall of 44 per cent in Australian dollars). During this period, Australia is estimated to have increased its share of global nonferrous exploration expenditure (from 13 per cent to 16 per cent).
International factors therefore clearly explain part of the recent downturn in exploration activity in Australia. Some major factors include the following:

- **Demand side impacts through the business cycle** — growth in OECD industrial production moderated in 1996 (2.5 per cent), 1998 (1.8 per cent) and declined markedly in 2001 (–2.6 per cent) as the latest economic downturn became relatively widespread. The decline in OECD industrial production in 1998 was mainly associated with the sharp downturn in Japan (–7.1 per cent) that followed the Asian economic downturn in 1997.

- **Official gold sales by major central banks since 1997** — assessments by gold market participants have also been influenced by a series of announcements in 1997, 1998 and 1999 that indicated a major change in the attitude and behavior of major central banks on official gold holdings.

- **The ‘merger wave’ among international minerals companies since 1997** — substantial mergers and acquisitions activity in the minerals sector since 1997 signals major industry restructuring that aims to increase industry profitability over the medium to longer term, and has resulted in a rationalisation of exploration budgets.

The rise and subsequent fall in domestic mineral exploration expenditure during the 1990s in Australia occurred against a background of substantial policy reform. Importantly, the Commonwealth government’s microeconomic reform process has progressed change in business taxation and industrial relations, increasing the economic efficiency of the Australian economy. Since the economic downturn in 1990-91 and 1991-92, macroeconomic policy settings have generally achieved a low inflation, low interest rate, strong economic growth environment.

However, there are domestic economic circumstances that are likely to have adversely affected the international competitiveness of domestic mineral exploration activity. Most notably, a large backlog in exploration and mining title applications has emerged in Australia, mainly since the High Court’s Wik decision in December 1996 which extended native title to pastoral lease land (figure 2). In the first three quarters of 2000-01, exploration title applications in Australia comprised 5809 pending and 1003 granted, and mining title applications comprised 7488 pending and 329 granted.

In Australia, exploration is particularly important for gold and base metals where the level of economic demonstrated resources, relative to
production, tends to be significantly lower than for other resources. With increased difficulties in accessing new areas for exploration in recent years, mainly associated with native title and environmental issues, industry and government research agencies have responded in two important ways:

- first, by increasing mineral exploration in production lease areas (from 11 per cent in the 1980s to 23 per cent in the 1990s); and
- second, by developing new technologies — for example, FALCON, TEMPEST and Glass Earth — to enable explorers to assess mineral prospectivity at greater depths than was previously feasible.

Despite the recent downturn, mineral exploration, production and processing activities continue to make a substantial contribution to the national, state, territory and regional economies. In 2001-02, Australian mining and mineral processing (including petroleum) accounted for:

- 9.0 per cent of gross domestic product;
- 4.3 per cent of total employment;
- 24.7 per cent of new capital expenditure; and
- A$43.7 billion in exports of minerals and metals (excludes petroleum, in current prices) or 29 per cent of Australia’s total exports of goods and services.

Excluding petroleum, the sector accounted for A$4.3 billion in total tax payments in 2000-01, comprising A$1.1 billion, A$2.8 billion and A$0.5 billion for resource based, direct and indirect taxes respectively.

2 Backlog in exploration and mining title applications in Australia

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If the current downturn in mineral exploration activity is sustained, however, Australia’s mineral production and exports will decline over the medium to longer term, with reduced economywide benefits sourced from this sector.

**Economic impacts**

**Gold exploration and production linkages**

Over the past two decades, exploration has resulted in discoveries that, together with technology adoption in mining and mineral processing, have supported growth in mineral production and exports, with commensurate flow-on benefits to the national, state, territory and many regional economies.

The lead–lag relationship between exploration and production in the gold industry is representative of the (longer term) relationships evident in other mineral commodities. As such, the analysis presented of the Australian gold industry aims to provide insights into the importance of exploration for the minerals industry more generally. Gold is an important commodity — for example, the value of gold exports of Australian origin is estimated to have been A$3.9 billion in 2001-02. Gold also accounted for 52 per cent of Australia’s mineral exploration expenditure in 2001-02.

In recent years, the decline in gold exploration expenditure has been followed by a decline in gold production:

- gold exploration expenditure fell by 59 per cent between 1996-97 and 2001-02; and
- gold production increased by 6 per cent in 1996-97, but is estimated to have declined by 14 per cent between 1997-98 and 2001-02 (or 8 per cent between 1997-98 and 2002-03, based on ABARE forecasts, reflecting a temporary sharper drop in 2001-02).

An econometric model is used to estimate relationships between exploration, capital investment and production for Australia’s gold industry over the period 1985-86 to 2000-01. These estimated historical relationships are applied to derive a set of outlook simulations to examine the impact of changes in exploration expenditure for gold production over the period 2002-03 to 2006-07. The simulation results indicate the importance of exploration expenditure to the future of the gold industry:
if gold exploration expenditure is assumed to be constant, gold production falls further, by 2.0 per cent, between 2002-03 and 2006-07;

if gold exploration expenditure falls by a further 20 per cent, gold production falls by 6.5 per cent between 2002-03 and 2006-07; and

if gold exploration expenditure recovers by 20 per cent, gold production increases by 2.5 per cent between 2002-03 and 2006-07.

The simulation results also indicate that exploration will be a significant determinant of future capital investment in the gold industry.

Macroeconomic impacts of a change in mineral production

The macroeconomic impacts of an expansion or contraction in mineral production have been quantified using the MONASH-MRF model of the national, state and territory economies.

For example, a 10 per cent increase in mineral production would, over the longer term, result in a 0.2 per cent rise in national output (compared with its baseline level). This may imply significant impacts in aggregate terms — 0.2 per cent of national output in 2000-01, for example, is A$1.3 billion.

The macroeconomic impacts vary widely between different jurisdictions, reflecting the relative economic importance of minerals in the state or territory economy. A 10 per cent increase in mineral production has the largest impacts in Western Australia (a rise of 3.6 per cent in gross state product), the Northern Territory (3.0 per cent), Queensland (1.9 per cent) and Tasmania (1.1 per cent).

Stoeckel (1999) applied a 10 per cent expansion to a more broadly based definition of the mining and mineral processing sector using the G-Cubed model and obtained stronger output and wealth impacts. For example, Australia’s real gross domestic product was 0.7 per cent higher than the baseline projection after five (and ten) years.

From the outlook simulations for Australia's gold industry, a fall in gold production of 6.5 per cent or 2.0 per cent by 2006-07 corresponds to a fall in national output of less than 1 per cent (compared with its baseline level and using the MONASH–MRF simulation results).
Policy issues

Exploration investment decisions are influenced by a range of geological, economic and policy factors. Private explorers assess the expected profitability of investing in mineral exploration taking into account the risks associated with this activity.

Reduced costs and uncertainties associated with land access arrangements, particularly native title, and changes in the taxation treatment of exploration costs to achieve full exploration loss offset have the potential to increase exploration activity by affecting the private explorer’s risk adjusted assessment of the profitability of mineral exploration.

Land access issues

Land access is an issue for the mining industry because mineral explorers and producers need access to land to continue to operate. There are often competing interests, requiring some system for determining the socially optimal combination of uses. When property rights to a particular use of the land can be assigned, a market based system for determining the optimal combination of uses is generally best. When property rights cannot be assigned, administrative processes and procedures are required.

Native title issues

Native title legislation, and the native title regime more broadly, assigns property rights to native title parties. This permits native title parties to negotiate agreements with mining companies that involve the receipt of economic benefits in return for (the temporary impairment of) cultural and social rights. This can be viewed as a market for ‘future act agreements’ — that is, agreements that cover future acts on land that is or may be subject to native title. The important objective of policy is to enable this market to work as efficiently as possible.

Since enactment of the Native Title Act in 1994, applications for minerals tenements must be subject to the native title process as well as the mining act process that prevails in each state or territory. A substantial rise in the backlog of applications for minerals tenements occurred because applications were not submitted to the native title process or stalled awaiting the start of substantive negotiations during this period. Many uncertainties have now been resolved and most parties appear to have decided to engage in good faith in the native title process.
A high priority in this process is the development of effective expedited procedures with standardised terms and conditions that will obviate the need for Aboriginal groups to lodge objections. Realistically, even with an effective negotiating framework agreement in place, agreements will take time until relationships are developed and a suitable body of precedent has been established.

The backlog suggests that the current ‘marketplace’ in which mining companies and native title parties negotiate future act agreements does not operate efficiently. Key requirements for a more efficient marketplace are:

- decision making processes that enable counterparties to engage effectively in commercial negotiations;
- good information on which to make decisions;
- a market infrastructure that enables counterparties to identify and then physically transact with each other; and
- an effective contracting technology, including mechanisms for monitoring the implementation of agreements over time.

Intermediaries are likely to be important in delivering these requirements. Properly resourced native title representative bodies of good standing should facilitate the process of negotiating agreements and monitoring their implementation over time.

Smaller exploration companies appear to be at a disadvantage in the market for future act agreements because:

- the fixed costs of negotiation bear more heavily on smaller companies;
- there is a perception that native title parties can strike better deals with larger companies; and
- larger companies are more likely to employ resources dedicated to native title matters.

This suggests that a more efficient market for future act agreements is particularly important for smaller companies.

**Environmental and heritage issues**

In contrast to native title, it is difficult to assign property rights to environmental and heritage uses of the land, and therefore it is not possible to rely on market mechanisms to determine the socially optimal level of environmental and heritage uses.
The important objective of policy is to design administrative processes that replicate as closely as possible the outcomes that would be achieved in a functioning market. This requires measures of environmental and heritage use values that can be used to make genuine tradeoffs between alternative uses, that can be clearly signaled to market participants such as mining companies and that can change over time in response to changing social and economic imperatives.

**Taxation treatment of exploration expenditure**

There are at least two significant issues in the current taxation treatment of exploration costs in Australia — most importantly:

- native title costs that are incurred in mineral exploration are not clearly and unambiguously immediately deductible for company income tax purposes; and
- junior exploration companies are not able to use tax credits unless, and until, they begin to earn revenue and/or merge with, or are acquired by, another minerals company.

The lack of full exploration loss offset in the industry increases industry costs and reduces mineral exploration activity. Native title costs are an unavoidable expense and, as a consequence, should be deductible together with other exploration costs.

Exploration companies with insufficient taxable income to immediately use tax credits are most likely to be juniors. A preliminary discussion of the role of junior explorers in Australia, and related policy options, is provided below.

**Junior explorers in Australia**

Geoscience Australia estimates that, since the 1960s, junior exploration companies have accounted for around 60 per cent of total discoveries, rediscoveries and renewals for gold, base metals and nickel.

Information on market capitalisation, exploration expenditure and net profit for 105 junior mineral explorers in 1999-2000 is obtained from the Minmet database. Junior explorers are defined as companies that are engaged primarily in exploration and that have a market capitalisation of less than A$200 million.

The correlation between net profit and exploration expenditure is close to zero (figure 3). Of these 105 junior explorers:
87 companies (83 per cent of the total) recorded exploration expenditure of less than A$2 million in 1999-2000; and

93 companies (89 per cent of the total) recorded net loss positions at an average of A$2.1 million in 1999-2000 — the net loss of 77 of these companies was less than A$0.3 million.

The aggregate market capitalisation for this group of 105 junior explorers is A$1.8 billion. Total exploration expenditure in 1999-2000 was A$113 million, accounting for 17 per cent of Australian mineral exploration expenditure in that year.

The aggregate net loss of the 93 companies was A$196 million, with these companies accounting for exploration expenditure of A$100 million.

**Policy options for non-taxpaying junior explorers**

Under current taxation arrangements, mineral exploration expenditure is deductible against income earned in the same financial year by the company. For junior exploration companies that do not have adequate revenue in a given year, exploration tax credits may be carried forward in nominal terms by the company that incurred the expenditures. The tax credit is used when revenue is earned by the junior exploration company, or when the company merges with or is acquired by another company.

The main issue is that the present value of the accumulated tax credits is lower than the value of an immediate tax deduction. As a consequence, industry exploration costs are higher than would otherwise be the case and the level of mineral exploration activity lower. There are two impor-
tant points that justify considering some policy response to allow immediate deductibility:

- first, on behalf of the community, government is responsible for the efficient management of the discovery, development and production of Australia’s mineral resources; and
- second, junior explorers are highly efficient at certain types of exploration activity (with the majors increasingly targeting the discovery of world class ore deposits).

Three policy options considered briefly in this study that would enable non-taxpaying junior explorers immediate access to tax credits are:

- refundable tax credits;
- limited trade in tax credits; and
- flow-through shares.

A refundable tax offset (similar to the current arrangement for franked dividends) or limited trade in tax credits (similar to the approach in the Northern Territory in the context of the treatment of exploration expenditure for mineral royalty purposes) would enable junior exploration companies to gain immediate access to those tax deductions.

In the absence of refundable tax credits or trading rights in tax credits, a system of flow-through shares with a tax deduction at the company tax rate (currently 30 per cent) would provide investors in non-taxpaying junior exploration companies with immediate deductibility of those costs.

A system of flow-through shares whereby investors are able to claim a 100 per cent deduction for exploration expenditure, potentially at a marginal tax rate above the company tax rate, would only be justified in the presence of sufficient positive externalities in private mineral exploration activity.

A refundable tax offset is likely to be the lowest administrative cost means of providing non-taxpaying junior explorers with immediate deductibility of costs.

ABARE is currently undertaking a more detailed assessment of taxation issues relating to junior explorers.
Mineral exploration is currently experiencing a substantial downturn in Australia and overseas. Over the five years from 1996-97 to 2001-02, Australia’s mineral exploration expenditure (excluding petroleum, and in 2000-01 Australian dollars) declined by 49 per cent from A$1229 million to A$623 million, the lowest level since 1978-79 (ABS 2002a). The downturn was largely associated with reduced spending on exploration for gold, base metals (copper, lead and zinc) and nickel, although exploration expenditure has also declined in recent years for coal and uranium, diamonds and iron ore.

A key issue is whether this downturn in mineral exploration is part of a normal market response that occurs over the medium to longer term to major changes in economic circumstances. Another key issue is the extent to which there are policy options that may be identified that may facilitate the efficient discovery of Australia’s mineral resources.

The main objectives in this study are to examine the implications of the recent exploration downturn, to demonstrate linkages between exploration, subsequent production and flow-on impacts to the national, state and territory economies, as well as to examine policy measures that may facilitate future mineral exploration activity in Australia.

The focus in this study is on exploration for mineral resources other than petroleum. All references throughout this report to mineral exploration excludes petroleum. In addition, the term mining is often used in reference to minerals (excluding petroleum). In Australia the petroleum industry is mainly located offshore, in contrast to other mineral resources, which are located onshore and, except for uranium, are under the jurisdiction of the corresponding state or territory government.

Mineral exploration expenditure is an investment in knowledge about the location, size and quality of mineral deposits. Exploration is an ongoing activity that is required for the continued discovery and extraction of mineral resources. Exploration is particularly important for resources such as gold and base metals where the level of economic demonstrated resources (EDR) relative to production is substantially below that of other major resources such as iron ore and coal. In 2001-02, for example, nearly three-quarters of Australia’s mineral exploration expenditure was focused on gold (52 per cent) and base metals and nickel (21 per cent).

In aggregate, twelve resources accounted for around 96 per cent of mineral exploration expenditure (excluding petroleum) in 2001-02. For seven of these resources, the level of economic demonstrated resources relative to production was lower in 2000 than the average over the period 1979–2000.
Mineral exploration activity is characterised by substantial cyclical or medium term fluctuations caused by a range of factors (such as price shocks or the adoption of new technologies). However, the recent major downturn has raised concern about medium to longer term prospects for minerals, and the international competitiveness of the Australian minerals sector, particularly for the gold industry. Factors that have contributed to this concern include:

- the additional costs and uncertainties associated with land access in Australia, most importantly due to native title issues;
- a significant decline over the past two decades in the share of exploration activity that is conducted in greenfield or grassroots areas;
- the coordinated reduction in gold stockholdings by several major central banks;

Key findings

Trends
There has been a recent major downturn in mineral exploration in Australia and overseas.

- In Australia, real mineral exploration expenditure (excluding petroleum) declined by 49 per cent between 1996-97 and 2001-02 to the lowest level since 1978-79.
- Ongoing exploration activity remains particularly important for gold, base metals (copper, lead and zinc) and nickel, together accounting for 72 per cent of exploration expenditure in 2001-02.

Important international factors contributing to the downturn are: demand side impacts through the global business cycle, official gold sales by major central banks since 1997, and the ‘merger wave’ among international minerals companies since 1997 that has resulted in a rationalisation of exploration budgets. Land access is a major domestic issue.

- In the first three quarters of 2000-01, exploration title applications in Australia comprised 5809 pending and 1003 granted, and mining title applications comprised 7488 pending and 329 granted.

Economic impacts
Estimated historical relationships are used to examine linkages between exploration and gold production over the medium term.

Between 2002-03 and 2006-07, if gold exploration expenditure:

- is constant, gold production falls by 2.0 per cent;
- falls by a further 20 per cent, gold production falls by 6.5 per cent; and
- recovers by 20 per cent, gold production increases by 2.5 per cent.

Flow-on impacts of mineral exploration and production activity are quantified using a version of the MONASH-MRF model of the Australian, state and territory economies.

- In general terms, a 10 per cent increase in mineral production results in a rise in national output (relative to the baseline level) of 0.2 per cent in the longer term (or 0.7 per cent for a more broadly based expansion, including petroleum and using the G-cubed model).
the reintroduction of a flow-through shares system in Canada to facilitate mineral exploration in that country;

- the resumption of mining investment in developing countries over the past decade, particularly in Latin America; and

- increased global recycling of metals and metal products.

In Australia, mining has been an important economic activity since gold was first discovered in Victoria in the 1850s. Mining and mineral processing have contributed to the pace and location of regional economic development, and provided substantial taxation revenues to finance public economic and social infrastructure and other government expenditures. For example, mining and mineral processing (including petroleum) accounted for 9.0 per cent of national output in 2001-02 (ABARE 2002). Total tax payments from the sector, excluding petroleum, were A$4.3 billion in 2000-01 (PricewaterhouseCoopers 2001). On a balance of payments basis, Australia’s exports of minerals and metals were valued at A$44 billion, representing 29 per cent of Australia’s total exports of goods and services (ABARE 2002).

### Policy issues

**Native title issues**

- A high priority is the development of effective expedited procedures with standardised terms and conditions that will obviate the need for Aboriginal groups to lodge objections.

- Native title representative bodies, serving as intermediaries, would appear to be key to improving the efficiency of the market for ‘future act agreements’.

**Taxation issues**

Lack of full exploration loss offset increases industry costs and reduces mineral exploration activity. There are at least two significant issues in the current taxation treatment of exploration costs in Australia:

- native title costs that are incurred in mineral exploration are not clearly and unambiguously immediately deductible for company income tax purposes; and

- junior exploration companies are not able to use tax credits unless, and until, they begin to earn revenue and/or merge with, or are acquired by, another minerals company.

Native title costs are valid costs incurred in mineral exploration and should be deductible.

Policy options considered briefly in this study relating to the status of non-taxpaying junior explorers are:

- refundable tax credits;

- limited trade in tax credits; and

- flow-through shares.

Flow-through shares allow exploration expenditures by a company to flow through to investors who can claim them as a tax deduction either at the company tax rate (currently 30 per cent) or the investor’s personal marginal tax rate. Evidence on the costs and benefits of these, and additional policy options, will be examined in more detail in further ABARE research.
Background on the mineral exploration process, industry structure and Australia’s mineral resources is provided in chapter 2. The importance of the further research, development and adoption of new or more advanced technologies to facilitate mineral exploration, mining and mineral processing in Australia is also considered.

An overview of mineral exploration activity in recent decades is provided in chapter 3. The recent mineral exploration downturn is examined in a historical and international context, and the significance of exploration, mining and mineral processing activities is considered for the Australian, state and territory economies.

Given the importance of gold in Australia’s ongoing mineral exploration activity, economic linkages between exploration, investment and production in Australia’s gold industry are estimated using an econometric model in chapter 4. The implications of exploration for gold production over the medium term are examined under a range of assumptions. The economy-wide impacts of a change in minerals production are quantified using a version of the MONASH-MRF model of the Australian, state and territory economies.

Approaches for reconciling native title, environmental and heritage uses with mining uses of land are discussed in chapter 5. The number of applications pending for exploration licences and mining leases has more than doubled since June 1992. Requirements for more efficient negotiations of future act agreements between mining companies and native title parties are discussed.

A preliminary discussion of issues in the taxation treatment of mineral exploration expenditures is provided in chapter 6. The extent to which non-taxpaying junior exploration companies do not utilise their tax credits is examined. Refundable tax offsets, tradable tax credits and flow-through shares mechanisms are policy options that are considered. Australia’s previous experience with a flow-through shares system during the period 1967–73 is discussed.

Some concluding comments are provided in chapter 7.
the exploration process, mineral resources and technology adoption in Australia

Exploration expenditure is an investment in knowledge about the location, size and quality of mineral deposits. Discovery of mineral deposits is required before mining and mineral processing may proceed. Private explorers invest in mineral exploration based on an assessment of the expected profitability of such an activity, taking into account the various geological, economic and sovereign risks.

Mineral exploration in Australia is conducted by companies that range from large diversified resource companies to relatively small specialised junior explorers. Junior explorers represent a significant part of the industry — two important issues relating to junior explorers are:

- a significant number are not in a position to pay tax, or to deduct legitimate exploration expenditures, until revenue is earned or the junior company is merged with, or acquired by, another company (this issue is discussed further in chapter 6); and
- increasing difficulties in accessing equity markets.

In recent decades in Australia the adoption of new or more advanced technologies has facilitated the profitable discovery, extraction and rehabilitation of more remote, sometimes smaller and lower quality mineral ore deposits.

In this chapter, the exploration process and the structure of Australia’s exploration industry are outlined. Linkages between the public provision of basic geoscientific information, private mineral exploration, production and processing operations, and flow-on economic impacts are emphasised. Background information on Australia’s mineral resources and the role of research and development in facilitating mineral exploration and related activities is also provided.

The mineral exploration process

The decision to explore

Mineral exploration is the process of finding and assessing the characteristics of mineral deposits. Information relating to mineral deposits can be obtained directly or indirectly.
Methods for directly obtaining information include, for example, drilling core samples that intersect a mineral deposit. Indirectly obtained information includes the information on unexposed deposits obtained from the analysis of data generated by a range of available geoscientific survey methods.

Exploration is a high risk process that involves a number of sequential information gathering steps. A decision to initiate an exploration program or to proceed to the next stage of an existing program implies that the expected benefits of obtaining additional information outweigh the expected costs, taking into account the risks. When a company is assessing whether exploration should take place, an implicit or explicit assessment is made of the probability of discovering an economic mineral deposit.

A range of geological, economic and policy factors influences the assessment of risk adjusted profitability including, most notably, expectations and risks relating to mineral prospectivity, mineral prices, exploration, mining and processing technologies, input costs more generally, land access and government policies. A range of government policies are relevant to industry, from sector specific policies such as mineral taxation and approval processes to broader policy processes such as microeconomic reform and macroeconomic policy settings.

Exploration activity may be usefully categorised by the level of exploration and mining activity that has previously occurred in the location. Some terms commonly used in mineral exploration (discussed in Bowler 2002), are as follows.

- An area where there is current or past mining of a particular resource is referred to as a brownfield area.
- An area where there are no current mining operations or known mineral resources is referred to as a greenfield area.
- Grassroots exploration techniques are usually taken to be those used early in an exploration program for new economic deposits, including the generative and primary stages (see next section).

Since the early 1980s, there has been some increased emphasis on exploration in brownfield areas. This shift reflects to some extent increasing land access difficulties, mainly relating to environmental issues (1980s and 1990s) and native title issues (1990s) (see chapter 5 for a discussion of these issues).

Mineral exploration in greenfield areas tends to be higher risk than in brownfield areas since less information is available about the geology of the location. Lack of knowledge may imply that there is a relatively low probability of discovering a large ore deposit. However, exploration in greenfield areas increases the probability of discovering a new mineral province in Australia.

Delayed, or forgone, access to land postpones or reduces the opportunities for private explorers to acquire knowledge about Australia’s mineral resources base. There are potentially both direct and indirect industry benefits from mineral exploration that are delayed, reduced or forgone.
Private explorers benefit directly from mineral discoveries by typically gaining production rights over the ore deposit, but these discoveries may also provide or signal important information to other explorers — these indirect industry benefits from discoveries are referred to as positive externalities or spillover effects. In the presence of positive externalities, an exploration company does not capture fully the benefits of its activity, resulting in a suboptimal level of activity from the perspective of the general economy.

There are two important sources of information externalities:

- A significant new discovery in a greenfields area provides information to other exploration companies about the location of the deposit — this may signal the prospectivity of the area to other exploration companies; and

- Discovery of a new type of deposit provides information to other exploration companies about the geology of the deposit — this may lead to the enhancement of geological models that may increase the probability, or reduce the costs, of discovering further deposits.

In each case, exploration companies benefit from the exploration costs incurred by the original company.

**Key stages in mineral exploration, production and processing**

Key stages in exploration, mining and mineral processing are outlined in figure 4. Mining and mineral processing activities also have significant flow-on impacts on local and regional economies as well as on the state, territory and national economies. These economywide impacts are discussed further in chapters 3 and 4.

There are two major underlying influences on mineral exploration, production and processing.

- The process of the discovery and (at least) economic depletion of mineral ore deposits requires ongoing exploration activity, typically in more remote areas, to maintain the mining sector.

- The adoption of new and more advanced exploration, production and processing technologies reduces costs and increases the efficiency of the mining sector by, for example, enabling new mineral ore deposits to be discovered and previously uneconomic mineral ore deposits to be developed.

In the **generative stage** of private mineral exploration, companies identify areas that are considered to be prospective for target minerals using public geoscientific information and supplementary private reconnaissance work. These maps and survey data are an essential element in the development of an exploration model that provides a description of the sought after mineral deposit and helps guide the exploration effort. Exploration models are generally based on descriptions of other known deposits.

The **primary exploration stage** commences after the completion of the generative phase of exploration. Areas that have been identified as prospective for target minerals are acquired
Key stages in mineral exploration, production and processing

1. Geological, economic and policy setting
   - Australia’s mineral resources
   - World mineral market conditions
   - Government policies

2. Public geological surveys
   - Basic geoscientific information
   - Historical exploration information

3. Generative stage
   - Selection of areas for more detailed exploration

4. Primary exploration stage
   - Exploration of lease areas for mineral occurrences

   - No discovery of mineral occurrences
   - Discovery of mineral occurrences

5. Evaluation stage
   - Exploration of economic viability of mineral occurrences

   - Uneconomic project
   - Economic project

6. Development stage
   - Construction of minesite, processing and related infrastructure

7. Production/processing stage
   - Mineral extraction, processing and transport to markets

8. Minesite rehabilitation stage
   - Minesite rehabilitation following economic depletion of lease areas

9. Macroeconomic impacts
   - Income, employment, exports, etc.

10. Interindustry impacts
    - Backward and forward linkages

Exploration activity involves searching for concentrations of naturally occurring solid, liquid or gaseous materials and includes new field wildcat and stratigraphical and extension/appraisal wells and mineral appraisals intended to delineate or greatly extend the limits of known deposits by geological, geophysical, geochemical, drilling or other methods. This includes drilling of boreholes, construction of shafts and adits primarily for exploration purposes but excludes activity of a developmental or production nature. Exploration for water is excluded (ABS 2002a). In this study, ABS information on exploration activity refers to mineral resources other than petroleum.
and tested in much greater detail by private explorers. The targeted areas are subjected to geochemical and geophysical analysis and exploratory drilling to determine and delineate zones of likely mineralisation.

This targeted exploration may identify new zones of mineralisation that prove to be economic to mine. The discovery of a new economic ore body results in further drilling and geochemical testing in order to fully map and define the size, grade and geometry of the mineral deposit. Definition of the ore body both physically and geochemically is an essential step before proceeding toward development of a mining plan and feasibility study.

Where exploration activity has resulted in the discovery of a mineral deposit, the evaluation stage involves reserve delineation, mine planning, metallurgical testing, feasibility studies and predevelopment planning, including financing and government approvals and an assessment of the least cost method of mining.

Where the evaluation stage indicates an economic project, the development stage involves construction and development of the minesite and related mineral processing facilities. The requirements of the development stage will also be influenced by the availability and cost of other infrastructure services such as energy, transport and water. Housing and other infrastructure associated with the labor force and their families is a further consideration.

Mining companies have historically made substantial contributions toward financing the expansion of existing towns where the minesite is within daily commuting range. In more remote areas, the traditional approach to mining was to establish a new company town, either as a single company or central mining town, although there has been a trend toward long distance commuting (or fly in – fly out) options over the past fifteen years in Australia (Hogan, Berry and Thorpe 1999; Hogan and Berry 2000).

In the production/processing stage, companies undertake mineral extraction, processing and marketing activities. Processing of minerals includes smelting, refining and chemical processes, which result in the production of a refined metal cathode, ingot or equivalent basic forms. Mineral processing at or close to the minesite reduces transport costs. As the purity of the metal increases with processing, it becomes relatively more cost effective to locate the final processing plants closer to other inputs such as electricity generators.

Declining reserves at a particular minesite may encourage further exploration around the existing deposit (brownfield exploration) in order to extend the longevity of the mine and processing plant.

In the minesite rehabilitation stage, companies rehabilitate the minesite according to a strategy approved by government. This may require environmental restoration during as well as at the end of the mining operation depending mainly on the nature of the mining operation (Allen, Maurer and Fainstein 2001).

The mineral exploration process is discussed in, for example, Gocht, Zantop and Eggert (1988), Mackenzie and Doggett (1992), Williams and Huleatt (1996) and PMSEIC (2001).
Industry structure

There has recently been significant change in the structure of the mineral exploration industry in Australia. This is evidenced most clearly in the large number of mergers and acquisitions in the mining industry over the past five years. The internationalisation of the Australian mining industry during the 1990s is discussed for example in Maponga and Maxwell (2000).

It is useful to distinguish the following sectors of the mineral exploration industry.

- **Major production companies:** These are large capitalisation mining companies that are major producers and that typically engage in some exploration activity. For the purpose of this classification, major production companies are defined as mining companies with market capitalisation greater than A$1 billion. Many of these are foreign companies operating in a global marketplace, with Australia accounting for only a proportion of their total activities. Examples include BHP Billiton, Rio Tinto and the recently merged Barrick/Homestake.

- **Midsized production companies:** These are medium sized mining companies that are significant producers and that also engage in some exploration activity. For the purpose of this classification, midsized production companies have market capitalisation between A$200 million and A$1 billion. Their activities tend to be concentrated in Australia, but they are also likely to be engaged in significant exploration and/or production overseas. Examples include Sons of Gwalia, Iluka, AurionGold and Anaconda Nickel.

- **Junior exploration and production companies:** These are small capitalisation mining companies that are engaged primarily in exploration. For the most part, junior exploration companies have market capitalisation less than A$200 million. They include listed companies that have raised external equity financing via an initial public offering and small unlisted explorers. Their activities tend to be concentrated in Australia, but a significant number are engaged in exploration overseas.

There is a natural ‘life cycle’ for companies through these market segments. Small unlisted companies may raise funding from private sources or development capital funds (pooled development funds) or they may be sponsored by larger mining companies.

Small companies may expand their activities and grow by raising external capital from the public capital markets via an initial public offering. Given the risky nature of minerals exploration, success in raising external capital will depend largely on the preferences of investors for high-risk equity investments.

Companies that achieve exploration success have a choice of selling discoveries or prospective tenements to existing producers, joint venturing in the development with other companies or attempting to develop the resource themselves. The transition from explorer to producer is likely to require further external capital raisings, for example through a rights offering to existing shareholders.

Medium sized companies with some production capacity may expand through further exploration successes and further development of existing resources, or through mergers and
acquisitions. Most of the very large mining companies with limited opportunity to grow organically have engaged in significant merger and acquisitions activity in recent years.

The Minmet database provides an indication of the number of companies in each market sector in Australia:

- **10 major production companies:** The number of mining companies in Minmet classified as producers and with market capitalisation greater than A$1 billion (including BHP Billiton).

- **15 midsized production companies:** The number of mining companies in Minmet classified as producers and with market capitalisation between A$200 million and A$1 billion.

- **314 junior exploration and production companies:** The number of mining companies classified as producers by Minmet and with market capitalisation less than A$200 million or classified as explorers by Minmet (all but one of the explorers have market capitalisation less than A$200 million).

It should be noted that not all companies included in Minmet are currently active explorers. Also, apart from a small number of exceptions, Minmet does not include unlisted companies, some of which (for example, the Worsley Alumina and Robe River Mining Company joint ventures) are large and significant entities.

Based on information provided by the Minerals Council of Australia, at least 106 junior exploration and production companies are owned or controlled by the major or midsize production companies. This suggests that there are up to 204 junior exploration and production companies that are separate entities to the larger companies, although this number may include nonoperating companies.

In recent years, there have been increasing difficulties for junior explorers in accessing equity markets. Given their risk profile, junior exploration companies typically obtain external financing through the equity markets and in particular the speculative end of the equity markets. For much of the past five years other industries such as biotech and the dotcoms have appeared to offer the prospect of better returns than mineral exploration and may have attracted speculative capital away from minerals exploration. The problem for smaller exploration companies may have been exacerbated by the fact that Australia does not have a large and well developed development capital industry. ABARE is currently undertaking further research on the issue of access to venture capital by junior explorers.

Larger mining companies have been shielded from this problem to some extent by the fact that they typically have some access to internal funding from cash flows. Furthermore, since they tend to be more diversified and therefore less risky than smaller exploration companies, larger companies are typically able to access the external debt markets as an alternative to equity financing. (ABS 2002b reports a debt to assets ratio of 66.3 per cent for the metal ore mining industry in 2000-01).
One motivation for mergers and acquisitions in the mining industry has been to achieve sufficient size and diversity to attract the attention of global financiers and funds managers, and facilitate access to global debt and equity markets.

There appears to have been some tendency in recent years for larger firms to scale back their in-house exploration activity and rely on the successes of smaller exploration companies. For example, BHP Billiton now has a philosophy of farming out exploration acreage to smaller exploration companies, and then buying back (into) acreage that is highly prospective. To the extent that larger companies rely on the successes of smaller exploration companies, this testifies to the importance of a healthy junior exploration sector.

Among the possible explanations for this trend are that:

- production companies may value a degree of certainty about the supply of resource that is difficult to achieve with an in-house exploration program — exploration is highly uncertain, particularly with regard to the timing of discoveries, and production companies may be better served by purchasing prospective tenements from exploration companies on an as-needs basis;
- require a degree of innovation and quick decision making; and
- possibly some refocusing by larger production companies from inhouse exploration to better servicing the needs of their end customers.

**Australia’s mineral resources**

**Classification of mineral resources**

Mineral resource classification systems are typically based on some version of the McKelvey box (figure 5; AGSO / Geoscience Australia 2001). The classification system includes both geological and economic assessments. The geological assessment takes into account information on quantity (tonnage) and chemical composition (grade), while the economic assessment takes into account information on economic factors such as commodity prices, costs and discount rates.

A resource is a concentration of naturally occurring solid, liquid or gaseous materials in or on the earth’s crust that are either identified or presently undiscovered, and in such form that its economic extraction is presently or potentially (within a 20–25 year time frame) feasible.

**Identified** resources are specific bodies of mineral bearing material or petroleum accumulations, the location, quantity and quality of which are known from specific measurements or estimates from geological evidence.

Identified resources may be either **demonstrated** — measured from detailed sampling on site, or indicated from less detailed sampling — or **inferred** from broad geological knowledge of the site with few, if any, samples or measurements.

**Undiscovered** resources are unspecified accumulations that are expected to exist based on broad geological knowledge and theory. Undiscovered resources may be **hypothetical**, which
may be expected to exist in a known province under known geological conditions, or speculative, which may occur in known geological conditions where no discoveries have previously been made.

In Australia, identified (or discovered) resources are assessed for mineral resources other than petroleum. (Both identified and undiscovered resource assessments are conducted for petroleum — see Geoscience Australia 2002).

Identified resources are further classified as economic or subeconomic. An economic resource implies that, at the time of determination, profitable extraction or production under defined investment assumptions has been established, analytically demonstrated or assumed with reasonable certainty. Subeconomic resources are resources that are less likely to be profitable to extract. Subeconomic resources may be paramarginal, which almost satisfies the criteria for economic, or submarginal that would require, for example, a substantially higher

5 Classification of mineral resources

a. The McKelvey box

b. Interpretation of the industry JORC code within the McKelvey box
commodity price or some major cost reducing advance in technology to render them economic.

Economic demonstrated resources (EDR) are specific bodies of mineral bearing material or petroleum accumulations where the location, quantity and quality are known from specific measurements or estimates from geological evidence and where production is assessed to be profitable with reasonable certainty (figure 5).

In the preparation of Australia's identified mineral resource assessments, Geoscience Australia uses data reported for individual deposits by mining companies based on the Australasian code for reporting mineral resources and ore reserves, commonly referred to as the JORC code (JORC 1999; see also www.jorc.org).

The JORC code sets out minimum standards, recommendations and guidelines for public reporting of exploration results, mineral resources and ore reserves. The code has been prepared by the Joint Ore Reserves Committee (JORC) which comprises the Australasian Institute of Mining and Metallurgy, the Australian Institute of Geoscientists and the Minerals Council of Australia.

Ore reserves are the economically minable part of the indicated and measured mineral resources (figure 5). Industry assessments take into account mining, metallurgical, economic, marketing, legal, environmental, social and government factors to demonstrate that production could reasonably be justified. Ore reserves are subdivided in order of increasing confidence into proved or probable ore reserves.

The required minimum standard for public reporting is prepared for the purpose of informing investors or potential investors and their advisers. The JORC code has been incorporated into the listing rules of the Australian Stock Exchange since 1989 and the New Zealand Stock Exchange since 1992.

The JORC code reduces, but does not eliminate, the possibility of a false announcement of a discovery such as the Bre-X announcement in Indonesia based on a ‘salted’ mine. Several countries have recognised the importance of reporting standards for ore resources. For example, Canada has recently developed a code modeled strongly on the Australian system. The JORC code has also strongly influenced the preparation of recently published reporting codes and guidelines in South Africa, the United States, the United Kingdom, Ireland and other European countries.

Australia's identified mineral resources

By international standards, Australia is relatively abundant in mineral resources (AGSO / Geoscience Australia 2001). Australia is a leading nation in the production and export of several mineral commodities, as well as in exploration, mining and processing technologies (ABARE 2001a; PMSEIC 2001).

As a consequence of historical exploration activity, for example, Australia ranks in the top four countries in terms of economic demonstrated resources (EDR) for base metals (copper,
lead and zinc), nickel, mineral sands, gold and iron ore (table 1). Australia is also a major world producer of these mineral resources. The selection of mineral resources reflects their importance in Australia’s mineral exploration expenditure.

The extent to which private explorers ‘prove up’ mineral occurrences varies both over time and between resources. The ratio of economic demonstrated resources to production, which provides an indication of stockholdings for each resource, is substantially lower for gold and base metals than for other major resources such as iron ore and coal (table 1).

Economic demonstrated resources for selected minerals is provided in figure 6 to indicate trends over the past two decades. Key points are provided in the figure, corresponding to each mineral or mineral group. Between 1980 and 2000, economic demonstrated resources declined for lead and iron ore, and increased for other minerals (excluding diamonds).

In general terms, economic demonstrated resources may fluctuate over time as a result of new discoveries, reassessments of identified ore deposits and production, as well as changes in prices and other factors that influence the economic assessment of ore deposits. Notably, economic demonstrated resources for base metals fluctuated widely in the mid-1980s and early 1990s due to major reassessments of resources at major deposits.

### Economic demonstrated resources (EDR) and production of selected resources, Australia, 2000

<table>
<thead>
<tr>
<th></th>
<th>Australia in world EDR</th>
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<th>Australia’s EDR to production ratio a</th>
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<tbody>
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<td></td>
<td>no.</td>
<td>%</td>
<td>no.</td>
<td>%</td>
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<tr>
<td>Gold</td>
<td>3</td>
<td>10</td>
<td>3</td>
<td>12</td>
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<tr>
<td>Base metals and nickel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Lead</td>
<td>1</td>
<td>23</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Zinc</td>
<td>1</td>
<td>18</td>
<td>2</td>
<td>16</td>
</tr>
<tr>
<td>Nickel</td>
<td>1</td>
<td>34</td>
<td>3</td>
<td>14</td>
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<td>Coal and uranium e</td>
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<td>Black coal</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Uranium d</td>
<td>1</td>
<td>29</td>
<td>2</td>
<td>28</td>
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<tr>
<td>Diamonds e</td>
<td>3</td>
<td>15</td>
<td>1</td>
<td>24</td>
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<tr>
<td>Mineral sands</td>
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<tr>
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<td>1</td>
<td>29</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>Rutile</td>
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</tr>
<tr>
<td>Zircon</td>
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<td>40</td>
<td>1</td>
<td>37</td>
</tr>
<tr>
<td>Iron ore</td>
<td>4</td>
<td>10</td>
<td>3</td>
<td>16</td>
</tr>
</tbody>
</table>

- a EDR (end of calendar year data) as a share of production in the same calendar year. b Average annual data over the period. c Based on financial year production (for example, 2000-01 instead of 2000). d World EDR ranking is based on resources recoverable at less than US$80/kg U. e World EDR rankings are based on industrial diamonds only, although Australia has one of the largest EDRs for gem/near gem diamonds. World production is based on natural gem and cheap gem diamonds. na Not available.

Sources: ABARE (2001a); AGSO-Geoscience Australia (2001).
In general terms, there is some tendency for the major resources that are sought in mineral exploration to have a lower EDR to production ratio. For example, the EDR to production ratio in 2000 was seventeen years for gold, 20–29 years for copper, lead, zinc and silver, and seven years for diamonds (table 1). The EDR to production ratio for nickel has increased sharply in recent years, reflecting significant changes in the economics of nickel production over the past decade. Even in industries where there is a relatively high EDR to production ratio, such as iron ore (80 years), significant exploration activity may occur to discover better quality deposits than currently available.

Detailed information on Australia’s identified resources, by category, as at the end of 2000 is provided in AGSO / Geoscience Australia (2001).

6 Economic demonstrated resources of selected minerals

- **Gold**: EDR for gold increased from 332 tonnes in 1980 to 4454 tonnes in 1996 and 4959 tonnes in 2000. Major discoveries in the 1980s include Mt Leyshon, Boddington and Granny Smith. Major discoveries in the 1990s include Cadia Hill, Ridgeway, Jundee, Kanowna Belle and Sunrise Dam.

- **Base metals and nickel**: Between 1980 and 2000 EDR for lead declined by 8 per cent, while EDR for copper, zinc and nickel increased. Major base metal discoveries in 1990 include Cannington and Century. EDR reassessments occurred in the mid-1980s and 1993-94 (including Olympic Dam and McArthur River). Nickel EDR increased strongly during the 1990s. Major nickel ore deposits include Murrin Murrin and Ravensthorpe.

- **Coal and uranium**: EDR for both coal and uranium increased between 1980 and 2000. EDR for black coal is mainly located in Queensland (62 per cent) and New South Wales (35 per cent). Major uranium deposits include Olympic Dam, Ranger, Jabiluka, Koongarra, Kintyre and Yeelirrie. Changes to EDR mainly reflect extensions of known deposits.
It can be seen from a location map of Australia’s mines and major mineral deposits (AGSO / Geoscience Australia 2001) that certain types of resources in Australia are concentrated within particular geographical regions, whereas others are more widely dispersed.

Gold for example is concentrated in Western Australia, particularly around Kalgoorlie in the Eastern Goldfields region. Similarly, large resources of iron ore are concentrated in the Pilbara region in the north west of Western Australia. By contrast, mineral resources such as base metals and mineral sands are found in different locations across the continent.

6 Economic demonstrated resources of selected minerals

Information on the EDR for diamonds is only available from Geoscience Australia since 1983. EDR for diamonds is mainly influenced by estimated reserves (including reassessments in 1990) at the Argyle deposit, discovered in 1979.

Between 1980 and 2000, EDR for minerals sands has increased, with a particularly strong rise for ilmenite.

A significant share of mineral sands deposits have been placed in national parks and are unavailable to mining. Areas quarantined from mining represent around 10 per cent, 26 per cent and 30 per cent of ilmenite, rutile and zircon, in 2000.

Between 1980 and 2000 EDR for iron ore declined by 9 per cent.

Major iron ore deposits include Mt Tom Price, Mt Whaleback, West Angelas and Robe River.

Over 80 per cent of resources occur in the Pilbara region in Western Australia.
Technology adoption in Australian mineral exploration, production and processing

Since European settlement, Australia has had a history of major minerals discoveries that have contributed strongly to the nation’s economic development. Historically, the major mineral discoveries such as gold at places like Bendigo, Ballarat, Kalgoorlie and base metals deposits such as Broken Hill and Mount Isa were typically high grade deposits with surface expressions of mineralisation that aided the location of these deposits. The higher grade and proximity to the surface of these deposits suited both the prospecting and mining methods of their times.

The economic viability of a mine is largely determined by the size and quality of the mine’s ore resource. Typically, the most important determinants of the quality of an orebody are the grade of ores and its accessibility. These factors determine mine life for a given production rate, the type of mine (opencut or underground), infrastructure development and economies of scale. Other factors include the chemistry of ores, which may determine processing method, and distance from transport and settlement, which may affect production costs.

Technology adoption has an important impact on the economics of locating, extracting and processing mineral resources. For example, with many of Australia’s known high quality ore resources having already been developed, there has been a strong trend toward the mining of lower grade deposits. The introduction of new and cheaper extraction and processing technologies has meant that ore bodies of much lower grade (and size) can be treated for the economic recovery of minerals.

Research and development is undertaken within individual companies, industry–government partnerships and public organisations (PMSEIC 2001).

- Universities tend to focus on basic research into geological processes and Australia’s geology.
- Geoscience Australia and the state and territory geological surveys are mainly responsible for providing basic geoscientific information.
- CSIRO focuses on applied research and development activities relevant to the Australian geological environment.
- Cooperative research centres (CRCs) bring together private and public organisations to solve particular problems.
- AMIRA International is an independent association of minerals companies that develops, brokers and facilitates collaborative research for its members.

Extraction and processing technologies

In recent decades the carbon-in-pulp (CIP) and carbon-in-leach (CIL) processes have been adopted for recovering gold from low grade deposits (Allen et al. 1999). The CIP/CIL technology (which uses carbon to extract gold from solution) made the treatment of low grade ore (below 1 gram per tonne of gold) profitable and allowed the handling of opencut or tailings material that was high in clay content and was not sensitive to water with a high salt
content. This technology was directly responsible for the strong increase in Australian gold production during the 1980s, with the bulk of Australian gold mines now using these methods. These include major mines such as Plutonic, Kanowna Belle and Telfer (in Western Australia), as well as many smaller mines with low grade ores.

- **Telfer** — Newmont initially discovered gold at Telfer in 1971, in quartz vein outcrops. Gold production commenced in 1977. The mine was later expanded and the processing of low grade ores commenced with the use of CIL technology during the 1980s. Falling ore grades and higher costs resulted in the closure of Telfer in late 2000. However, Newcrest (successor company of the mine’s original owners) has recently announced a reopening and major expansion of the mine as a result of the discovery of major ore reserves at the mine site. The mine is expected to reopen in 2003 or 2004 at a much higher rate of production (Minmet Ozmine 2002).

Hydrometallurgical extraction processes have also contributed to making low grade mineral discoveries more economic. Solvent extraction – electro winning (SX–EW) and pressure acid leach (PAL) technologies have been producing an increasing proportion of the world’s refined base metals as a result of the cost and environmental advantages of producing refined metal at the mine site (Castleman 2001). Significant mine facilities using this technology include Mount Gordon (Queensland), Girilambone (New South Wales) and Murrin Murrin (Western Australia).

- **Murrin Murrin** — Murrin Murrin is a laterite nickel mine and pressure-acid-leach (PAL) refining facility in Western Australia. Mining commenced in 1998. At full production of 45 000 tonnes a year, the mine will be the world’s fourth largest nickel mine and third largest cobalt mine, with a projected mine life of thirty years. Murrin Murrin was planned to have cost and environmental advantages over traditional nickel sulphide producers, although problems related to the new technology encountered with the plant have resulted in a slow build up to full capacity production and higher costs (Resource Information Unit 2001; Minmet Ozmine 2002).

Complementing the use of hydrometallurgical processes is the rising importance of biotechnology (Mining Journal 2001; Mining Magazine 2002). Bioleaching and bio-oxidation are processes that have the potential to become common practice following the successful completion of trials. Bioleaching and bio-oxidation use naturally occurring bacteria to promote the extraction of precious and/or base metals from sulfide or concentrates. These processes have environmental advantages over traditional techniques such as roasting and smelting which create toxic byproducts.

- **BioHeap** — An example of biotechnology currently in trial prior to commercialisation is the BioHeap bacterial heap leaching process patented by Titan Resources (Titan Resources 2001; Bell 2001). After successful trials in 2000, Titan Resources commissioned a A$4 million stage two pilot plant in Western Australia, and separate laboratory trials for nickel miners WMC and Inco. Titan Resources appears to be close to signing its first commercial deal for BioHeap with China’s largest nickel producer, Jinchuan Non-Ferrous Metals Corporation (Mangan 2002). BioHeap aims to economically process low grade nickel deposits.
Fine grinding of ores has also been a major development in minerals extraction. With many mineral deposits being fine grained and disseminated throughout the ore, fine grinding has allowed for the more efficient extraction of metals in flotation cells. This technology was a particularly important factor in the development of the Century and McArthur River mines in Northern Australia.

**Century** — The Lawn Hill area (site of the Century Mine) in Northern Queensland has a long history of mining (mainly for lead and silver) back to 1887. In 1990, CRA Exploration made the initial discovery of strong zinc mineralisation at Discovery Hill, which led to a resource definition drilling program that identified a large economic resource suitable for open cut mining. After the sale of the Century lease to Pasminco, the mine was developed to have a capacity of 500,000 tonnes of zinc in concentrate a year, with first production in late 1999. Given the remoteness of the Century mine, with difficulties in transporting mine production, zinc concentrate is pumped in a slurry form via a pipeline to port at Karumba, while mine staff work on a fly in fly out roster system (Register of Australian Mining 2001/02).

Another mining technology that has had a major impact on the economics of mining a deposit is the development of bulk mining methods. This entails the use of large scale infrastructure that allows large amounts of ore to be extracted in a short period of time. This infrastructure includes large haulage trucks, high volume conveyor systems and large processing plants. Mining methods such as opencut mining, block caving and longwall facilities also contribute to the economies of scale of bulk mining methods. Examples of bulk mining methods include Northparkes, Lenard Shelf and Ernest Henry.

**Ernest Henry** — The Ernest Henry copper deposit was discovered in 1990 and subsequent opencut mine development resulted in first concentrates being produced in mid-1997. Ernest Henry has a mining rate in excess of a million tonnes of ore a year and the mine’s mills and flotation cells are among the largest in the world. Concentrates are trucked to Mount Isa for smelting and then to Townsville for refining and export. The mine has an expected life of fifteen years from late 1997 (Minmet Ozmine 2002).

In February 1999 BHP Billiton’s hot briquette iron (HBI) plant was completed at Port Hedland in Western Australia. The plant processes iron ore fines into partially metallised iron granules that are compressed into small briquettes for use in electric arc and blast furnace operations. The HBI process allows for value adding to iron ore fines, which have a lower market value than iron ore lumps. The HBI plant, when running at full capacity, will allow operational advantages to BHP Billiton as they can value add to multiple mine products.

**Exploration technologies**

Developments in aeromagnetic and gravimetric survey technology in recent decades has contributed to some major discoveries such as Olympic Dam in 1975 and the Mount Woods deposit in 2001, both in the Gawler Craton region of South Australia.

**Olympic Dam** — Olympic Dam is a fully integrated mine and refinery, combining a grinding/concentrator circuit, hydrometallurgical plant and recovery circuit for uranium.
and precious metals. The ore body was discovered in 1975 by a drilling program carried out by Western Mining Corporation, after theoretical studies of the formation of copper ore bodies led to the choice of the Stuart Shelf area of South Australia as an exploration target. The Olympic Dam site itself was chosen on the basis of anomalies identified in the government regional gravity and aeromagnetic data, and favorable tectonic lineaments. With no surface expression of mineralisation (ore is buried beneath 330 metres of overlying sedimentary rock) all initial geological sampling was collected from surface diamond drill cores. The Olympic Dam ore body is a very large, but low grade resource, with considerable potential to further expand minable reserves. First production from the mine was in 1988 and at current rates of production, Olympic Dam has an expected mine life of over 100 years (Register of Australian Mining 2001/02).

Mount Woods — Following exploration by CRA, Burmine and Normandy, in the Mount Woods area, survey work by Minotaur Resources concentrated on gravity and geomagnetic anomalies in the Mount Woods area. Exploration drilling in 2001 has revealed strong copper and precious metals mineralisation, similar in style to that of Olympic Dam, which lies in the same Gawler Craton region. Like Olympic Dam, Mount Woods mineralisation lies below a surface layer of sedimentary rock, with no surface indications of target minerals. Further exploration drilling in the Mount Woods area is thought likely to reveal a large ore resource suitable for development as a major mine (Minnet Ozmine 2002).

More discoveries are expected in future, with the development of new geoscience technologies such as FALCON (BHP Billiton), TEMPEST (CRC AMET) and Glass Earth (CSIRO) which provide more detailed data on subsurface geology (PMSEIC 2001).

FALCON was developed from US naval technology and BHP Billiton has adapted it for mineral exploration purposes. FALCON uses sensitive gravity based measurements to measure the density of rocks below the earth’s surface. See www.falcon.bhpbilliton.com for further information.

TEMPEST was developed by the CRC Australian Mineral Exploration Technology (CRCAMET), comprising Geoscience Australia, AMIRA International, CSIRO, Curtin University, the Geological Survey of Western Australia, Macquarie University and World Geoscience Corporation (now Fugro Airborne Surveys). TEMPEST is an airborne system similar to FALCON, but differs because it uses electromagnetic pulses to generate small but measurable secondary magnetic fields in target bodies. See www.crcamet.mg.edu.au for further information.

Glass Earth projects are designed to discover the next generation of economic mineral deposits by making the top kilometre of the Australian continent, and the processes operating within it, transparent. See www.csiro.au for further information.

Airborne surveys, in general, allow for the rapid acquisition of data and accelerate the identification or sterilisation of exploration areas, while minimising environmental impacts and access problems. The use of airborne surveys has a significant economic advantage over traditional ground based surveys in that they are more cost and time effective. These technologies can also be valuable environmental management tools — for example Tempest is able to detect groundwater salinity (PMSEIC 2001).
Mineral exploration activity both in Australia and overseas is subject to substantial medium term or cyclical fluctuations. Changes in economic conditions can trigger expansionary or contractionary phases in mineral exploration. Influences vary and include actual and anticipated world commodity price increases or falls, the adoption of new technologies (and the international transmission of those technologies), and the discovery of a newly prospective mineral province (country specific influence).

A key issue in the latest downturn is whether there have been impediments specific to Australia that have had an adverse impact on the international competitiveness of mineral exploration in Australia. In this chapter, the recent downturn in mineral exploration activity in Australia is examined in a historical and international context. Mineral exploration activity in Australia is discussed in several other papers including Davies et al. (1999), Allen and Waring (2000) and AGSO / Geoscience Australia (2001).

The importance of mineral exploration, production and processing for the Australian, state and territory economies is also discussed. In chapter 4, the economywide impacts of a minerals expansion are quantified using a version of the MONASH-MRF model of the Australian, state and territory economies (see appendix A).

**Global exploration: Australia in context**

**MEG survey of overseas exploration**

The recent downturn in mineral exploration in Australia has coincided with a substantial fall in global mineral exploration. Each year, the Metals Economics Group (MEG) undertakes a survey of global nonferrous exploration (see their web site: www.metalseconomics.com).

MEG estimates that over the period 1991–2001 the survey coverage ranges between 76 per cent (1995) and 90 per cent (2000 and 2001) of global nonferrous mineral exploration expenditure. Expenditures that are not covered by the survey are listed as origin unknown (figure 7).

In 2000 US dollars, global nonferrous exploration expenditure is estimated to have declined by 61 per cent from US$5.6 billion in 1997 to US$2.2 billion in 2001 (figure 7). Reflecting exchange rate changes, in Australian dollars, real global nonferrous exploration expenditure is estimated to have declined by 44 per cent between 1997 and 2001 (figure 7).
There has been considerable variation in the experience of individual countries or regions over the past decade.

- **Australia**’s share of global nonferrous mineral exploration expenditure fluctuated within a relatively narrow band during the decade, falling from 15.3 per cent in 1991 to a low of 12.9 per cent in 1997 before recovering to 15.7 per cent in 2001.

- **North America**’s share declined from 33.4 per cent in 1991 to a low of 14.9 per cent in 1998, but has since increased to 22.1 per cent in 2001.

- **Latin America**’s share increased from 8.7 per cent in 1991 to 25.9 per cent in 2000.

- **Africa**’s share declined from 13.7 per cent in 1991 to 4.0 per cent in 1993 but recovered to 12.5 per cent in 2001.

- **Other countries** recorded an overall increase in share from 8.9 per cent in 1991 to 13.9 per cent in 2001.

Australia has therefore maintained its competitive position over the decade, while Latin America has gained significant market share, and north America and Africa have lost market share.

The growth in mineral exploration activity in Latin America and other developing countries largely reflects the economic and political reforms undertaken in those regions over the past decade (Middleton, Huggan and Clarke 1996; Otto 1998). Further, many of these countries implemented policies specifically aimed at encouraging foreign mining investment: for example, Argentina’s 1993 Mining Investment Law guaranteed that mining companies will not be subject to an increase in their total tax exposure for thirty years (Albarracin 1997).

If the origin unknown category is allocated equiproportionately to regions, Australia’s share in global nonferrous exploration expenditure increased slightly from a low of 16.7 per cent in 1997 to 17.5 per cent in 2001 (compared with 19.1 per cent in 1991).
Overseas exploration by Australian companies

PricewaterhouseCoopers (2001), on behalf of the Minerals Council of Australia, undertakes an annual survey of the location of exploration expenditure by Australian companies. Information on overseas exploration expenditure by Australian companies is sought, by commodity and by overseas region.

To facilitate an assessment of trends over time, PricewaterhouseCoopers (2001) reports separately a constant group category based on respondents that have provided data over the past decade (figure 8).

Based on this constant group of respondents, real domestic and overseas exploration expenditure together increased from A$394 million in 1988-89 to a peak of A$950 million in 1996-97 and has since decreased to A$481 million in 2000-01 (all values are in 2000-01 prices).

Between 1996-97 and 2000-01, overseas and domestic exploration expenditure by Australian companies declined by 62 per cent and 40 per cent respectively. The proportion of expenditure by Australian companies that is allocated for overseas exploration increased markedly from 30 per cent in 1988-89 to a peak of 46 per cent in 1998-99, and has since declined to 32 per cent in 2000-01.

### Survey data on overseas exploration expenditure by Australian companies

**constant group**

**a. Expenditure in Australian dollars**

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<tbody>
<tr>
<td>Value</td>
<td>A$394</td>
<td>A$429</td>
<td>A$584</td>
<td>A$596</td>
<td>A$481</td>
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**b. Share of total**

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<tr>
<td>%</td>
<td>30</td>
<td>40</td>
<td>50</td>
<td>55</td>
<td>32</td>
</tr>
</tbody>
</table>

**Australia’s recent exploration history**

**Overview**

Summary information on exploration expenditure for mineral resources other than petroleum (subsequently referred to as mineral exploration expenditure) in Australia over the past two decades is provided in table 2. Exploration expenditure for individual mineral resources is allocated according to the major mineral sought by the exploration or mining company.

The share of gold was 52 per cent in 2001-02, lower than the share of 54 per cent in 2000-01 and the average share of 57 per cent in the 1990s but higher than the average share of 42 per cent in the 1980s. The share of base metals and nickel was 21 per cent in 2001-02, compared with 24 per cent in 2000-01, and an average of 23 per cent in the 1990s and 1980s. Over the past two decades, the shares for mineral sands and iron ore have increased, while
the shares for coal and uranium, diamonds and the ‘other’ category have decreased (although each increased in 2001-02).

This information includes expenditure on aerial surveys, general surveys, report writing, map preparation, airborne surveys, administration expenses and other activities indirectly attributable to mineral exploration (ABS 2002a). The goods and services tax (GST) which came into effect on 1 July 2000 is not included in the expenditure estimates, although the previous wholesale sales tax is included up to the June quarter 2000.

Throughout this report, exploration expenditure has been adjusted for general price movements by deflating the original series using Australia’s consumer price index (CPI) excluding the impact of the introduction of the GST. Thus, for example, Australia’s inflation rate excluding the impact of the GST is estimated to have been 3.2 per cent in 2000-01, compared with a 6.0 per cent increase in the published consumer price index. In this report, all values in Australian dollars are expressed in constant 2000-01 prices (unless otherwise specified).

There have been four distinct peaks in mineral exploration during the past three decades (figure 9). Investment decisions in mineral exploration, production and processing are based on expected geological, economic and policy conditions, taking into account associated risks. In general, the economic incentives to increase mineral exploration expenditure in each episode are either consistent with or resulted in discoveries that led to an increase in investment in mine site and related developments.

### 2 Real mineral exploration expenditure in Australia, by resource a

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<tbody>
<tr>
<td></td>
<td>Level</td>
<td>Share</td>
<td>Level</td>
<td>Share</td>
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<tr>
<td></td>
<td>A$m</td>
<td>%</td>
<td>A$m</td>
<td>%</td>
</tr>
<tr>
<td>Gold</td>
<td>412.2</td>
<td>42.0</td>
<td>523.7</td>
<td>57.3</td>
</tr>
<tr>
<td>Base metals and nickel</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Copper</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Silver, lead–zinc</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Nickel, cobalt</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Total</td>
<td>227.5</td>
<td>23.2</td>
<td>213.8</td>
<td>23.4</td>
</tr>
<tr>
<td>Coal and uranium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coal</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
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<tr>
<td>Uranium</td>
<td>na</td>
<td>na</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Total</td>
<td>158.3</td>
<td>16.1</td>
<td>57.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Diamonds</td>
<td>68.8</td>
<td>7.0</td>
<td>50.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Mineral sands</td>
<td>11.2</td>
<td>1.1</td>
<td>15.0</td>
<td>1.6</td>
</tr>
<tr>
<td>Iron ore</td>
<td>22.5</td>
<td>2.3</td>
<td>27.2</td>
<td>3.0</td>
</tr>
<tr>
<td>Other</td>
<td>79.9</td>
<td>8.1</td>
<td>26.3</td>
<td>2.9</td>
</tr>
<tr>
<td>Total</td>
<td>980.4</td>
<td>100.0</td>
<td>913.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>

a Excluding petroleum. b Percentage change from 1999-2000. c Percentage change from 2000-01. na Not available.
Industry profitability has fluctuated widely since 1976-77, the first year for which data are available (figure 9). World commodity prices, which summarise international market conditions, have also fluctuated widely in recent decades (figure 9). Notably, industry profitability may increase prior to an investment boom (as in the late 1970s) or be reduced if, for example, anticipated world commodity price rises were not realised or sustained (early 1980s). Alternatively, there may be a lag between the time of increased investment in exploration and related activities, and the return on these investments in the form of increased profit rates (late 1990s).

The four peaks in mineral exploration expenditure that have occurred since 1969-70 vary widely in terms of the coverage of mineral resources that are targeted. Exploration expenditure since 1979-80 is provided in figure 10 for three major resource groups — gold, base metals and nickel (copper, silver–lead–zinc, nickel and cobalt), and coal and uranium — and a residual ‘other’ category.

Some background to each of these expansionary phases, and the corresponding contractionary phase, is provided below.

**Nickel boom, peak in 1970-71**
The peak in mineral exploration expenditure of A$1.2 billion in 1970-71 is mainly attributed to a nickel boom, triggered by the discovery of a new type of nickel deposit in Western Australia which increased the prospectivity of the region together with a significant increase in real nickel prices since 1967-68. Eleven major nickel deposits were discovered between 1966 and 1970, compared with only four between 1971 and 1975.

Blain (1992) notes that there was also an increase in base metals exploration during this period against a background of increases in base metal prices between 1967 and 1970.

**Broadly based resources boom, peak in 1981-82**
The peak in mineral exploration expenditure of A$1.4 billion in 1981-82 was triggered by actual and expected world commodity price increases following the
second oil price shock in the late 1970s. Notably, higher energy prices provided the economic incentive to increase exploration expenditure for coal and uranium from A$67 million in 1974-75 to a record high of A$389 million in 1981-82.

Between 1979-80 and 1981-82 annual exploration expenditure increased for gold (by 162 per cent), diamonds (62 per cent), base metals and nickel (51 per cent) and iron ore (23 per cent).

The anticipated resources boom did not eventuate (in terms of both magnitude and duration) and an economic downturn in OECD countries placed downward pressure on world commodity prices in the early 1980s. Mineral exploration expenditure in Australia fell to a low of A$0.8 billion in 1985-86.

**Gold boom, peak in 1987-88**

Mineral exploration expenditure increased to A$1.2 billion in 1987-88. Despite a relatively small decline in 1982-83, gold exploration expenditure increased overall from A$85 million in 1979-80 to a record high of A$867 million in 1987-88. The share of gold in mineral exploration expenditure also reached a record high of 72 per cent in 1987-88.

The increase in mineral exploration for gold followed the adoption since the early 1980s of a new gold ore processing technology that markedly lowered economic cutoff grades. The substantial rise in world gold prices during the 1970s (mainly reflecting increased demand for gold as a store of value during a period of high inflation) is likely to have contributed to the increased interest in gold exploration and mining.


An economic downturn in OECD countries from 1991 to 1993 contributed to a more general fall in world commodity prices during this period. Mineral exploration expenditure in Australia fell to a low of A$0.7 billion in 1991-92.

**Boom in gold and other resources, peak in 1996-97**

Mineral exploration expenditure increased to A$1.2 billion in 1996-97. Gold accounted for the major part of the overall rise, increas-
ing its share in mineral exploration expenditure from 50 per cent to 63 per cent during this period.

The timing and magnitude of this expansionary phase varied between resources. Real exploration expenditure increased for:

- gold and diamonds, by 113 per cent and 48 per cent, respectively, over the period 1991-92 to 1996-97;
- base metals and nickel, by 57 per cent over the period 1991-92 to 1995-96;
- coal and uranium, by 138 per cent over the period 1992-93 to 1997-98;
- iron ore, by 221 per cent over the period 1994-95 to 1998-99; and
- mineral sands, by 393 per cent over the period 1994-95 to 2001-02.

The release of new government aeromagnetic data in prospective areas, several major gold and base metal discoveries in the early 1990s that encouraged further exploration activity, and the adoption of a new nickel ore processing technology are major factors that contributed to the upturn. A recovery in OECD economic growth rates in 1994, and a corresponding rise in world commodity prices, are also likely to have contributed to increased exploration activity.

The recent mineral exploration downturn in Australia

Between 1996-97 and 2001-02, mineral exploration expenditure in Australia declined by 49 per cent to A$623 million, the lowest level since 1978-79. The outcome in 2001-02 was A$102 million or 14 per cent lower than the 1991-92 trough and A$151 million or 19 per cent lower than the 1985-86 trough.

Major international and domestic factors associated with the recent mineral exploration downturn in Australia are discussed below.

International factors associated with the downturn

Price movements summarise changes in supply and demand conditions in world commodity markets. Notably, the business cycle has a strong influence on commodity prices through demand side impacts — that is, there are significant linkages between annual fluctuations in OECD industrial production and world commodity prices (figure 11).

Following the prolonged economic downturn in the early 1990s, OECD member countries recorded strong economic growth in 1994 and 1995. Growth in OECD industrial production moderated in 1996 (2.5 per cent) and 1998 (1.8 per cent), and declined markedly in 2001 as the latest economic downturn became relatively widespread (–2.6 per cent).

The decline in OECD industrial production in 1998 was mainly associated with the sharp downturn in Japan (–7.1 per cent) that followed the Asian economic downturn in 1997. Japan and other Asian countries are particularly important for Australia’s exports of minerals and metals. In 2001-02, for example, Asia accounted for 60 per cent and 77 per cent of Australia’s minerals and energy exports respectively (Penm et al. 2002).
The economic downturn in 2001 was experienced in North America, western Europe as well as Japan (Penm 2002). Notably, US industrial production declined in 2001 (–3.7 per cent) following a period of sustained growth between 1992 and 2000 (averaging 4.6 per cent). In Japan, industrial production fell by 7.7 per cent in 2001. OECD industrial production is assumed by ABARE to fall by a further 0.4 per cent in 2002 before recovering by 2.3 per cent in 2003 (Penm 2002).


Assessments by gold market participants have also been influenced by a series of announcements in 1997, 1998 and 1999 that indicated a major change in the attitude and behavior of central banks toward official gold holdings. There remains substantial uncertainty about central bank gold sales over the medium term. The current signatories to the Washington Agreement are likely to extend their arrangement beyond September 2004, and additional central banks may join the agreement. (Official sector gold sales and other influences on the gold market are discussed in more detail in chapter 4.)


World mineral commodity prices when expressed in Australian dollars are clearly influenced by exchange rate movements. Notably, the US dollar has strengthened appreciably against other major international currencies and the Australian dollar since 1997 — on a trade weighted basis, the US dollar appreciated by around 30 per cent between 1997 and early 2002 (Penm et al. 2002).

Between 1996-97 and 2001-02 the Australian dollar depreciated by 33 per cent against the US dollar, from US$0.78 to US$0.52. The depreciation of the Australian dollar against the US dollar in recent years has modified the impact of lower world mineral commodity prices when expressed in Australian dollars (figure 12).
The real price of several commodities declined in 1996. Between 1996 and 2001, in Australian dollars, the real prices of gold and lead declined (by 5 and 14 per cent respectively). Over the same period, however, real prices of other selected mineral commodities increased, including zinc (18 per cent), copper (1 per cent), nickel (8 per cent), coal (13 per cent between 1996-97 and 2001-02), uranium (4 per cent between 1996-97 and 2001-02), diamonds (164 per cent), ilmenite (39 per cent), rutile (16 per cent), zircon (31 per cent) and iron ore (32 per cent).

Penm et al. (2002) examine some key implications for Australia’s commodity exports of a possible depreciation of the US dollar under two scenarios — a ‘soft landing’ and a sharp

### 12 Real mineral price indexes in Australian dollars

**base 1980=100**

#### a. Gold

Real gold prices in Australian dollars trended down over the past two decades, falling by 65 per cent between 1980 and 2001.


Between 1996 and 2001, real gold prices in Australian dollars fell by 5 per cent.

#### b. Base metals and nickel

Between 1980 and 2001, real prices declined for lead (–57 per cent), copper (–48 per cent), nickel (–28 per cent) and zinc (–3 per cent).

There was some variation in the timing of cyclical peaks. Real prices for base metals and nickel tended to peak in the mid-1980s, the late 1980s, the mid-1990s and 2000.

#### c. Coal and uranium

Real export unit values for coal and uranium in Australian dollars trended down over the past two decades, although the rate of decline slowed markedly during the 1990s.

Real export unit values for coal and uranium in Australian dollars fell by 40 per cent and 75 per cent, respectively, between 1980-81 and 2001-02.
depreciation. Under a ‘soft landing’ the trade weighted value of the US dollar declines gradually by around 10–15 per cent over the next two to three years. ABARE’s current set of commodity forecasts is based on the assumption of a ‘soft landing’ of the US dollar (see ABARE 2002 for short term commodity forecasts).

International mergers and acquisitions activity in the mining sector has resulted in a significant rationalisation of mineral exploration budgets in recent years. Declining profit rates, and more general industry concern about prospective profit rates over the medium to longer term, are likely to have been major contributing factors to the international merger wave that has been evident since 1996. (Mergers and acquisitions activity are discussed in chapter 2.)

### Real mineral price indexes in Australian dollars base 1980=100

<table>
<thead>
<tr>
<th>d. Diamonds</th>
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<tbody>
<tr>
<td><img src="diamonds_graph.png" alt="Graph" /></td>
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<tr>
<td>Real export unit value for diamonds in Australian dollars fluctuated widely after the late 1990s, peaking in the period 1993–95, and increasing again in 2000. The real export unit value for diamonds increased by 88 per cent between 1988 and 2001.</td>
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<th>e. Mineral sands</th>
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<tbody>
<tr>
<td><img src="mineral_sands_graph.png" alt="Graph" /></td>
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<tr>
<td>Real export unit values for zircon and ilmenite in Australian dollars trended strongly upward over the past two decades, rising by 335 per cent and 181 per cent between 1980 and 2001. The real export unit value for rutile increased by 23 per cent over the period. The real export unit value for zircon was subject to substantial cyclical fluctuations, peaking in 1989 and 1997.</td>
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<thead>
<tr>
<th>f. Iron ore</th>
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<tr>
<td><img src="iron_ore_graph.png" alt="Graph" /></td>
</tr>
<tr>
<td>The real export unit value for iron ore in Australian dollars fell by 39 per cent between 1980 and 1996 before recovering by 32 per cent between 1986 and 2001. The real export unit value for iron ore was 19 per cent lower in 2001 than in 1980. The real export unit value for iron ore peaked in 1982, 1985, 1992 and 1998.</td>
</tr>
</tbody>
</table>
Any efficiency gains from mergers and acquisitions activity, and attempts to streamline exploration budgets, may flow through to increased profit rates over the medium to longer term. In Australia, the return on shareholders’ funds in the mining and mineral processing industries (excluding petroleum) averaged 2 per cent between 1996-97 and 1999-2000, but increased markedly to 11 per cent in 2000-01 (see figure 9).

**Land access issues associated with native title areas in Australia**

According to the ResourceStocks/AIG world investment risk survey for 2002, Australia has the lowest aggregate risk rating for resource investment within the group of twenty countries included in the survey (comprising Canada, the United States, the Russian Federation and a range of developing countries) (Bell 2002). However, there are three individual categories for Australia that were rated equally as relatively important sources of risk (each with a score of 3 out of 5, with 5 as most important). These are land access, green tape and land claims.

The increased difficulties associated with land access in Australia over the past decade are indicated by the divergence between the number of exploration and mining title applications pending and those granted (figure 13). The backlog has become particularly significant in the period after the Wik decision of December 1996 which extended native title to pastoral lease land.

In the first three quarters of 2000-01, exploration title applications in Australia comprised 5809 pending and 1003 granted, and mining title applications comprised 7488 pending and 329 granted.

It should be noted that most of the mining lease applications are essentially exploration licence applications. The backlog in applications may also be overstated to the extent that companies have lodged applications in excess of their expected short term requirements — a strategy that is a response to the substantial uncertainties about the time delays involved in the processing of applications.

Land access issues for exploration and mining activities relating to native title areas, and environmental and heritage uses are discussed in chapter 5. It should also be noted that increased environmental standards and land access issues have been significant factors in a number of countries.
Mineral exploration expenditure and discoveries in Australia

In Australia, there has been considerable variation in exploration expenditure and discovery rates between resources in recent years (figure 14).

Discoveries in a given calendar year are estimated from changes in economic demonstrated resources (end of calendar year data) taking into account production during the calendar year. This simple relationship is readily derived by observing that economic demonstrated resources at the end of year \( t (EDR_t) \) may be assumed to be equal to economic demonstrated resources at the end of year \( t-1 (EDR_{t-1}) \) plus production during the calendar year \( (P_{t}) \) and minus new discoveries during the year \( (D_{t}) \):

\[
EDR_t = EDR_{t-1} + P_t - D_t
\]

Significant discoveries in the period 1989–93 resulted in followup expenditure on reserve delineation and encouraged further exploration for new deposits, a number of which were discovered in 1996 and 1997.

Gold discoveries tend to be more frequent and smaller than for some other resources such as base metals, coal and iron ore.

Historical time series data for exploration expenditure are only available for copper, lead, zinc and nickel in aggregate.

Higher prices in the late 1980s and major base metal discoveries in 1990 encouraged exploration expenditure in subsequent years.

The recent increase in discoveries mainly reflects a rise in nickel discoveries.

The increase in discoveries for coal in 1987 followed a major review by the NSW Department of Mineral Resources of the state’s resources. The recent fall follows company reassessments.

Restrictions on uranium mining — the three mines policy — were introduced in 1983, with three other projects shelved. The policy was reviewed in 1988–91, and relaxed in 1996 (see www.uic.com.au).

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**Exploration expenditure and discoveries in Australia for selected mineral resources**

- **a. Gold**

  Significant discoveries in the period 1989–93 resulted in followup expenditure on reserve delineation and encouraged further exploration for new deposits, a number of which were discovered in 1996 and 1997.

- **b. Base metals and nickel**

  Historical time series data for exploration expenditure are only available for copper, lead, zinc and nickel in aggregate.

- **c. Coal and uranium**

  The increase in discoveries for coal in 1987 followed a major review by the NSW Department of Mineral Resources of the state’s resources. The recent fall follows company reassessments.

**a** Discoveries include revisions to EDR and are calendar year data (for example, 2000 where 2000-01 is indicated). EDR information is published by Geoscience Australia.
resources at the end of the previous year, \( t-1 \) (\( EDR_{t-1} \)) plus discoveries (\( D_t \)) less production (\( Q_t \)) during year \( t \); that is:

\[
EDR_t = EDR_{t-1} + D_t - Q_t
\]

which, rearranged, becomes:

\[
D_t = EDR_t - EDR_{t-1} + Q_t
\]

The discovery of the world class Argyle diamond deposit in 1979 encouraged further exploration for new deposits.

Fluctuations in discoveries mainly reflect reassessments of reserves at the Argyle mine.

Price movements are also likely to have had some impact on EDR assessments.

There are very strong linkages between exploration expenditure and discoveries of mineral sands.

Fluctuations in exploration expenditure for mineral sands are strongly influenced by price movements.

Substantial mineral sands deposits were recently discovered in the Murray Basin.

Linkages between exploration expenditure and iron ore discoveries were strong between 1980-81 and the mid-1990s.

Iron ore exploration in recent years has mainly targeted higher quality deposits.

Average discovery costs for iron ore approximately doubled in the 1990s compared with the 1980s.

\( \text{a} \) Discoveries include revisions to EDR and are calendar year data (for example, 2000 where 2000-01 is indicated). EDR information is published by Geoscience Australia.
Discoveries are therefore estimates of economic discoveries. Discoveries may reflect discoveries of new ore deposits that are assessed to be economic, reassessments of reserves at discovered ore deposits and changes in economic factors (such as price or technological change). Discoveries may fluctuate widely mainly reflecting new significant discoveries and major reassessments of reserves at significant deposits, although substantial changes in economic factors can have an impact (see chapter 2 for information on economic demonstrated resources).

The recent downturn is largely associated with reduced spending on exploration for gold, base metals and nickel. Exploration expenditure has also declined in recent years for coal and uranium, diamonds and iron ore (although exploration expenditure for copper and coal has each recovered somewhat since 1999-2000).

While there is a significant random element in the timing and nature of discoveries of mineral ore deposits, reduced investment in exploration activity tends to result in a lower level of discoveries.

Discoveries of gold ore deposits have declined sharply, from a peak of 1100 tonnes in 1995 to 200 tonnes in 2000 (although there was a brief peak of 900 tonnes in 1999). Discoveries of base metals and nickel ore deposits have also declined from the peak of 49 million tonnes in 1993, although discoveries increased again to 15 million tonnes in 2000 (the recent peak was mainly discoveries of nickel ore deposits) — annual discoveries averaged 2 million tonnes between 1994 and 1999.

In each case, significant discoveries in the early 1990s encouraged further exploration expenditure both for reserve delineation purposes and to discover additional new deposits. The recent peaks, particularly for gold, reflect to some extent the impact of subsequent discoveries and associated reserve delineation activity.

The time path for discoveries of uranium ore deposits (not included in figure 14) has been similar to that for base metals, with a sharp decline from a peak in 1993, a period of relatively few discoveries, followed by a recent (but lower) peak in 2000.

It should be noted that some mineral resources may be more readily proven up to the levels of economic demonstrated resources than others. For example, resources such as coal, bauxite and iron ore are generally found in large deposits, allowing for large quantities of economic demonstrated resources to be proven up for a single discovery. By contrast, gold is typically found more frequently in smaller deposits.

For some mineral resources, such as iron ore, exploration activity may occur to discover better quality deposits than currently available. In addition, technological developments can lead to previously uneconomic deposits becoming economic. A contemporary example is Rio Tinto’s HIsmelt project which if successful could lead to more than a billion tonnes of currently uneconomic ore (due to high phosphorous content) becoming minable.

Exploration spending may vary between resources, reflecting differences in incentives to discover mineral deposits in previously unexplored areas using current technologies (green-
fields exploration), as well as differences in the economics of proving up resources (part of brownfields exploration) during the course of a mining operation.

For example, the identified resource estimates published by Geoscience Australia imply that there are substantial inferred resources for diamonds. Exploration for inferred resources is likely to be significantly lower risk, and lower cost, than for undiscovered resources. In the case of diamonds the key influence on exploration has been the discovery of the Argyle deposit in 1979. This discovery led to an increase in diamond exploration in the early 1980s, not only to delineate the Argyle orebody but also in response to Australia’s increased prospectivity for large diamond deposits.

Indexes of the EDR to production ratio in Australia for selected mineral resources
base 1980=100

Between 1980 and 2000, the EDR to production ratio for gold declined by 14 per cent. The rise in the EDR to production ratio during the 1990s largely reflects a leveling off in gold production. In 2000-01, 69 per cent of gold production occurred in Western Australia.

Between 1980 and 2000, the EDR to production ratio for lead and zinc declined by around 50 per cent, while the ratio for copper and nickel increased. The strong rise in the EDR to production ratio for nickel during the 1990s reflects the impact of technology adoption on the economics of nickel ore mining.

Between 1980-81 and 2000-01, the EDR to production ratio for coal and uranium declined by 49 per cent and 10 per cent respectively. Coal production increased from 87 million tonnes in 1980-81 to 257 million tonnes in 2000-01. The peak in the ratio for uranium in the mid-1990s reflects an increase in EDR in 1993 and a temporary fall in production.
The increased importance of exploration in brownfield areas is indicated by exploration activity on production leases. A production lease is an area in which production or development is actually taking place (ABS 2002a).

Mineral exploration activity in production lease areas has increased significantly since the early 1980s, peaking in 1996-97. Increased mineral exploration in production lease areas is likely to have occurred to some extent as a consequence of increased difficulties in accessing new areas.

Between 1986 and 2000, the EDR to production ratio for diamonds almost halved.

The EDR to production ratio for diamonds fell sharply between 1983 and 1986, prior to the commencement of full production at the Argyle diamond mine.

In 2000-01, 99.5 per cent of diamond production occurred in Western Australia.

Between 1980 and 2000, the EDR to production ratio for mineral sands increased markedly.

In 2000-01, mineral sands were mainly produced in Western Australia — 96 per cent of ilmenite, 61 per cent of rutile and 86 per cent of zircon.

The EDR to production ratio for iron ore fell to 49 per cent between 1980 and 2000.

Iron ore production increased from 96 million tonnes in 1980 to 170 million tonnes in 2000.

In 2000-01, 97 per cent of iron ore production occurred in Western Australia.
The level of mineral exploration activity in a particular lease area may be indicated by expenditure and metres drilled. The share of mineral exploration expenditure on production leases has increased from 11 per cent in 1979-80 to 21 per cent in 2001-02, peaking at 27 per cent in 1996-97. There has been a corresponding increase in the share of metres drilled on production leases from 16 per cent in 1981-82 (the first year available) to 29 per cent in 2001-02, peaking at 35 per cent in 1996-97.

On average, exploration expenditure on production leases was 23 per cent of total expenditure in the 1990s and 11 per cent in the 1980s. Metres drilled on production leases was an average of 30 per cent of total metres drilled in the 1990s and 21 per cent in the 1980s (excluding 1980-81).

Exploration in a brownfields area using grassroots techniques for a different resource may be regarded as greenfields (for that resource). However, exploration activity on production leases provides the best indication available of the relative importance of lower risk brownfields exploration activity.

**Australia's economic demonstrated resources relative to production**

Over the past two decades, technology adoption was sufficient to reduce the average discovery costs in the 1990s for several resources, including gold, base metals and nickel, diamonds and mineral sands. In general, exploration has resulted in discoveries which, together with technology adoption in mining and mineral processing, has supported growth in mineral production for all selected mineral resources except rutile and zircon.

The EDR to production ratio provides some indication of the number of years that current resources would maintain the industry at current production levels. For seven of the twelve resources, the level of economic demonstrated resources relative to production was lower in 2000 than the average over the period 1979–2000 (see table 1).

Between 1995 and 2000, discoveries were sufficient to increase economic demonstrated resources for some minerals (such as gold, nickel and ilmenite). However, economic demonstrated resources have declined in recent years for a number of other minerals (such as zinc, lead and iron ore) (see chapter 2 for more information). Over the same period, production increased for all selected mineral resources except diamonds and zircon.

Indexes of economic demonstrated resources relative to production for selected mineral resources are provided in figure 15. Between 1995 and 2000, economic demonstrated resources relative to production declined for gold (−1 per cent), copper (−54 per cent), lead (−51 per cent), zinc (−43 per cent), coal (−34 per cent), uranium (−45 per cent) and iron ore (−36 per cent). The ratio increased for nickel (231 per cent), diamonds (26 per cent) and mineral sands (ilmenite, 33 per cent; rutile, 44 per cent; and zircon, 72 per cent).

An assessment of the implications of current exploration expenditure, if maintained, for future discoveries and production levels for each of the selected mineral resources is beyond the scope of this study. However, linkages between gold exploration and production are examined in further detail in chapter 4, with some simulations provided over the medium term.
The importance of mineral exploration, production and processing in Australia

A range of economic variables may be used to indicate the importance of exploration, mining and mineral processing in the national, state and territory, and regional economies.

Some widely cited economic indicators are output, employment, investment, taxation revenue and exports. Due to data limitations, this information varies by jurisdiction, timeliness and coverage of mining and mineral processing activities.

Economic contribution to the Australian economy

Output, employment and investment

The shares of mining and mineral processing activities in Australian output, employment and investment are given in table 3. In 2001-02, mining and mineral processing (including petroleum production and processing) accounted for 9.0 per cent of gross domestic product, 4.3 per cent of total employment, and 24.7 per cent of new capital expenditure.

Taxation payments

Taxation payments for resource based taxes, direct taxes and indirect taxes since 1982-83 are given in figure 16 based on data published in PricewaterhouseCoopers (2001). Net profit is also included in the figure to provide some benchmark for the taxation payments.

Total tax payments by the national industry (excluding petroleum) were A$4.3 billion in 2000-01, comprising A$1.1 billion, A$2.8 billion and A$0.5 billion for resource based, direct and indirect taxes, respectively.

3 Mining and mineral processing in Australian output, employment and investment, 2001-02

<table>
<thead>
<tr>
<th>Industry gross value added a</th>
<th>Employment p</th>
<th>New capital expenditure b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>Share</td>
<td>Level</td>
</tr>
<tr>
<td>A$m</td>
<td>%</td>
<td>'000</td>
</tr>
<tr>
<td>Mining</td>
<td>31 658</td>
<td>4.5</td>
</tr>
<tr>
<td>Mineral processing</td>
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<td></td>
</tr>
<tr>
<td>Petroleum, coal, chemical, etc.</td>
<td>10 333</td>
<td>1.5</td>
</tr>
<tr>
<td>Nonmetallic mineral products</td>
<td>4 230</td>
<td>0.6</td>
</tr>
<tr>
<td>Metal products</td>
<td>16 221</td>
<td>2.3</td>
</tr>
<tr>
<td>Total mineral processing</td>
<td>30 784</td>
<td>4.4</td>
</tr>
<tr>
<td>Total mining and mineral processing</td>
<td>62 442</td>
<td>9.0</td>
</tr>
<tr>
<td>Australia</td>
<td>697 606</td>
<td>100.0</td>
</tr>
</tbody>
</table>

a Chain volume measures, reference year 2000-01. b In current prices. p Preliminary. 
Source: ABARE (2002).
Between 1982-83 and 2000-01, total tax payments in 2000-01 prices ranged between $2.0 billion (1983-84) and $4.9 billion (1989-90), with an average of $3.2 billion. By contrast, net profit ranged between $0.6 billion (1997-98) and $5.5 billion (1989-90), with an average of $2.2 billion over the period.

Exports

Australia’s competitive advantage in mining and mineral processing is highlighted by the export data (figure 17). Australia’s exports of minerals and metals (that is, mineral resource exports excluding petroleum, in 2000-01 prices) increased from $9.3 billion in 1969-70 to A$42.5 billion in 2001-02. This represents an average annual growth rate of 4.9 per cent, slightly above the 4.6 per cent growth rate recorded for total exports of goods and services.

Minerals and metals accounted for an average of 32 per cent of Australia’s total exports of goods and services during this period, recording a high of 37 per cent in 1989-90.

In 2001-02, the share of each sector in Australia’s total exports of goods and services was:

- 29 per cent for minerals and metals
- 7 per cent for petroleum
- 22 per cent for the rural sector
- 22 per cent for other merchandise goods
- 20 per cent for services.

Between 1969-70 and 2001-02, exports of other merchandise goods and services increased strongly, at an average annual rate of 6.4 per cent and 5.3 per cent respectively. (In 2001-02, however, exports of other merchandise goods and services fell by 0.8 per cent and 9.1 per cent respectively.)

Exports from the mining technology services (MTS) sector are likely to have increased significantly over the past decade, contributing to the strong growth in exports of other merchandise goods and services over this period. Based on survey information from member companies, Austmine estimates that exports of mining technology, equipment and services
in current prices were around A$1.3 billion in 1999-00 and are likely to have increased to around A$1.7 billion in 2000-01 (Austmine 2001).

Given further strong export potential in mining related goods and services, on 6 June 2001 Senator the Hon. Nick Minchin, then Minister for Industry, Science and Resources, announced the development of the Mining Technology Services Action Agenda (Minchin 2001). Background to the Action Agenda is provided in Department of Industry, Tourism and Resources (2002).

ABARE has undertaken a research project on behalf of the Department for use in the Action Agenda process. In this study, a survey based approach is used to estimate production, exports and employment in the mining technology services sector and to identify the importance of a range of issues (Tedesco, Copeland and Hogan 2002).

**Contribution to the state and territory economies**

As indicated in chapter 2, Australia’s identified mineral resources are dispersed unevenly across the continent, with regional clustering for some important resources such as gold, iron ore and coal (see AGSO / Geoscience Australia 2001; ABARE 2001a,b). The economic contribution of exploration and mining therefore varies markedly between states and territories in Australia.
Notably recent exploration activity has been mainly located in Western Australia (table 4).

While a given jurisdiction may comprise a relatively small share of the national industry, exploration, mining and mineral processing activities may have significant implications for the corresponding state or territory economy.

This is highlighted in figure 18 which provides the share of minerals and metals exports in total exports of goods and services in each jurisdiction in 2000-01. Most notably, Tasmania accounted for only around 3 per cent of Australia’s exports of minerals and metals in 2000-01, but minerals and metals accounted for around 43 per cent of Tasmania’s exports of goods and services.

### Mineral exploration expenditure, by state and territory, 2001-02

<table>
<thead>
<tr>
<th>Level</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Australia</td>
<td>381.1</td>
</tr>
<tr>
<td>Queensland</td>
<td>92.7</td>
</tr>
<tr>
<td>New South Wales</td>
<td>48.3</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>48.4</td>
</tr>
<tr>
<td>Victoria</td>
<td>33.9</td>
</tr>
<tr>
<td>South Australia</td>
<td>32.1</td>
</tr>
<tr>
<td>Tasmania</td>
<td>4.0</td>
</tr>
<tr>
<td>Australia</td>
<td>640.6</td>
</tr>
</tbody>
</table>


### Contribution to regional economies

Mining is also important for many regional economies. The revealed competitive advantage of a region with respect to particular industries indicates the economic activities in which each region is relatively competitive. Hogan, Berry and Thorpe (1999) estimated the revealed competitive advantage of mining in regional economies using ABS employment census data for Australia’s statistical divisions for 1996. Employment data for mineral processing activities were unavailable.

The revealed competitive advantage of mining in regional economies is estimated by dividing the regional mining industry’s share in regional employment by the national mining industry’s share in national employment. A ratio that exceeds 1 — that is, where the mining industry has a higher share in regional employment than in national employment — indicates that the region has a revealed competitive advantage in mining.
Hogan et al. (1999) found:

- three regions that have a very strong revealed competitive advantage in mining are the Pilbara, the South Eastern region in Western Australia (which includes Kalgoorlie) and the North West region in Queensland (which includes Mount Isa);

- regions relatively close to capital cities that have a revealed competitive advantage in mining include, for example, the Hunter, Illawarra and Central West in New South Wales, East Gippsland in Victoria, and Perth and the South West in Western Australia;

- the regions that do not have a revealed competitive advantage in mining are mainly located in south east Australia.

The role of mining in regional economies is particularly important given the Commonwealth government’s policy initiative — the ‘Regional Australia Strategy’ — that was announced in 1998 and aims to achieve sustainable growth in regional Australia (Anderson and MacDonald 1999).

Further information on mining and other economic activities in rural and remote regions of Australia is provided in ABARE (1999) and Garnaut, Connell, Lindsay and Rodriguez (2001), and related policy assessments in, for example, Productivity Commission (1999) and Hogan and Byrne (2000).
gold exploration, production and economywide impacts in Australia

A detailed analysis of the Australian gold industry is presented in this chapter. This analysis includes a quantitative assessment of the linkages between exploration and production levels. Analysis of exploration and production in the gold industry is important for several reasons. First, the gold industry has historically represented a significant and increasing component of total private minerals expenditure in Australia.

In addition, the cycle between exploration and production in the gold industry is representative of the (longer term) cycles evident in other mineral commodities. That is, the impact of a decline in exploration on production (reduction in future production) will be mirrored in other commodities, albeit on a longer time frame. As such this analysis of the Australian gold industry is expected to provide insights into the importance of exploration for the mining industry more generally.

Trends and issues in the gold industry

World gold market

There are a number of global factors that can have an impact on the Australian gold industry, including official sector activities and world gold prices. For example, an increase in the size of sales or lending activity by the central banks will have a downward effect on price, unless it is prompted by a sharp increase in fabrication consumption or a fall in supply from other sources.

The dynamics of the world gold market are different from many other metals because annual consumption of gold continues to be higher than the volume of annual mine production. This shortfall is met by sales from above ground gold stocks, namely central bank sales (the official sector), disinvestment by the private sector and accelerated supply from producers in the form of hedging. Currently, central banks and private investors are estimated to hold around 50 000 tonnes of gold, all of which has the potential to be sold into the market and push the price of gold down (Simms 2002).

The level of world supply and its relative components are given in figure 19.

There were key peaks in official sector activity in 1989 and 1991. The key reason for the 1989 peak was that the official sector became a net source of supply, providing the market with 225 tonnes of gold. This reversed the trend of previous years, where central banks had
been net buyers of gold. This selling resulted in some weakness in the gold price during the year. However, the underlying strength of physical demand was able to absorb this additional supply without a significant fall in price.

The major seller in 1989 was Belgium, which sold 127 tonnes, or 10 per cent of its total reserves. This selling reflected a desire by this central bank to have greater flexibility with its reserves (by holding a higher proportion of its reserves in foreign currencies) to meet balance of payments requirements or for intervention in foreign exchange markets.

Official sector supply also peaked in 1991 as some central banks undertook a policy of reducing the gold content of official reserves, in line with the reasoning held by Belgium. There was also an increase in official sector sales in response to the deteriorating gold price, which had been declining in real terms since 1987.

In addition, it should be noted that there was a major peak in gold scrap supply in 1998. This was brought on by the east Asian economic downturn (devaluation of many east Asian currencies), which led to a 75 per cent increase in the volume of scrap gold supplied to the market.

A summary of key official sector activities from 1997 is given in box 1. It is evident from these activities that central banks have reduced their desire to hold gold as a reserve asset. A range of global influences underlies this trend and these are not expected to change substantially over the medium term. These influences include increasing liberalisation of the world’s financial markets; increasing economic and political stability in a range of developing nations; a desire for central banks to derive a return from their holdings of reserve assets; and the declining real price of gold. Such changes have resulted in managers of international gold reserves coming under increasing pressure to improve returns on their holdings (Smeeton 1998).

In September 1999, 15 European central banks announced that (under the Washington Agreement on Gold) there would be an annual sales quota of 400 tonnes of gold from official holdings. Although the quota was more than double the average level of sales for the
Box 1: Key gold official sector activities

1997

January: The Netherlands announces that it has sold 300 tonnes of its gold in the previous year.

March: The Swiss National Bank announces a reduction in the gold backing of the franc from 40 per cent to 25 per cent and that it will sell 800 tonnes of gold over seven years for a humanitarian fund.


July: The Reserve Bank of Australia announces that it has sold 167 tonnes of gold (two thirds of the bank’s holdings) over the previous six months.

December 3: Argentina announces that it has sold 124.4 tonnes (90 per cent of its reserves).

1998

March: Belgian and Czech central banks announce sales (undertaken on a forward basis) in late 1997 of 299 and 25 tonnes respectively.

May–July: The newly formed European Central Bank decides to hold gold reserves amounting to 15 per cent of all financial reserves.

September: The Canadian central bank announces sales of 9.2 tonnes undertaken in July and August; 12 tonnes reportedly sold by the Luxembourg central bank; Czech Republic announces 31 tonne sale.

1999

September: Declaration by 15 European central banks that they had decided to cap their collective sales at 2000 tonnes over the next five years and to limit lending and other activities at prevailing levels (Washington Agreement on Gold).

2000

March: The UK treasury confirms plans to sell a further 150 tonnes in the next year.

August: The Swiss National Bank confirms 85 tonnes was sold to mid-August and that there will be 200 tonnes of further sales in 2001.

2001

March: The UK Treasury confirms a further sale of 120 tonnes over a series of 6 auctions every two months. April: Austrian National Bank confirms the sale of 30 tonnes.

September: The Swiss National Bank confirms further sales of 283 tonnes by the end of September 2002.

2002

March: The final UK Treasury gold auction under the Washington Agreement on Gold occurred, bringing to an end the program to restructure the United Kingdom’s official reserves.

September: The Swiss National Bank confirms that a total of 603 tonnes has been sold under the Washington Agreement and that a further 283 tonnes will be sold by September 2003.
group in the 1990s, this outcome was viewed as being bullish for gold, as it created greater certainty for above ground supply levels.

Although there is some uncertainty about central bank gold sales over the medium term, it is expected that sales will increase. This outlook is based on the premise that current signatories to the Washington Agreement will extend their arrangement beyond September 2004, and that additional central banks may join the agreement.

Official sector sales are projected to increase from 490 tonnes in 2002 to 650 tonnes in 2007 (Simms 2002). Some of the official sector gold that will be sold over the next five years will be from non-Washington agreement signatories (90 tonnes in 2002). However, official sector sales for nonsignatories are expected to remain low for two main reasons — reduced demand, and the fact that non-Washington Agreement signatories are already lending nearly 50 per cent of their holdings on average, compared with signatories lending around 14 per cent.

Although there has been some recent commentary on a medium term decline in North American production, ABARE expects that this decline will be offset by an increase in aggregate production from other major producing countries. Total world gold mine production is projected to remain a fairly stable element of the gold market over the outlook period, with production remaining close to 2500 tonnes a year. Over the same period, fabrication consumption is forecast to increase by 15 per cent, to 4000 tonnes. Given the outlook for gold supply and demand, the medium term forecast for gold prices is for the price to be around A$463 per ounce in 2007, around 7 per cent lower than in 2001 (Simms 2002).

Australian gold industry

Australia is currently the world’s third largest gold producer and gold is Australia’s third largest commodity export earner. In 2000-01, the gold industry added value of A$1.8 billion, representing around 19 per cent of the total value added by the metal ore mining sector (ABS 2002b).

Note that in this chapter, all values in Australian dollars are expressed in constant 2000-01 prices (unless otherwise specified).

Over the period 1988-89 to 2001-02 the real value of gold exports increased by around 40 per cent to $4.8 billion (ABARE 2002). ABARE projections indicate that annual exports (in 2001-02 Australian dollars) over the period 2002-03 to 2006-07 are expected to be the range of $5–6 billion (Simms 2002).

In addition to export wealth, the gold mining industry provides Australia with other significant benefits. These include significant employment and income benefits throughout Australia, and particularly in regional areas. As of June 2001, the gold industry employed around 35 per cent of the total persons employed by the metal ore mining sector.

The importance of capital expenditure by the gold industry relative to mining sector expenditure has increased in recent years. In 2000-01, gold capital expenditure ($631 million) was
around one-third of the total fixed capital expenditure ($1.7 billion) by the metal ore mining sector (ABS 2002b).

Over the period 1980-81 to 1989-90, spending on gold exploration represented 42 per cent of total mineral exploration expenditure. This share had risen to 52 per cent in 2001-02 (see table 2).

The gold mining industry is the second highest contributor (behind iron ore) of mineral royalties paid by the metal ore mining sector. In 1999-2000, the gold industry paid around A$68 million in mineral royalties.

**Gold exploration expenditure and productivity**

Real gold exploration expenditures over the period 1981-82 to 2000-01 increased by around 65 per cent to A$370 million, despite real gold prices falling by 40 per cent (figure 20). The strong increase in gold exploration reflects several key factors. The first factor is that although gold prices have declined since the 1980s, real gold prices have remained relatively high compared with those in the early 1970s. This feature has in recent years been assisted by the role of exchange rates. While the US dollar price of gold in 2001 (US$270) was 30 per cent lower than in 1995, the Australian dollar price of gold was the same for those two calendar years (A$521), reflecting the 30 per cent decline in the exchange rate (to US$0.51 in 2001).

The relatively high Australian gold price, together with the development of new gold processing technologies — which had a positive impact on the rates of return for gold ore processing (relative to costs) and lowered the cutoff grade for economic gold deposits — increased the overall profitability of the industry. Together with favorable financial and policy conditions (for example, low rates of interest on gold lending for producer hedging and taxation arrangements), these factors resulted in a significant increase in gold exploration and production during the 1980s.

During the 1990s the gold price fell by around 20 per cent to A$483 an ounce in 1999-2000. Despite declining gold prices, gold exploration expenditure increased in the mid-1990s. This was primarily due to an increased number of major gold discoveries in the mid-1990s, which subsequently required substantial exploration expenditure to allow reserve delineation and mine development. However, by 2000-01, exploration expenditure had declined to a level similar to that of a decade earlier (around $370 million).

There have been two periods of significant declines in gold exploration expenditure. The decline over the period 1987-88 to 1992-93 was primarily a result of a fall in the world gold price and in global stock markets in 1987. More recently, exploration...
expenditure fell from $694 million in 1997-98 to $322 million in 2001-02 (the lowest level since 1983-84).

This outcome may reflect the global downturn in nonferrous exploration expenditure, or may reflect factors that are specific to the Australian gold sector. These factors include land access issues and the trend for mergers and acquisitions in the gold industry (reflecting the fact that the exploration budget of a consolidated company is likely to be lower than the aggregate of the individual companies’ exploration budgets prior to the merger).

Security of access to gold resources may be a factor that has contributed to the downturn in Australian exploration expenditure and may also be important in explaining the trend for greater brownfield exploration (centred around existing mines), rather than exploring prospects in new areas. A qualitative assessment of the impact of land access is given in chapter 6. This impact is also incorporated into the quantitative assessment of exploration and gold production (see section below on modelling methodology).

One simple indicator of the trend in exploration productivity for gold is the average exploration costs for additions to resources (figure 21). The trend in the indicator would suggest that the productivity of exploration for gold increased significantly since the 1980s.

**Gold production and reserves**

Australia’s economic demonstrated resources (EDR) of gold ranked second in the world (11 per cent) in 2000 after South Africa (39 per cent). Western Australia had around 60 per cent of Australia’s total economic demonstrated gold resources (AGSO / Geoscience Australia 2001).

The ratio of production to EDR (gold ore reserves) provides an indication of the time frame that gold ore stockholdings would sustain the gold industry at current production levels (if no further resources were discovered). Economic demonstrated resources for the gold industry have typically represented around ten to twenty years of production. The EDR to production ratio for the industry is presented (as an index) in figure 6, chapter 2.

Economic demonstrated resources are a significant influence on gold mining activity, including exploration activity. Since 1986, EDRs above fifteen years of production have typically been associated with decreases in total exploration expenditure, and vice versa. It is possible that the industry may in aggregate target an economic demonstrated resource to production ratio. A high EDR to production ratio would then be expected to result in a relative decline in exploration expenditure. However, this impact may be partially offset by the continued preference to discover and mine higher quality ore deposits.
Given the increase in exploration expenditure and the breakthrough in gold ore processing technology in the early 1980s, production in Australia has dramatically increased since the 1980s (figure 23). Production increased from around 18 tonnes in 1979-80 to 224 tonnes in 1989-90 and to a historic high of 316 tonnes in 1997-98. Production in 2001-02 was 271 tonnes (ABARE 2002).

Australian gold production is undertaken by a relatively large number of producers, and there were 76 operational mines in 2001. Production from the top 51 per cent of these operational mines ranged from 2.4 tonnes (76 000 ounces) to 19.2 tonnes (616 000 ounces) in 2001. Aggregate production from these mines accounted for around 87 per cent of Australia’s annual gold production. Around 40 per cent of Australian production comes from opencut mines, 10 per cent from underground mines, with the remainder produced by mines with combined opencut and underground operations (Minmet 2002).

From the locational map of Australia’s gold producing mines (map 1), it can be seen that gold production is concentrated in Western Australia, and in particular in the Eastern Goldfields region. Of the top 22 gold producing mines, all but five are located in Western Australia. In 2001, there were 42 operational mines in Western Australia that contributed around 70 per cent of total Australian gold production.

Average real production (cash) costs in Australia declined by around 17 per cent between 1996 and 2001, to $332 an ounce, when Australia was the lowest cash cost producer of gold.
in the world. In 2001, average total costs for Australian gold production (inclusive of royalties and taxes) were US$226 an ounce compared with the world average of US$228 an ounce (GFMS 2002).

Average industry cash margins will have an impact on incentives to invest in that industry. Although there was a decline in cash costs for the gold industry over the period 1986-87 to 2000-01, gold prices have declined at a relatively higher rate (figure 22), resulting in a decrease in industry margins.

Looking at average (five year) industry margins, the margin ratio (industry margin as a percentage of cash costs) declined from around 75 per cent for the period 1986-87 to 1990-91 to around 40 per cent for the period 1996-97 to 2000-01.

Recent industry margins have increased relative to their lowest point in 1996-97 (around 30 per cent). Given the higher Australian gold price in 2000-01 (and the continued decline in cash costs), the margin ratio for that year was around 50 per cent.

Over the period 1991-92 to 1995-96, average production was around 253 tonnes, compared with an average 303 tonnes over the period 1996-97 to 2000-01. This increase in part reflects an increase in exploration and capital investment levels (reflecting higher industry profitability). The recent increased practise of ‘high grading’ — that is, extracting the most profitable, most easily obtained and lowest cost ores in order to reduce the cost of production — has also increased average production levels.

Generally, the larger gold mining operations in Australia have lower production costs per unit of output and greater operational flexibility to cut costs by restructuring mine and production plans, than do smaller operations. Amalgamations, mergers and takeovers are also likely to continue in the short term, with further rationalisations of high cost operations. A further feature of the gold industry is that the larger operations tend to have higher reserve to production ratios than do the smaller producers. Together these factors indicate that the share of production from larger, lower cost operations is likely to increase over the medium term.

Gold production from operational mines in 2006-07 is projected by ABARE to be around 277 tonnes, around 3.2 per cent lower than aggregate production in 2001-02 (Simms 2002). The current largest 22 operational mines are expected to maintain production at around 2001 levels, resulting in a marginal increase in their share of total production (from 67 per cent in 2001; see map 1). By contrast, production from the smallest 22 operational mines in 2001 is expected to decline slightly from their current share of production (3.8 per cent). In aggregate it is expected that the relative share of Australian gold production by state will remain relatively constant.
Modeling gold exploration and production

A model of Australian gold supply, capital investment and exploration is developed to examine the major economic determinants and the links between these factors.

Time lags between exploration, mine development and production mean that current decisions about levels of exploration spending and gold mine development will affect the capacity of the Australian industry in the short term. Beyond this time frame, forecasting Australian gold production requires assumptions about levels of investment in gold exploration and mine development (capital investment).

This model represents a more comprehensive model of the Australian gold industry than presented in Allen et al. (1999). In common with the earlier model, exploration, investment and supply are modeled as a function of a number of economic variables, including gold prices, technological change and capital stock. However, to update this model to reflect more recent influences, and to more adequately capture the link between exploration and production levels, the impact of land access issues has been explicitly modeled.

It should be noted that the model is for national aggregated gold exploration, capital investment and production. An individual gold mine will operate in a regional component of this ‘aggregated’ market. At a regional level, there are significant differences in market and cost structures. However, whether estimating exploration or production at a regional or aggregated level, it is important to capture the influences on the levels of exploration, investment and production.

Model methodology and estimation

An overview of the model methodology and estimation is provided in this section. Further details of the rationale and methodology underlying the approach are provided in appendix B.

Exploration expenditure is initially modeled as a function of gold prices and the impact of land access on the granting of exploration permits. A positive relationship is expected between the real gold price and exploration levels. An increase in the gold price (given an accompanying rise in profitability) provides an incentive to increase exploration and capital investment (providing the price increase was expected to be sustained in the medium to longer term). Given the linkages between exploration, capital investment and production, future production levels would then also be expected to increase.

The expectation is that the level of exploration is related to the relative level of land access. To incorporate the impact of land access, an index was created, which is a ratio of applications pending relative to the number granted in any one year. Details of these numbers, by jurisdiction, are provided in table 7 in chapter 5. The expectation is that, the greater the issue with land access (higher index value), the relatively lower will be exploration expenditure.

It was also hypothesised that, in aggregate, the industry may target an EDR to production ratio, with the expectation that the level of exploration is negatively related to the level of this ratio.
Real capital investment is modeled as a function of real exploration expenditure and real gold prices, with the expectation that capital investment would be positively related to both exploration expenditure and gold prices.

To develop a model of Australian gold supply, it is assumed that long run changes in supply will be driven mainly by decisions to invest in exploration and subsequent capital investment to extract new resources. This assumption is based on the close historical relationship between the capital stock and gold mine production.

To capture the impact of the adoption of new processing technology (carbon-in-pulp and carbon-in-leach technology) on gold production, an indicator was developed which measured the rate of adoption of this technology.

**Model results**

**Exploration expenditure**
The model results show a positive relationship between exploration expenditure and gold prices (lagged one year). The change in the gold price alone accounts for around 40 per cent of the change in exploration expenditure. The model results indicate that gold exploration expenditure would be expected to increase/decrease by A$1.2 million for every A$1/oz increase/decrease in the real gold price.

As expected, the model results show a relationship between the index of land access and exploration expenditure. That is, when this index is higher (greater backlog of pending exploration permits relative to those granted), there is likely to be (all other factors being constant) a decrease in exploration expenditure. For example, if the land access index doubled from 1 to 2 (as it did between 1992 and 1998), exploration expenditure in that year (for example, 1998) would be around $36 million lower than would otherwise be expected. The model results also indicate that the targeting of an EDR to production ratio was not found to have a significant effect on exploration expenditure.

**Capital investment**
The model results show that capital investment has a positive relationship with exploration expenditure and prices (both lagged one year). These two factors account for around 65 per cent of the change in capital investment over the period 1985-86 to 2000-01.

The results indicate that capital investment would increase/decrease by A$130 million for every A$1/oz unit change in the real gold price, and would increase/decrease by A$0.6 million for every A$1 million change in exploration expenditure.

**Gold production**
Changes in gold production were found to be directly and positively related to changes in capital stock. Changes in capital stock accounted for around 50 per cent of the change in production. The effect of the technological advance was found to have a significant and positive effect on gold production. In addition this technological advance had an even higher impact on production in the latter part of the adoption period.
The model results indicate that production over the period 1987-88 to 1989-90 was significantly higher (an annual average of 18 tonnes) than what might otherwise be expected, after accounting for the impact of changes in capital stock and technology on production levels.

Although the model structure may represent a simplified structure for the gold industry, the results indicate that the model adequately captures the dynamics of the industry. The model framework accounted for around 80 per cent of the changes in historical production levels. This outcome illustrates that changes in exploration (and capital investment) are the major drivers for changes in production.

**Outlook simulations**

The gold industry is a significant component of the Australian minerals sector and it is expected that the industry will continue to be a major feature of this sector. However, the direction of the industry will be dependent on future gold prices, costs, the impact of land access and the resulting levels of production.

To assess the outlook for the gold industry, three scenarios were constructed to assess the impact of exploration on future production. The decline in gold production in 2001-02 to 271 tonnes was assessed to be a temporary decline, primarily resulting from a number of older mines reaching their end of life. Given the expected startup of new mines, the ABARE forecast is for an increase in gold production to 292 tonnes in 2002-03 (ABARE 2002). To account for this expectation, this production forecast is used for the first year of the simulation period.

The simulation scenarios were undertaken for the period 2002-3 to 2006-7. The price assumption underlying all scenarios is that real gold prices remain constant in 2001-02 prices (A$534) over this period. This assumption removes the impact of changes of prices on the scenario outcomes.

In the base case, it was assumed that real exploration expenditure would remain constant at 2001-02 levels. In the high and low exploration scenarios, it was simulated that, by 2006-07, exploration expenditure would increase or decrease by 20 per cent respectively. These scenarios allow the analysis of the impact of higher or lower exploration on production.

In all the scenarios, it was assumed that there would be no new major technological advances over the simulation period.

### Simulation results for gold

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td>322 A$m</td>
<td>258 A$m</td>
<td>-20%</td>
<td>322 A$m</td>
<td>0 A$m</td>
<td>20%</td>
<td>387 A$m</td>
<td>+20%</td>
<td></td>
</tr>
<tr>
<td>Production</td>
<td>292 tonnes</td>
<td>274 tonnes</td>
<td>-6.5%</td>
<td>287 tonnes</td>
<td>-2 tonnes</td>
<td>2.5%</td>
<td>300 tonnes</td>
<td>+2.5%</td>
<td></td>
</tr>
</tbody>
</table>
A summary of the simulation results are given in table 5, while figure 23 and box 2 illustrates the results.

**Gold production outlook**
In the base case scenario, Australian gold production is forecast to be 287 tonnes in 2006-07, around 2 per cent lower than the level in 2002-03. Under the higher and lower exploration expenditure scenarios, Australian gold production is forecast to increase/decrease by around 4.5 per cent compared with the base case. Australian gold production would only be higher than the 2002-03 level of 292 tonnes under the higher exploration scenario.

The simulation results indicate the importance of exploration to the future direction of the gold industry. In the model framework, land access issues and prices were shown to have an impact on exploration expenditure. A resolution of land access issues or a higher gold price would be expected to result in increased exploration.

**Economywide impacts of changes in mineral production**
The MONASH-MRF (MMRF) model is a general equilibrium representation of the Australian, state and territory economies. A version of this model is used in this study to quantify the macroeconomic impacts of an expansion or contraction of the minerals sector at the national, state and territory level. The minerals sector includes the iron ore, nonferrous metal ore and black coal industries.

The modeling approach and simulation results are presented in appendix A. A summary of some key macroeconomic impacts of an increase (or decrease) in production from the minerals sector on the Australian, state and territory economies is given in box 3.
In this study, a modified version of the MONASH-MRF (MMRF) model is used to quantify the short and long run economywide impacts of a 10 per cent increase in mineral production sourced at either the national, state or territory level.

The adjusted MONASH-MRF model has fourteen industries comprising agriculture, minerals, other mining, manufacturing and ten services industries. The minerals sector includes the iron ore, nonferrous metal ore and black coal industries.

Each simulation is designed to represent the discovery, and subsequent development, of economic mineral deposits that expand production by 10 per cent in the corresponding jurisdiction. A proportionate 10 per cent increase in minerals production is assumed in this report, to examine the relative importance of minerals in the various jurisdictions. The implied absolute size of the increase in mineral production therefore varies between jurisdictions according to the size of the sector.

**Impact of a 10 per cent increase in mineral production**

Following a 10 per cent increase in mineral production, output and private consumption expenditure are higher than would otherwise be the case in all simulations in both the short and long run. In the long run, for example, Australia’s real gross domestic product increases by 0.2 per cent, private consumption expenditure increases by 0.3 per cent and private investment expenditure increases by 1.0 per cent.

The macroeconomic impacts of increased mineral production in the state and territory simulations tend to be significantly larger in the long run compared with the short run outcomes. This reflects the adjustment of capital stocks in the long run to relatively more profitable economic activities and the migration of labor to the jurisdiction where the mineral expansion occurred.

The long run simulation results for output are presented in the graph below. In the state and territory simulations, the largest increases in real gross state product occur for Western Australia (3.6 per cent) and the Northern Territory (3.0 per cent), followed by Queensland (1.9 per cent), Tasmania (1.1 per cent) and New South Wales (0.7 per cent). The impact in both Victoria and South Australia is small.

**Long run simulation results for output based on the MONASH-MRF model**

<table>
<thead>
<tr>
<th>Position</th>
<th>State</th>
<th>Impact (per cent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Australia</td>
<td>3.6</td>
</tr>
<tr>
<td>2</td>
<td>Western Australia</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>Queensland</td>
<td>1.9</td>
</tr>
<tr>
<td>4</td>
<td>New South Wales</td>
<td>1.1</td>
</tr>
<tr>
<td>5</td>
<td>Northern Territory</td>
<td>0.7</td>
</tr>
<tr>
<td>6</td>
<td>Victoria</td>
<td>0.6</td>
</tr>
<tr>
<td>7</td>
<td>South Australia</td>
<td>0.5</td>
</tr>
<tr>
<td>8</td>
<td>Tasmania</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Continued →*
A description of the modeling approach and a more detailed discussion of the macroeconomic simulation results are presented in appendix A.

The results presented here may also be compared with Stoeckel (1999) who applied a 10 per cent expansion in the more broadly defined mining sector using the G-Cubed model and obtained stronger output and wealth impacts. For example, Australia’s real gross domestic product was 0.7 per cent higher than the baseline projection after five (and ten) years.

**Impact of a 10 per cent fall in mineral production**

The simulations may also be used to indicate the flow-on impacts of a 10 per cent fall in mineral production by simply changing the sign of the results. A fall in mineral production would be the more relevant option to consider if the downturn in exploration activity is sustained over the longer term. For example, a 10 per cent decline in mineral production would, over the longer term, result in a 0.2 per cent fall in national output.

The simulation results may also be used to indicate the flow-on impacts of production changes for a particular resource by adjusting the shock by the size of the industry in the base year. The estimated industry shares for the national minerals sector in the base year are presented in table 6.

The estimated impact of an illustrative 20 per cent fall in resource production on national output in both the short and long run is also provided in table 6.

For example, a 20 per cent fall in gold production is estimated to reduce national output by 0.15 per cent in the short run and 0.08 per cent in the long run. Thus, from the outlook simulations presented in the previous section, a fall in gold production of 6.5 per cent or 2 per cent between 2002-03 and 2006-07 corresponds to a fall in national output of less than 1 per cent (compared with its baseline level).

### Resource output shares and national output simulation results for a 20 per cent fall in resource production

<table>
<thead>
<tr>
<th>Resource</th>
<th>Resource shares in minerals sector output a</th>
<th>20 per cent fall in resource production</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>Output from the minerals sector b</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>Short run</td>
</tr>
<tr>
<td>Gold</td>
<td>22.8</td>
<td>−4.6</td>
</tr>
<tr>
<td>Base metals and nickel</td>
<td>8.6</td>
<td>−1.7</td>
</tr>
<tr>
<td>Black coal</td>
<td>39.3</td>
<td>−7.9</td>
</tr>
<tr>
<td>Mineral sands</td>
<td>2.6</td>
<td>−0.5</td>
</tr>
<tr>
<td>Iron ore</td>
<td>16.9</td>
<td>−3.4</td>
</tr>
<tr>
<td>Other</td>
<td>9.8</td>
<td>−2.0</td>
</tr>
<tr>
<td>Minerals sector</td>
<td>100.0</td>
<td>−20.0</td>
</tr>
</tbody>
</table>

a Base year 1993-94 shares. b The percentage change in output from the minerals sector that would result from a 20 per cent fall in production of the corresponding resource alone. For example, a 20 per cent fall in black coal production is estimated to reduce output from the minerals sector by 7.9 per cent. c The percentage change in national output resulting from a 20 per cent fall in resource production.

land access issues

Mining activities represent one among a number of different uses for land in Australia. To the extent that there are competing interests, lack of access to land becomes a potential constraint on mining activity.

Jurisdictions differ according to the value placed on these alternative uses and therefore the extent to which alternative uses may be an impediment to mining activity. The Fraser Institute Annual Survey of mining companies 2000-01 notes that for Australia, 36 per cent of respondents identified native title issues as a strong deterrent to exploration investment, 10 per cent identified environmental regulation as a strong deterrent and 14 per cent identified protected areas as a strong deterrent (see also Bell 2002).

However, to a large extent the problem for mining companies considering investment in exploration in Australia is not the need to consider native title, environmental and other matters as such, but the uncertainty surrounding policy and processes regulating access to the land. This suggests that the important objective is to design policies and processes for reconciling alternative uses of the land and otherwise regulating access to the land that are as clear and transparent as possible.

Approaches for reconciling native title, environmental and heritage uses with mining uses of the land are discussed in this chapter. These issues are extremely complex — this chapter aims to focus on some key aspects relevant to this study.

Native title issues

The Commonwealth Native Title Act is the basis of the native title regime in Australia. The act includes provisions for alternative state and territory native title legislation.

Together, the Commonwealth, state and territory legislation, the institutions that support the legislation and the common law interpretations of the legislation constitute the native title regime in Australia.

Backlog of exploration title applications

Prima facie, native title has been associated with a significant increase in the backlog of exploration and mining title applications. Tables 7 and 8 show the number of exploration title and mining title applications pending (and granted) in each jurisdiction since 1991-92 (the native title period).
The number of applications pending has increased in all jurisdictions. Over the native title period, the total number of exploration and mining title applications pending increased by about 175 per cent. The increases were particularly significant in the period after the Wik decision of late 1996 which resulted in heightened legislative and judicial uncertainties about the native title regimes that would operate in each jurisdiction.

### ‘Market’ for future act agreements
From the perspective of the exploration industry the most important element of the native title regime is that concerning ‘future acts’ on land that is or may be subject to native title. The future act provisions of the Commonwealth Native Title Act provide native title parties (native title holders and registered claimants) with the right to negotiate over certain future acts and the right to be consulted over other future acts.

### Exploration title applications pending and granted, by jurisdiction in Australia

<table>
<thead>
<tr>
<th></th>
<th>NSW no.</th>
<th>Vic. b no.</th>
<th>Qld no.</th>
<th>SA c no.</th>
<th>WA d no.</th>
<th>NT no.</th>
<th>Tas. no.</th>
<th>Total no.</th>
</tr>
</thead>
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<tr>
<td>Exploration title applications pending</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991-92</td>
<td>194</td>
<td>194</td>
<td>95</td>
<td>17</td>
<td>1 211</td>
<td>427</td>
<td>0</td>
<td>2 138</td>
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<tr>
<td>1992-93</td>
<td>208</td>
<td>249</td>
<td>94</td>
<td>61</td>
<td>1 236</td>
<td>753</td>
<td>0</td>
<td>2 378</td>
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<tr>
<td>1993-94</td>
<td>337</td>
<td>309</td>
<td>78</td>
<td>175</td>
<td>1 515</td>
<td>638</td>
<td>0</td>
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<tr>
<td>1994-95</td>
<td>388</td>
<td>259</td>
<td>118</td>
<td>0</td>
<td>1 439</td>
<td>745</td>
<td>0</td>
<td>2 949</td>
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<tr>
<td>1995-96</td>
<td>324</td>
<td>366</td>
<td>162</td>
<td>69</td>
<td>1 430</td>
<td>695</td>
<td>0</td>
<td>3 046</td>
</tr>
<tr>
<td>1996-97</td>
<td>285</td>
<td>388</td>
<td>447</td>
<td>231</td>
<td>2 052</td>
<td>728</td>
<td>0</td>
<td>4 131</td>
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<td>132</td>
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<td>70</td>
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<td>0</td>
<td>2 684</td>
<td>898</td>
<td>0</td>
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<td>1999-00</td>
<td>92</td>
<td>92</td>
<td>1 218</td>
<td>0</td>
<td>2 775</td>
<td>1 194</td>
<td>21</td>
<td>5 392</td>
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<tr>
<td>2000-01 e</td>
<td>84</td>
<td>110</td>
<td>1 181</td>
<td>0</td>
<td>3 099</td>
<td>1 310</td>
<td>25</td>
<td>5 809</td>
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<table>
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<th>SA c no.</th>
<th>WA d no.</th>
<th>NT no.</th>
<th>Tas. no.</th>
<th>Total no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration title applications granted</td>
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<td></td>
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<td>1991-92</td>
<td>300</td>
<td>150</td>
<td>535</td>
<td>52</td>
<td>955</td>
<td>271</td>
<td>0</td>
<td>2 263</td>
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<td>1992-93</td>
<td>157</td>
<td>235</td>
<td>433</td>
<td>56</td>
<td>1 104</td>
<td>231</td>
<td>0</td>
<td>2 216</td>
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<tr>
<td>1993-94</td>
<td>161</td>
<td>220</td>
<td>514</td>
<td>107</td>
<td>1 498</td>
<td>307</td>
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<td>2 807</td>
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<td>201</td>
<td>239</td>
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<td>148</td>
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<td>220</td>
<td>0</td>
<td>2 286</td>
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<tr>
<td>1995-96</td>
<td>205</td>
<td>311</td>
<td>359</td>
<td>97</td>
<td>1 306</td>
<td>282</td>
<td>0</td>
<td>2 560</td>
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<td>1996-97</td>
<td>273</td>
<td>292</td>
<td>226</td>
<td>187</td>
<td>1 231</td>
<td>190</td>
<td>0</td>
<td>2 399</td>
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<td>1997-98</td>
<td>178</td>
<td>274</td>
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<td>142</td>
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<td>1 805</td>
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<td>1998-99</td>
<td>90</td>
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a Exploration applications include title applications for mineral exploration only. b Between 1996-97 and 1997-98 Victoria revised the basis on which figures are determined for exploration applications pending. They believe that the more recent figures are more accurate. c There is no delay under the South Australian scheme for the granting or registration of exploration authorisations (that is, exploration licences and mineral claims). However, after the grant or registration of the exploration authorisation it is the responsibility of the holder of the mineral claim or exploration licence to negotiate with the relevant native title parties if the activity proposed on the tenement is on native title land and will affect native title. d Western Australian figures are for exploration licences only (that is, prospecting licences are excluded). e Latest figures to 31 March 2001.

These rights provide native title parties with significant economic leverage. They enable the parties to negotiate agreements with mining companies that may involve economic benefits for the parties and economic costs to mining companies.

In many cases, these agreements can be viewed as tradeoffs of cultural and social rights in return for economic benefits. In this sense they establish a ‘price’ for (the temporary impairment of) cultural and social rights. This suggests that the future act provisions of the Native Title Act can be viewed as establishing a ‘market’ in which mining companies and native title parties can negotiate prices for land access. In this market, native title parties are suppliers of an input (land, or more particularly, agreements over the doing of future acts on the land) to the exploration and mining process.

### Mining title applications pending and granted, by jurisdiction in Australia

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a Mining applications include applications for mining leases and mineral claims (where a breakdown was available the two figures were added). b Between 1996-97 and 1997-98 Victoria revised the basis on which figures are determined for exploration and mining applications pending. They believe that the more recent figures are more accurate. c There is no delay under the South Australian scheme for the granting or registration of exploration authorisations (that is, exploration licences and mineral claims). However, after the grant or registration of the exploration authorisation it is the responsibility of the holder of the mineral claim or exploration licence to negotiate with the relevant native title parties if the activity proposed on the tenement is on native title land and will affect native title. d Latest figures to 31 March 2001.

*Source: Land Access (Native Title) Task Force (2001).*
Impact of native title on mineral exploration

Native title affects mineral exploration and mining through the market for agreements over the doing of future acts (‘future act agreements’). If this market works efficiently, the impact of native title on mineral exploration and mining should be limited.

However, to the extent that this market is poorly designed, or otherwise inefficient, native title may make participants reluctant to engage with each other. The market for future act agreements has been less than efficient for the following reasons:

Uncertainty about the native title regime (the rules governing the operation of the marketplace)

Key amendments to the Commonwealth Native Title Act provided for alternative state and territory native title legislation, subject to final ratification by both houses of the Commonwealth parliament. Combined with the broader political debate over native title, these provisions contributed to a period of legislative uncertainty about the native title regimes that would operate in each jurisdiction.

Furthermore, the High Court’s Wik decision and a number of other important High Court and Federal Court decisions generated a degree of judicial uncertainty about common law interpretations of the Native Title Act.

These uncertainties led to an environment in which key participants were reluctant to engage in the native title process and a significant increase in the backlog of exploration licence and mining lease applications, particularly in the period after the Wik decision of 1996.

More recently there has been significant progress in resolving this legislative and judicial uncertainty. Western Australia and the Northern Territory have formally adopted the Commonwealth native title provisions and Queensland has enacted alternative state provisions. A number of recent High Court and Federal Court decisions have also contributed to a growing body of relevant common law. As a result, meaningful attempts are now being made to address the backlog of exploration licence and mining lease applications.

Uncertainty about the outcome of negotiations (the ‘prices’ at which it is possible to transact)

To date there have been relatively few negotiated agreements and for many of these, the details remain confidential. Combined with the fact that terms and conditions are likely to vary across different agreements, this suggests a degree of uncertainty about the terms on which participants are likely to be able to transact. The development of a suitable body of precedent, including benchmark agreements, should mitigate this problem over time.

In the shorter term, however, uncertainty may be exacerbated by aspects of the current right to negotiate procedures, such as the provision for arbitration by the National Native Title Tribunal. Many participants have noted that arbitration tends to create a litigious environment that is not conducive to agreement making. Furthermore, the tribunal appears to be constrained in its ability to impose commercial outcomes on the negotiating parties. For example, it cannot impose future act compensation conditions based on a percentage of income, profits or production and does not appear willing to push out the boundaries with
respect to commercial payments. Participants may be reluctant to submit to a process that is likely to end in arbitration but where the arbiter is unlikely to be able to further their negotiating positions.

Under these circumstances, one might expect native title parties in particular to prefer a more conventional approach to negotiating agreements such as that represented by Indigenous Land Use Agreements.

**Excessive transactions costs, including costs associated with delays in finalising negotiations**

Transactions costs refer to the expenses involved in executing transactions in a market. In the market for future act agreements, they would include the cost of physically engaging in negotiations (for example, convening meetings of Aboriginals from outlying areas) and any costs associated with delays in finalising negotiations.

These costs are likely to be relatively high because of differences that currently exist between Aboriginal and western approaches to negotiation. A key feature of western business practice is the delegation of decision making authority to a relatively small number of individuals with suitable expertise. This does not appear to occur in the same way in Aboriginal communities. Smith (1997, p. 104) notes that ‘… a multiplicity of negotiating agendas asserted by different native title parties who are in conflict with each other, can make the negotiation process more complex and problematic for all parties …’ and ‘… it may be that formal mechanisms for arriving at consensus or majority decision-making between native title parties (whether they be Western democratic or traditional Aboriginal decision-making methods, or both) need to be developed and agreed upon at the beginning of the normal negotiating procedure.’

Native title representative bodies are likely to play an important part in resolving these issues.

There is an important distinction to be made between transactions costs and the wealth transfers (that is, prices) provided for in negotiated agreements. Sensible bargaining should limit prices to a level that does not seriously affect the level of activity because native title parties only derive economic benefits if activity proceeds. Such bargaining should result in prices that are sufficiently high to compensate native title parties for any impairment of cultural and social rights, but not so high as to render a project uneconomic.

Sensible bargaining does, however, require that the parties act as rational maximising economic agents and that they have good information about their own costs and benefits and those of the other party.

**Strategic behavior arising from unintended distortions to the incentives faced by different participants**

By definition, it is difficult to predict whether and in what form strategic behavior will occur. However, when it does occur, it is important to view it as a rational response by participants to the system that they are presented with, to be addressed by improving the system, rather than by ‘improving’ the participants.
One form of strategic behavior that seems to have occurred in these markets is the ‘ware-housing’ of exploration acreage by applicants for exploration licences. Companies appear to have lodged exploration licence applications, thereby tying up exploration acreage in the knowledge that processing would be slow because of the backlog of unprocessed applications.

A second form of strategic behavior that seems to have occurred is the routine lodgement by native title parties of objections to the use of the expedited procedures. The ability to slow the process of granting exploration licences has provided native title parties with greater leverage in negotiating conditions attaching to the grant of these licences.

**An efficient market for future act agreements**

Making the market for future act agreements as efficient as possible can mitigate the adverse effects of native title on mineral exploration and mining. Among the requirements for a more efficient market are:

**Clear and unambiguous identities for relevant native title parties**

This rests on the native title determination process and is not discussed further in this report.

**Effective decision making processes for native title parties**

Native title parties generally comprise a relatively large number of individuals from a number of different communities, each with their own leaders and possibly each with their own set of priorities. In order to engage in negotiations, native title parties need decision making processes that involve delegating authority to a small number of individuals to represent the group in negotiations. These individuals should have expertise in negotiation and should have access to good information (for example, about the outcome of other negotiations and the nature of the mining activity proposed) on which to base their negotiating strategies.

Some specialisation in engaging in negotiations is likely to be the key to efficient outcomes. Native title representative bodies would appear to be of central importance since any one native title party is unlikely to engage in many transactions. Smith (1997, p. 104-5) notes that native title representative bodies ‘serving as the “transaction floor” (Dodson 1996) for dealings between native title parties, industry and governments could serve to greatly streamline the negotiating process …’ and that ‘to perform such a role, Representative Bodies will need to establish their own representative credentials and accountability within the Aboriginal domain.’ This appears to have been achieved in some Central Land Council areas in the Northern Territory, for example, where timely and satisfactory negotiated outcomes have been achieved.

**Full information**

From the perspective of facilitating the negotiation of new future act agreements, the most important information is knowledge about the economic terms and conditions of previous agreements. Participants will be more inclined to transact if they are confident that they have transacted at reasonable prices. They will also be less likely to dishonor the ongoing terms and conditions of their agreements.
Gathering and maintaining information about previous transactions is costly. Because it is less costly (per negotiation) for repeat negotiators to gather and maintain information, this again suggests some advantage to specialisation in negotiating agreements. Alternatively, it suggests some advantage to a central and readily accessible database of previous transactions.

Information asymmetries between potential counterparties can be a particular problem. When one participant knows that it is at an information disadvantage relative to the other, it is rational to discount the terms on which it will trade. It is well known that in extreme cases information asymmetries may lead to market failure. Information asymmetries are likely to be present in the market for future act agreements if relatively well informed mining companies negotiate with relatively less informed native title parties.

**Market infrastructure**

Market infrastructure refers to the institutions and mechanisms that enable buyers and sellers to identify and then physically transact with each other. A common infrastructure for less efficient markets (such as the current market for future act agreements) involves the participation of intermediaries of one kind or another.

The use of intermediaries is particularly valuable for participants that do not transact repeatedly. By dealing with a range of different participants, intermediaries can justify the cost of acquiring expertise and knowledge. Intermediaries can also acquire a reputation over repeated transactions for dealing honestly and fairly. This is particularly valuable when there are significant information asymmetries.

This suggests an important role for native title representative bodies acting as intermediaries. Martin (1997, p. 159) says ‘… [native title representative bodies] should be seen as primarily service delivery organisations, even if part of that service is advocacy in native title matters.’

**Contracting technologies**

In the market for future act agreements, transactions are executed in the form of contractual arrangements that require participants to perform in the future. This makes it particularly important that the correct participants are involved in negotiations and that there are mechanisms for monitoring the implementation of agreements over time. Native title representative bodies are likely to have to play an important statutory role.

**Discussion**

Viewing the negotiation of agreements to engage in exploration and mining activity as a market focuses attention on what is required for a market to work well. It suggests less emphasis on arbitration and more on enabling participants to freely negotiate commercial agreements.

In the market for future act agreements, three requirements are particularly important:
to the extent that native title parties participate in an economic marketplace, they should be organised in such a way that they are able to function effectively as rational economic agents;

there should be as full and free a flow of information between participating agents as possible, particularly on the terms and conditions of past agreements; and

there should be credible intermediaries of good reputation and standing with the expertise to assist in negotiating agreements and monitoring their implementation.

The proper development and resourcing of native title representative bodies would appear to be important in delivering these requirements.

**Environmental issues**

Mining activities compete for land access with environmental uses as well as native title uses. From an economic perspective, the objective is to determine the combination of these uses that is socially optimal.

Markets provide one way in which the socially optimal uses of a scarce resource (in this case land) can be determined. However, in order for markets to function in this way, ‘property rights’ associated with alternative uses need to be clearly assigned and need to be ‘tradable’, enforceable and excludable (Rose 1997). As discussed in the previous section, the native title legislation and the native title regime more generally does assign property rights to native title holders that can be ‘traded’ through negotiations and then agreements with mining companies. This obviates the need for a third party to (somehow) assign comparative values to native title uses and mining uses of the land.

It is much more difficult to assign property rights to environmental uses of the land. As a result, markets cannot currently provide a ‘solution’ to the problem of determining the socially optimal uses of land when environmental uses are included as alternatives. The problem therefore is to design an alternative system for determining the optimal uses of land across environmental and mining uses (as well as other uses). Implicitly, this must involve a third party (somehow) assigning values to environmental as well as mining uses.

**Current system**

The basis of the current system for determining the optimal uses of land across environmental and mining uses is the Commonwealth, state and territory environment legislation, together with the environmental aspects of the Commonwealth, state and territory mining acts. Appendix D provides an overview of this legislation.

The legislation provides for a series of administrative processes that involve:

- gathering information on environmental and mining values of the land;
- determining the tradeoffs between mining and environmental uses (for example, the likely impact of the proposed mining activity on environmental values); and
choosing a specific tradeoff (deciding whether the mining activity can proceed and, if so, under what conditions).

Essentially, and unavoidably, this process is tantamount to ‘pricing’ environmental values in the absence of a functioning market.

Policy issues
In broad terms, the objective of policy is to design processes that replicate as closely as possible the outcomes that would result in a market with no unwanted distortions. The important outcomes (which are discussed in more detail below) are:

- tradeoffs that properly reflect marginal use values of the land;
- an environment in which these tradeoffs are clearly signaled to market participants such as mining companies; and
- an environment in which appropriate tradeoffs can change over time in response to changing marginal use values of the land.

Marginal use values
In order to assess marginal use values, information is required on alternative uses of the land. The important issues are what information should be gathered, how much information should be gathered and who should pay for the cost of gathering information.

Information is required on the values attached to each of the alternative uses under consideration. These values need to be such that they can be ranked. This is relatively straightforward for mining uses where it is possible to estimate the expected profitability of mining in an area. It is more difficult to obtain ‘values’ associated with environmental uses. One possibility is simply to classify land into areas of higher and lower environmental significance and such classifications have been used in Australia. More refined approaches are also possible. Box 4 provides an example of one approach that is based on a measure of environmental value used in the ‘regional forest assessment’ process in Tasmania.

Sufficient information should be available to permit genuine assessments of alternative land use values. However, while decisions based on more information are always better than those based on less, policy makers need to be aware of the costs and benefits of marginal amounts of information in determining when enough information is available to enable a sensible decision to be made.

Generally, there are few private incentives to gather information on environmental uses of the land, primarily because individuals are unlikely to be able to capture the full benefits from collecting this information. Mining companies may have some incentive to gather environmental information (given that this is now required for mining approvals) together with information on the mining potential of an area. However, these incentives are significantly decreased when there is uncertainty over whether they will be able to capture the benefits of this information through approval for mining.
Box 4: Regional Forest Agreements in Australia

The National Forest Policy Statement of 1992 recognises and commits the Australian community to the goal of ecologically sustainable forest management. Regional forest agreements (RFAs) negotiated between the Commonwealth and state and territory governments are the key means for giving effect to the policy statement.

RFAs have a number of important objectives, including:

- the maintenance of regional environmental, heritage and social values;
- providing security of access to specified native forest areas for important forest related industries to facilitate investment in these areas; and
- the rationalisation of land use decision making processes and a reduction in uncertainty about outcomes.

A central element of each RFA is a comprehensive, adequate and representative (CAR) conservation reserve system for each region (Commonwealth of Australia 1995; JANIS 1997). In order to facilitate the negotiation of RFAs and the establishment of CAR reserve systems, comprehensive regional assessments (CRAs) were conducted to provide an evaluation of the full range of forest use values, including environmental, heritage, social as well as economic uses of forest areas.

Tasmania was one of the major regional assessments conducted as part of the RFA process. Three forest resource use options were examined in the development of an RFA for Tasmania, each based on reserving public forests outside designated production forests, but also accounting for the protection of rare and endangered species and for communities within production forests. The options varied according to the number of JANIS criteria for preserving forest biodiversity (including species’ biological diversity, old growth forests and wilderness) that were met.

The number of JANIS criteria that are met is a measure of the environmental use value of the land. The number represents a comparative measure of environmental use value that can be used to assess marginal use values. For example, an increase in the area under reserve by, say, 3 per cent may increase the number of JANIS biodiversity communities’ criteria met from 30 to 39.

For the Tasmanian RFA, ABARE provided estimates of the value of alternative economic forest use options including logging and wood processing, and mining and mineral processing (Dann et al. 1997; Hogan et al. 1998).

In order to assess the economic value of forest resources used in the logging and wood processing industries under alternative RFA reserve options, ABARE developed FORUM, a dynamic optimisation model that simulates the interactions between forest resources, wood based forest industries and final product markets. FORUM is designed to measure the direct economic impacts of changes in log availability on local or regional logging and wood processing industries.

The geological data required for economic assessments of mining and mineral processing potential are relatively difficult to obtain without engaging in some exploration activity beforehand. For the Tasmanian RFA, ABARE drew on information provided by the Bureau of Rural Sciences and Mineral Resources Tasmania, reported in Tasmanian Public Land Use Commission (1996), on the possible size and nature of mineral deposits in the area to estimate the net present value of prospective deposits.

Continued ➸
This points to a potential source of market failure that suggests that there may be a case for government to provide information on both environmental values and potential mining values.

Information on marginal use values enables an assessment of the tradeoffs between alternative uses and a decision to be made on the preferred tradeoff. As previously noted, in the absence of a functioning market it is not possible to be certain that the chosen tradeoff is ‘correct’ in the sense of giving the socially optimal outcome (although the actual tradeoff is likely to tend toward the correct tradeoff over time as a result of ongoing lobbying by mining and environmental interests).

**Clear policies and processes**

In well functioning markets, prices are easily observable by all participants and can be factored readily into economic decisions. An important policy objective is to ensure that the tradeoffs between mining and environmental uses (that is ‘prices’) are sufficiently clear that they can be properly factored into the decision making processes of mining companies without creating uncertainties that are a major problem in investment decision making. This requires:

- transparent and predictable processes for government approval — these processes should cover both exploration and the means by which companies would move from exploration to mining; and
- clear expectations of the environmental standards to be met — these standards should cover the exploration, extraction and rehabilitation stages of mining.

This would also minimise any administrative costs and delays that may further reduce the economic value of mining projects.

**Dynamic environment**

Market prices generally do not remain constant over time. They change in response to changes in the factors that determine alternative marginal use values. Similarly, it is important that policies and procedures provide an environment that is flexible enough to respond to new information such as advances in environmental research, exploration geoscience and mining technology. In addition it can be expected that changes in economic factors such as mineral prices and extraction costs may change the preferred tradeoffs between mining and environmental uses over time.
Heritage issues

Heritage sites include historic places and sites, natural environment places and Aboriginal and Torres Strait Islander places.

Sites with significant heritage value are included in the Register of the National Estate. The protection of the National Estate at the Commonwealth level is governed by the *Australian Heritage Commission (AHC) Act*. Among other things the Commonwealth government is constrained by the act from taking any action that adversely affects a place on the register, unless there is no feasible and prudent alternative.

State and territory governments are not bound by the act, but have their own legislation to protect heritage. However, such legislation usually covers only historic places and sites. Natural heritage places are protected at a state and territory level by a variety of environmental, nature conservation and other land use laws. Most national parks and conservation areas are established and managed by the states and territories according to their own legislation.

States and territories also have legislation that provides protection to indigenous archaeological sites. However, it is commonly believed that state and territory Aboriginal heritage legislation does not generally provide proper protection for places regarded as significant by Aboriginales (see, for example, the Western Australian Technical Taskforce on Mineral Tenements and Land Title Applications Discussion Paper, August 2001).

Given the location of historic places and sites in Australia, mining activities seldom threaten heritage places of this nature. The existence and protection of such places is not likely to represent a significant impediment to mining activities.

Since the protection of natural heritage places is largely governed at a state and territory level by a variety of environmental protection, nature conservation and other related land use laws, there is a significant overlap between environmental protection and natural heritage protection. The discussion in the previous section concerning the reconciliation of mining and environmental uses of the land therefore applies similarly to most natural heritage uses.

Prior to the advent of native title, state and territory Aboriginal heritage laws provided little direct protection from mining and other activities for places of significance to indigenous people. These issues have been comprehensively addressed by native title legislation and other aspects of the native title regime. As a result, the impact of aboriginal heritage legislation on mining activities is largely subsumed by the impact of native title on mining activities as discussed above.
taxation treatment of exploration costs

This chapter provides a preliminary discussion of two issues in the current taxation treatment of exploration costs in Australia:

- native title costs that are incurred in mineral exploration are not clearly and unambiguously immediately deductible for company income tax purposes; and
- junior exploration companies are not able to use tax credits unless, and until, they begin to earn revenue and/or merge with, or are acquired by, another minerals company.

Lack of full exploration loss offset in the industry increases industry costs and reduces mineral exploration activity.

Under current taxation arrangements, mineral exploration expenditure (excluding native title expenditure) is deductible against income earned in the same financial year by the company. For junior exploration companies that do not have adequate revenue in a given year, exploration tax credits may be carried forward in nominal terms by the company that incurred the expenditures. The tax credit is used when revenue is earned by the junior exploration company, or when the company merges with or is acquired by another company.

With the recent substantial downturn in mineral exploration activity in Australia, there has been substantial interest in the application of a system of flow-through shares as a means by which investors in junior exploration companies would gain immediate deductibility of exploration expenditures (see, for example, Hextall 2001; Macfarlane 2001; Middleton 2001).

In this chapter, the taxation treatment of native title costs is noted, some information is presented on the role of junior explorers in Australia and policy options to address this issue are briefly examined.

**Taxation treatment of native title costs**

Mineral exploration is an investment in knowledge about the location, size and quality of mineral deposits. The exploration, extraction and rehabilitation phases of mining should therefore be regarded as an *integrated economic activity*.

The Commonwealth government has made substantial progress in recent years in reducing nondeductible or ‘black hole’ expenditures. However, native title costs are incurred in the
process of mineral exploration in Australia but are not necessarily immediately deductible as an exploration expense.

An efficient market outcome is not achievable without full exploration loss offset. All expenditure incurred in the exploration for mineral deposits should be deductible against income earned by the mining company.

**Junior exploration companies, discoveries and net profit positions**

Some background information on junior exploration companies was provided in chapter 2. A junior exploration company is assumed in this report to have a market capitalisation less than A$200 million.

**Discoveries, rediscoveries and renewals by junior explorers**

Information on the economic demonstrated resources or production associated with discoveries made by junior exploration companies is unavailable. However, junior exploration companies are reported to have been responsible for a significant proportion of Australia’s discoveries of gold, base metals and nickel deposits.

Maponga and Maxwell (2000) report estimates by CRU International that, between 1970 and the 1997, 51 per cent of significant gold and copper discoveries in Australia were made by junior exploration companies.

Geoscience Australia recently provided ABARE with information on the contribution of junior exploration companies in Australian mineral discoveries, rediscoveries and renewals since the 1960s (figure 24). Junior exploration companies are particularly important in gold, accounting for nearly two-thirds of discoveries, rediscoveries and renewals since the 1960s.

![Australian mineral discoveries, rediscoveries and renewals since the 1960s](chart)

**Note:**

- Gold includes initial discovery, renewed interest at or near a previously known but dormant deposit and recommencement of operations at a mine that had been dormant for some substantial time.
- Source: Geoscience Australia.

---

**Figure 24**

24 Australian mineral discoveries, rediscoveries and renewals since the 1960s

- **Gold**: Includes initial discovery, renewed interest at or near a previously known but dormant deposit and recommencement of operations at a mine that had been dormant for some substantial time.

Source: Geoscience Australia.
Junior exploration companies also accounted for close to half of discoveries, rediscoveries and renewals for base metals and nickel.

In aggregate — for gold, base metals and nickel — junior exploration companies have accounted for around 60 per cent of total discoveries, rediscoveries and renewals since the 1960s.

**Exploration and net profit positions of junior explorers**

An important aspect of the assessment of the taxation treatment of exploration expenditures in this chapter is the extent to which junior exploration companies record losses and hence do not immediately use tax credits.

Information on market capitalisation, exploration expenditure and net profit for 105 junior mineral explorers in 1999-00 is obtained from the Minmet database. Eight junior mineral explorers were excluded from the sample because data were missing for one or more of the variables.

The market capitalisation for the sample of junior mineral explorers ranges from A$1.4 million to A$116 million, with an average of A$17 million (table 9). The aggregate market capitalisation of these companies is A$1.8 billion.

However, there is a substantial clustering of companies with a market capitalisation of less than A$30 million. There are 90 such companies, which represent close to half of the total market capitalisation of this sample of junior mineral explorers.

Exploration expenditure ranges up to A$8 million, with an average of A$1.1 million. Total exploration expenditure for this group of junior mineral explorers was A$113 million. This compares with total mineral exploration expenditure in Australia of A$676 million in 1999-2000 (in nominal terms).

The majority of junior mineral explorers recorded exploration expenditure of less than A$2 million. These 87 companies accounted for 42 per cent of total exploration expenditure.

Around three-quarters, or 79 companies, have a market capitalisation of less than A$30 million and exploration expenditure less than A$2 million. In general, there is some tendency

### Descriptive statistics for 105 junior mineral explorers from Minmet, 1999-2000

<table>
<thead>
<tr>
<th>Minimum</th>
<th>Maximum</th>
<th>Average</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A$m</td>
<td>Profit</td>
<td>Loss</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A$m</td>
<td>A$m</td>
</tr>
<tr>
<td>Market capitalisation</td>
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<td>18.9</td>
</tr>
<tr>
<td>Exploration expenditure</td>
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<td>8.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Net profit</td>
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<td>6.3</td>
<td>1.5</td>
</tr>
</tbody>
</table>

* a Market capitalisation less than A$200 million. b Twelve explorers with net profit; and 93 explorers with net losses.
for larger companies to invest more in exploration expenditure (figure 25) — the correlation coefficient between market capitalisation and exploration expenditure is 0.4.

There was a wide range in the net profit position of the junior mineral explorers, from a net loss of A$28 million to a net profit of A$6 million. There were twelve companies with positive net profit, averaging A$1.5 million.

The remaining 93 companies recorded net loss positions at an average of A$2.1 million — for 77 of these companies, the net loss was less than A$0.3 million. More importantly, the aggregate net loss of the companies was A$196 million.

The correlation between net profit and exploration expenditure is close to zero (figure 26).
Policy options for non-taxpaying junior explorers

As indicated in the Minmet data, a major issue in the industry is that significant numbers of junior exploration companies in any given year do not have revenue against which to deduct exploration expenditures. Under current arrangements, these companies carry forward those tax credits in nominal terms.

A junior exploration company that fails to make economic discoveries over time is eventually acquired by another company that may then use the accumulated tax credits. However, from an industry perspective, the real value of those tax credits is lower compared with the outcome under immediate deductibility. The negative impact on the company’s assessment of the risk adjusted profitability of any given exploration project is magnified by the impact of discounting (in addition to inflation impacts). As a consequence, industry exploration costs are higher than would otherwise be the case and the level of mineral exploration activity is lower.

Based on the Minmet data for 105 junior mineral explorers, the net losses of 93 companies amounted to A$196 million in 1999-2000. At a (current) company tax rate of 30 per cent, these losses represent a tax credit of A$59 million in 1999-2000. If these tax credits are carried forward in nominal terms, by 2004-05 for example the real value of the tax credit is A$51 million in 1999-2000 prices (based on an annual inflation rate of 3 per cent), 14 per cent below the 1999-2000 level.

The main issue is that the present value of the accumulated tax credits is lower than an immediate tax deduction. There are two important points that justify considering some policy response to allow immediate deductibility:

- first, on behalf of the community, government is responsible for the efficient management of the discovery, development and production of Australia’s mineral resources; and
- second, junior explorers are highly efficient at certain types of exploration activity (with the majors increasingly targeting the discovery of world class ore deposits).

Three policy options that would enable non-taxpaying junior explorers immediate access to tax credits, and that are considered briefly in this study, are:

- refundable tax offsets;
- limited trade in tax credits; and
- flow-through shares.

Refundable tax offsets

A refundable tax offset would enable the junior explorer to gain a payment from the tax office equivalent to the value of the deduction. This is similar to the approach adopted for the refundable personal tax offsets available to individual taxpayers — these include private health insurance offsets and franking rebates for franked dividends paid from 1 July 2000 (CCH Australia 2002).
Typically, in practice, governments prefer arrangements that do not result in direct payments to private companies or individuals.

Limited trade in tax credits
A system of limited trade in tax credits is an alternative approach to refundable tax offsets that does not involve a cash payment to private companies. In this system, junior explorers would be able to sell tax credits to other companies with sufficient company income tax to use those deductions. Such an approach would enable junior exploration companies to gain immediate access to those tax deductions less any transaction costs.

This is similar to the approach adopted in the Northern Territory in the context of the treatment of exploration expenditure for mineral royalty purposes. Under this system, any exploration expenditure relating to work performed in the Northern Territory is a transferable exploration expenditure and is deductible from the profit of any mine operating under the royalty system. It should be noted that profit has a specific definition under this system (see www.nt.gov.au for further details).

Flow-through shares
A system of flow-through shares has been adopted by the Canadian government (Department of Finance, Canada 1994; Prospectors and Developers Association of Canada 2001). The main objective in flow-through shares is to facilitate exploration by non-taxpaying junior exploration companies.

Flow-through shares allow exploration expenditures by a company to flow through to investors who can claim them as a tax deduction. In general terms, it is useful to identify two variants of the flow-through shares mechanism that vary according to the rate at which the tax deduction is claimed:
- the company tax rate (currently 30 per cent), or
- the investor’s personal marginal tax rate.

A system of flow-through shares with a tax deduction at the company tax rate would provide investors in non-taxpaying junior exploration companies with immediate deductibility of exploration costs.

Under a flow-through shares mechanism that allows investors to access income tax deductions at the personal marginal tax rate, the value of those income tax deductions varies according to the marginal income tax rate of investors. In addition, to the extent that investors obtain a tax deduction at a marginal personal income tax rate above the company income tax rate, the total tax cost to the government is in excess of what would be incurred under full exploration loss offset where expenditures are claimed as a tax deduction at the company income tax rate.

Given the presence of positive externalities in mineral exploration activity, however, access to a tax deduction in excess of the company income tax rate may be justified. That is, even
with full exploration loss offset, the level of mineral exploration in Australia may be sub-op-
timal since there are likely to be positive spillover effects or externalities from gaining knowl-
edge about the location and quality of mineral deposits in Australia (see chapter 2 for a
discussion of positive externalities in mineral exploration).

The presence of positive externalities in an economic activity is widely recognised as a justi-
fication for a tax deduction in excess of 100 per cent. For example, research and develop-
ment expenditures are subject to a 125 per cent tax deduction due to the positive externalities
from this activity. Further research would be required to assess such externalities, and the
extent to which other policies address this issue.

Based on the Minmet data for 105 junior mineral explorers, if the net losses of A$196 million
in 1999-2000 were deductible at the top personal marginal tax rate of 47 per cent, the tax
credit would be around A$92 million.

**Australia’s previous experience**

Australia’s previous experience with flow-through shares during the period 1967-68 to 1972-
73 is discussed in appendix C. A further area that is relevant to the flow-through shares
discussion is the recent product ruling cases in Australia.

In an attempt to gain an immediate tax deduction for exploration expenditure, the listed
company Charters Towers Gold Mines launched a prospectus to raise A$25 million to fund
mineral exploration where investors are able to claim a 100 per cent deduction for their
contribution (Keane 2001). The company achieved this outcome through a new tax ruling.

Metex Resources has also attempted to gain a similar tax ruling to Charters Towers but has
not yet succeeded (Quinn 2001).

An assessment of the rulings under each case is beyond the scope of this study. The approach
taken by Charters Towers is potentially similar in effect to a system of flow-through shares.
However, in Australia, each company that pursues this approach requires a product ruling
on a case by case basis. As a consequence, legal costs are incurred for an uncertain outcome.
The introduction of a flow-through shares system would avoid the uncertainties and costs
associated with this alternative informal approach.

A refundable tax offset is likely to be the least administrative cost mechanism to allow non-
taxpaying junior exploration companies immediate deductibility of costs. However, ABARE
is currently undertaking a more comprehensive economic assessment of taxation policy
options for junior explorers. In this research, evidence on the costs and benefits of several
policy options will be examined in some detail.
general equilibrium impacts of a minerals expansion in the Australian, state and territory economies

In this appendix, the general equilibrium impacts of a 10 per cent increase in mineral production in the national economy and each of the state and territory economies are quantified using a modified version of the MONASH-MRF model. Each simulation is designed to represent the discovery, and subsequent development, of economic mineral deposits that expand production by 10 per cent in the corresponding jurisdiction (that is, in Australia or a specific state or territory).

These results may be applied to the situation of a 10 per cent fall in production (or any proportion thereof) that may eventuate if the recent downturn in mineral exploration in Australia is sustained. Results for a 10 per cent fall in mineral production are obtained by simply changing the sign on the simulation results. Results for a different size shock are obtained by adjusting the shock proportionately (for example, the impact of a 5 per cent decrease in mineral production would be obtained by multiplying each result by –0.5).

Some key macroeconomic simulation results were presented in box 3. Further macroeconomic simulation results are presented in this appendix together with a description of the modeling approach.

Modeling approach

Model description
The MONASH-MRF model is documented in Peter et al. (1996), and is one of only two models that provide a full general equilibrium representation of the economic linkages between the eight states and territories of Australia.

The other model is MMRF-GREEN — the MONASH-MRF model with a greenhouse extension (see Adams, Horridge and Parmenter 2000). The equations of MONASH-MRF are also the core set used in MMRF-GREEN. The MONASH-MRF model has features in common with both the original ORANI general equilibrium model of the Australian economy (Dixon, Parmenter, Sutton and Vincent 1982) widely used in applied economywide studies and the considerably enhanced and extended version of the model known as MONASH (Dixon and Rimmer 1999).
The MONASH-MRF model is a representation of the Australian, state and territory economies in 1993-94. Ideally, the base year represents a typical year where the economy may be considered to be close to an equilibrium position and not in an adjustment phase to some major change in economic circumstances (for example, where the economy is not at, or close to, a cyclical peak or trough).

Simulation results are generally expressed as percentage deviations from the baseline level to indicate the proportionate impact of a minerals expansion on key economic variables.

Although the process of mineral exploration is not explicitly represented in MONASH-MRF and other general equilibrium models, mineral exploration expenditure (excluding petroleum), in 2000-01 prices, was A$924 million in 1993-94, which is close to the average of A$902 million recorded over the past two mineral exploration cycles (1985-86 to 2000-01).

Some modifications are made to the MONASH-MRF model’s database for this study. Most importantly, the database is modified to reflect the focus in this report on the economics of mineral resources other than petroleum. Using available data that limited the scope of the disaggregation, the mining sector is separated into:

- **minerals industries**, including iron ore, nonferrous metal ore and black coal industries; and
- **other mining**, including oil, gas, brown coal and services to mining.

The adjusted MONASH-MRF model has fourteen industries comprising agriculture, minerals, other mining, manufacturing and ten services industries.

Default settings for export price elasticities of demand are –20 for most industries. However, smaller values in absolute terms are more commonly used for the ‘traditional’ agricultural and minerals sectors. In this study, the export price elasticity of demand is set to –10 for each of these sectors.

The role of the mineral resource in production was recognised by separating resource rents from capital rents in the database for the minerals sector. The model includes equations for resources but positive resource rents in the database are needed for these to switch on. To implement this change, the long run price elasticity of supply is assumed to be 2.5 in most states and territories (5 in Tasmania and the Australian Capital Territory). The elasticity of substitution between capital, labor and resource inputs determines the extent of price induced substitution between inputs and is assumed in the minerals sector to be 0.15 (compared with a default setting of 0.5 in the model).

**Simulations**

The simulations are designed to quantify the short and long run economywide impacts of a 10 per cent increase in mineral production sourced at either the national, state or territory level. That is, for each economic environment (short run and long run), there are eight simulations corresponding to a 10 per cent increase in mineral production in a given jurisdiction.
**Simulation 1:** a 10 per cent increase in mineral production in Australia (including all six states and two territories);

**Simulation 2:** a 10 per cent increase in mineral production in Western Australia only;

**Simulation 3:** Queensland only;

**Simulation 4:** New South Wales only;

**Simulation 5:** Northern Territory only;

**Simulation 6:** Victoria only;

**Simulation 7:** South Australia only; and

**Simulation 8:** Tasmania only.

In each case, the output increase is caused by a joint increase in the resource and capital stocks of the minerals sector. The choice of a 10 per cent stimulus is arbitrary but, for wider use, the results can be adjusted to an x per cent sized output stimulus by multiplying them by x/10. (Linearisation error does, however, increase with the size of the shock.)

Key features of the model’s **short run economic environment** are as follows.

- Industry specific capital is generally held fixed. As a consequence, industry rates of return, and hence capital rental prices, adjust to clear capital rental markets. The only exception is the increase in the capital stock in the minerals industry associated with the exogenous 10 per cent increase in mineral production in a given jurisdiction.

- The national real wage is fixed above the market clearing level and increased labor demand is evident in increased total employment. Increased labor use reduces unemployment given a fixed national labor supply and fixed rates of interstate migration.

Key features of the model’s **long run economic environment** are as follows.

- An industry’s capital stock alters with long term profit opportunities. Capital stock ratios between industries in a region adjust until rates of return are equalised (adjusting for ‘beta’ risk diversification).

- Full employment is assumed at the fixed national labor supply. Increased demand for labor is evident in an increase in the national real wage and labor migrates to expanding sectors across the states and territories.

In both the short and long run economic environments, the real budget deficits (or surpluses) of the various governments are held fixed so that the mineral output stimulus is budget neutral. The consumer price index is the ‘numeraire’, which implies that all prices in the model are deflated by the consumer price index in the base year 1993-94.
Previous research

**Theoretical underpinnings**
There is a considerable theoretical literature on the economywide impacts of an increase in production, and exports, of mineral resources both in Australia (see, for example, Gregory 1976; Snape 1977) and overseas (Corden and Neary 1982; Corden 1984; Neary and van Wijnbergen 1986).

In general terms, when analysing the economywide impacts of a minerals expansion, there are two key effects that are emphasised.

- The **spending effect** is the impact of a rise in domestic expenditure on the national economy.

- The **resource movement effect** is the impact of the movement of resources or factors of production into the expanding minerals industry from unemployed labor resources (in the short run) and from other industries (in the long run).

An increase in mineral production results in an increase in both aggregate output and national income. As a consequence, domestic spending or expenditure is likely to also rise either directly (expenditure by industry) or indirectly (increased taxation revenue increasing government expenditure).

In the MONASH-MRF simulations, the minerals expansion is assumed to be budget neutral although real government expenditure moves in line with private consumption expenditure in the corresponding jurisdiction.

Increased domestic expenditure increases demand for importables (that is, goods and services either directly imported or produced by domestic import competing industries), although the price of these goods and services is assumed to be determined on world markets. Increased domestic expenditure also increases demand for nontraded goods and services, placing upward pressure on prices in this sector (the price of nontradables is assumed to be fully determined in the domestic market). This results in a real appreciation of the Australian dollar, reducing the international competitiveness of other export and import competing industries.

Following the expansion of the minerals industry, production in other export and import competing industries is lower than would otherwise be the case as factors of production are attracted to the relatively more profitable minerals industry. However, the net impact on the nontraded sector is ambiguous as the rise in the price of nontradables offsets to some extent the shift of factors of production from this sector to the minerals industry.

**Applied research**
There is a considerable applied literature which quantifies the impacts of mining on the Australian economy using ORANI-type general equilibrium models.

The economywide impacts of a mining boom in Australia were quantified in Stoeckel (1979) using a small general equilibrium model of the Australian economy and in Stoeckel (1999) using G-Cubed, a general equilibrium model of the world economy.
The economywide impacts of an expansion or contraction of Australia’s upstream oil and gas industry were quantified in Hogan and Naughten (1990), Higgs and Powell (1992), Clements and Greig (1994) and Hogan et al. (1996).

Clements, Ahammad and Qiang (1996) provide a detailed analysis of the macroeconomic and intersectoral effects of a comprehensive range of mining and mineral processing projects on the Western Australian economy using WAM, an ORANI-type model of that economy. There have been several further mineral applications using WAM (see, for example, Ahammad and Clements 1999).

Dann et al. (1997) used the MONASH-MRF model to examine the economywide impacts of reduced land access for the rural sector and the mining sector in Tasmania. The simulations include estimates of the impacts on the rest of Australia of changes in Tasmania.

In general, these empirical studies highlight the role of mineral expansions in raising aggregate output and stimulating activities in the nontraded services sector despite the fact that some of the models contain different levels of industry detail.

**Simulation results**

The key macroeconomic simulation results are presented in table 10. The direction of the economywide impacts are similar for each simulation in a given economic environment (short run or long run).

Differences in the magnitude of the impacts largely reflect the size of the minerals industry in the corresponding jurisdiction. A proportionate 10 per cent increase in minerals production provides an indication of the relative importance of minerals in the various jurisdictions. The implied absolute size of the increase in mineral production varies between jurisdictions according to the size of the industry. The simulation results should therefore be interpreted with some caution, particularly when comparisons are made between state and territory outcomes.

Following a 10 per cent increase in mineral production, output and private consumption expenditure are higher than would otherwise be the case in all simulations in both the short and long run.

Private investment expenditure increases in the short run are due solely to the increased investment in the minerals industry (in the short run, capital is fixed and there is no investment in other industries, by assumption). In the short run, labor is the only factor that is assumed to be mobile between all industries. Real wages are assumed to be fixed in the short run, but additional labor may be sourced from unemployed labor resources.

In the long run simulations, the private sector is able to increase the capital stock in relatively more profitable economic activities both through a reallocation of existing capital and by new investment. In the long run, national employment is assumed to be fixed and the national real wage adjusts to clear the labor market (that is, the national real wage changes
to equilibrate supply and demand for labor). However, labor migrates to industries in the states and territories where production expands.

Following a nationwide 10 per cent increase in mineral production, in the short run, Australia’s real gross domestic product (GDP) increases by 0.3 per cent, private consumption expenditure increases by 0.2 per cent and private investment expenditure increases by 0.7 per cent. In addition, national employment increases by 0.3 per cent and the national unemployment rate falls by 0.3 percentage points. The real exchange rate appreciates by 0.6 per cent in the short run. In the long run, the main differences to these results is that national employment is unchanged by assumption and private investment expenditure increases by 1.0 per cent.

Notably, increased mineral production in the state and territory simulations tends to result in considerably larger impacts on state and territory output and expenditure in the long run compared with the short run outcomes. This reflects adjustments in the capital stock that are possible over the longer term and associated labor migration to the state or territory where the minerals expansion occurred.

In the state and territory simulations, the largest increases in real gross state product (GSP) occur for Western Australia and the Northern Territory (both 1.4 per cent in the short run;...
3.6 per cent and 3.0 per cent, respectively, in the long run). Significant increases in real GSP also occur in Queensland (0.6 per cent; 1.9 per cent), Tasmania (0.4 per cent; 1.1 per cent) and New South Wales (0.3 per cent; 0.7 per cent). The impact in both Victoria and South Australia is small.

In the state and territory simulations, the percentage increases in employment in both the short and long run are broadly similar to the outcomes for real GSP in the corresponding jurisdiction.

Output and employment multipliers are often calculated to provide a summary measure of the economic impacts of a specific shock.

An output multiplier is the ratio of the absolute change in aggregate output to the absolute change in mineral production. Overall, the short run output multiplier for real GDP under a nationwide mineral production increase is 1.7. That is, in constant prices, a A$1 increase in national mineral production generates a A$1.7 increase in real GDP.

The short run output multipliers for real GSP range from 1.8 (Queensland) to 2.4 (South Australia and Tasmania), well within the range of previous studies for single region models. The short run national output multipliers tend to be lower than the corresponding state or territory multipliers as impacts dissipate with geographic distance from source to some extent.

The long run output multiplier for real GDP under a nationwide mineral production increase is 1.0. Simulations using the MONASH model resulted in a long run national output multiplier of 1.2 based on a standard export price elasticity of demand assumption of –10 (or 1.3 with an export price elasticity of demand assumption of –5). However, reflecting the greater impact at the state or territory level, the long run output multipliers for real GSP range from 4.7 (New South Wales and the Northern Territory) to 7.6 (South Australia).

A similarly large long run GSP multiplier estimate for South Australia (7.3) was obtained from the MONASH-MRF model by Dixon and Peter (1996) under a 1 per cent long run total factor productivity shock to its manufacturing sector. Also using the MONASH-MRF model and an earlier database, Dann et al. (1997) report a GSP multiplier estimate of 4.5 for Tasmania under a 10 per cent shock to mineral sector output as a whole from a capital stock shock alone. This is somewhat smaller than the long run estimate in the current study of 6.1.

The short run employment multipliers tend to be larger than the corresponding output multipliers, reflecting the use of previously unemployed labor in the short run. In the national simulation, the short run employment multiplier is 2.2 (that is, an increase in employment of 1 person in the national minerals industry increases national employment by 2.2 persons). The state and territory multipliers range from 2.5 (Queensland) to 4.8 (South Australia).

In general, the short run employment multipliers are well within the range of the previous studies for single region models described earlier where employment multipliers are reported. Values between 2 and 5 in rounded terms are quite common under comparable macroeconomic environments.
The long run employment multipliers are relatively large, ranging from 4.6 (New South Wales) to 13.4 (South Australia). In the long run, as modeled, the national employment multiplier is zero by definition. The long run state and territory employment multipliers therefore simply reflect labor migration from a fixed national labor pool.
econometric model of the Australian gold industry

Model data
The data used in the model estimation were:

- real gold prices in 2000-01 Australian dollars (ABARE);
- real exploration expenditure in 2000-01 Australian dollars (ABS 2002a);
- capital investment on mine development and plant and equipment (fixed tangible capital expenditure) (ABS 2001a);
- real capital stock (in 2000-01 A$) using ABS capital investment series (fixed tangible capital expenditure) deflated by the cost of capital index and the capital accumulation identity (see equation 4) — starting value of capital stock in 1966-67 was estimated on the basis of ABS estimates of total mining stock–output ratios applied to the gold mining industry’s share of mining output in 1969-70;
- production (tonnes) (ABARE 2001a);
- economic demonstrated resources (AGSO / Geoscience Australia 2001); and
- exploration permits — pending approvals and granted approvals.

The model was estimated using all data series in financial years. All the data series were available in financial years except for economic demonstrated resources. To derive the economic demonstrated resources to production (EDRP) ratio series, the EDRP ratio was first calculated in calendar years — that is, as the ratio of production in a given calendar year compared with the economic demonstrated resources level in that year. In the model the EDRP ratio for a given financial year (for example, 1999-2000) was taken as the EDRP ratio calculated for the concurrent calendar year (for example, 2000).

It should be noted that production in financial years was only available for the years 1984-85 to 1999-2000. To complete the earlier years of this series (back to 1972), production (in calendar years) was averaged over a two year period to derive an estimation of financial year production for the period 1971-72 to 1983-84.

To incorporate the impact of land access, an index was created using the number of exploration title applications pending (and granted) in Australia since 1991-92 (the native title period). Details of the numbers by jurisdiction are provided in table 7, chapter 5. The index
is a ratio of applications pending relative to the number granted in any one year. This index was ‘normalised’ so that the base year of 1991-92 was equal to one.

The introduction and adoption of new processing technology (carbon-in-pulp and carbon-in-leach technology) occurred over the period 1983–90. Analysis of industry data indicated that adoption of the new processes commenced in 1982-83, with full adoption in 1989-90. To capture the impact of this technological advance on gold production, an indicator was developed which measured the rate of adoption of this new processing technology. In addition a time trend was included, which would account for any decrease in unit production costs over time, over and above those reflected in the technological advance.

At an aggregated national level, exploration costs per unit of discovery have declined over the study period. A time trend was included in the model to account for the possible influence of this factor on exploration levels, relative to the effect of the level of economic demonstrated resources.

**Model notation**

- $Q_t$: Australian gold production in year $t$
- $P_t$: Australian gold price in year $t$
- $E_t$: Gold exploration expenditure in year $t$
- $K_t$: Australian gold mining capital stock in year $t$
- $KI_t$: Investment in Australian gold mining capital in year $t$
- $EDR_t$: Economic demonstrated resources to production ratio in year $t$
- $T^M_t$: Proportion of gold mines using new ore processing technology at time $t$
- $LA_t$: Ratio of pending exploration permits to actual approvals in year $t$
- $k$: Trend in the cost of gold mining capital
- $t$: Time trend.

**Model structure**

Several of the data series used in the model estimation exhibit trends and may follow a nonstationary trend process. To account for these trends a linear model was used incorporating first differences of the trending variables.

The model framework undertaken was used to provide an understanding of the dynamics of gold exploration and supply. In all the model stages, one and two year lags of the variables were included, where appropriate.

The gold production process is modeled as a three-stage process.

- The first stage of the model relates factors determining the level of gold exploration expenditure. In this stage, exploration expenditure is modeled as a function of gold
prices, the land access index and the ratio of economic demonstrated resources to production. The expectation is that the level of exploration is positively related to prices and negatively related to the levels of the other two variables.

The second stage of the model analyses the relationship between investment in mine development (and mining infrastructure) and the level of exploration expenditure, given the expected returns to mining (function of prices). In this stage the impact of changes in the level of exploration expenditure and gold prices on capital investment (and the subsequent level of capital stock) is modeled. The expectation is that the level of capital investment (and capital stock) is positively related to the level of gold prices and exploration expenditure.

The third stage of the model analyses the relationship between gold supply and production capacity. Gold production is then modeled as a function of the capital stock and the adoption of advances in gold processing techniques.

**Exploration expenditure**

In its general form the exploration equation is:

\[ E = f(P, \text{LA}, \text{EDRP}) \]

where

- \( E \) Exploration expenditure
- \( P \) Gold prices
- \( \text{LA} \) Index of land access
- \( \text{EDRP} \) Economic demonstrated resources to production ratio

**Capital investment**

The gold mining capital investment expenditure series was derived from the historical gold mining investment expenditure series (ABS 2002a). This was deflated by the cost of fixed private capital expenditure index.

The level of capital investment in the industry is a function of the expected returns to this investment, which itself will be influenced by the costs and productivity of gold mining capital. During the study period there was a significant change in unit production costs with the introduction of new processing technology. To account for this impact on capital investment and production, the rate of adoption of this technology was incorporated into the model framework. The levels of capital investment will also be influenced by recent discoveries, given that capital expenditure is required to extract these resources. Given the inadequacy of available time series data on proved discoveries, exploration expenditure was used as an indicator of recent discoveries.

In its general form the capital investment relationship is given by:

\[ KI = f(E, P, T^M, k) \]

where

- \( KI \) Capital investment
- \( K \) Trend in the cost of gold mining capital
**Exploration expenditure**

$p$ Gold prices

$TM$ Adoption new processing technology

**Production**

It is assumed there is a long term relationship between the levels of capital stock and gold production.

The general form of the production equation is given by:

\[ Q = f(K, TM) \]

where

$Q$ Gold production

$K$ Capital stock

$TM$ Adoption new processing technology

The capital stock series was constructed on the basis of historical levels of capital investment in gold mine development and processing capacity. A constant rate of depreciation (15 per cent) for capital expenditure was assumed, together with the assumption that capital expenditure becomes productive capacity over a two year period.

The calculation of the capital stock is given by:

\[ K_t = (KI_{t-1} + KI_{t-2})/2 + (1-0.15)K_{t-1} \]

To account for lagged effects, one and two year lags were initially included in the model for exploration, capital investment and production factors.

**Estimation results**

**Exploration expenditure**

The final estimation equation is given by:

\[ \Delta E_t = 85.65 + 1.21\Delta P_{t-1} - 36.18 LA - 260.88D_{89} \]

| Test statistic | 0.72 | F statistic 13.93 |

| Autocorrelation a | 0.84* |
| Heteroscedasticity b | 1.76* |
| Functional form e | 0.40* |
| Normality d | 1.08* |

a F version test for first order autocorrelation.

b F version test for first order heteroscedasticity.

c Ramseys RESET test of functional form.

d Jarque-Bera test of normality of residuals. * Insignificant at 5 per cent critical value.

99
A variable was included for exploration expenditure in 1988-89, when there was a significant downturn in exploration expenditure, which could not otherwise be adequately explained by the model structure. The descriptive statistics and model diagnostics indicate that the model is an adequate representation of gold exploration expenditure, with both prices and land access found to be significant determinants of exploration expenditure.

**Capital investment**
The final estimation equation is given by:

\[
\Delta K_I = 18.2 + 0.54\Delta E_{t-1} + 1.414\Delta P_{t-1} + 333.94D_{88}
\]

\[
(0.42) (1.94) (2.37) (1.79)
\]

Sample 1985-86 to 2000-01 \( \text{R}^2 \) 0.70 F statistic 12.28

<table>
<thead>
<tr>
<th>Diagnostic test</th>
<th>Capital investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test statistic</td>
<td></td>
</tr>
<tr>
<td>Autocorrelation a</td>
<td>0.86*</td>
</tr>
<tr>
<td>Heteroscedasticity b</td>
<td>0.68*</td>
</tr>
<tr>
<td>Functional form e</td>
<td>1.39*</td>
</tr>
<tr>
<td>Normality d</td>
<td>1.84*</td>
</tr>
</tbody>
</table>


A variable was included for capital investment expenditure in 1987-88, when there was a significant increase in expenditure. It is likely that this variable captures the higher than expected capital investment associated with the uptake of new gold processing technology. The descriptive statistics and model diagnostics indicate that the model is an adequate representation of capital investment in the gold industry, with both gold prices and exploration levels found to be significant determinants of capital investments.

**Gold production**
The final estimation equation is given by:

\[
\Delta Q_t = -1.16 + 0.045\Delta K_t + 46.070T^M - 45.75 \ T^{M2} + 18.75D_{88-90} - 29.39D_{99}
\]

\[
(-0.46) (3.33) (2.35) (-2.50) (3.09) (-3.72)
\]

Sample 1974-75 to 2000-01 \( \text{R}^2 \) 0.80 F statistic 20.82
<table>
<thead>
<tr>
<th>Diagnostic test</th>
<th>Capital investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autocorrelation</td>
<td>0.01*</td>
</tr>
<tr>
<td>Heteroscedasticity</td>
<td>2.25*</td>
</tr>
<tr>
<td>Functional form</td>
<td>3.36*</td>
</tr>
<tr>
<td>Normality</td>
<td>0.52*</td>
</tr>
</tbody>
</table>

a F version test for first order autocorrelation.

b F version test for first order heteroscedasticity.

c Ramseys RESET test of functional form.

d Jarque-Bera test of normality of residuals. * Insignificant at 5 per cent critical value.

A variable was included for the period 1988-90, when there was a significant increase in production, above what would be expected given the change in capital stock and the impact on production captured by the technology variable. The estimation results indicate that annual production over this period was around 19 tonnes higher than would otherwise be expected. In addition a dummy variable was included for the significant downturn in production in 1998-99, when production was around 29 tonnes lower than expected.

The time trend, which reflects any decrease in unit production costs over time (over and above those reflected in the technological advance) was not found to be significant.

The descriptive statistics and the model diagnostics verify the robustness of the model, indicating the specified model is an adequate representation of gold production. Both the change in the level of capital stock and the adoption of the new processing technology were found to be significant determinants of gold production levels.
A system of flow-through shares was introduced in Australia in 1967-68. After six years of operation, the system was repealed in May 1973. Australia’s previous experience with flow-through shares has been used to argue against a reintroduction of the system.

Fitzgerald (1984) cites a study by McKern who found that over the period 1964 to 1970, small companies with assets less than A$1.5 million employed nearly three-quarters of the funds raised by them in uses other than exploration or mines and plant.

Fitzgerald (1984, p. 19) argued that in some cases ‘the tax concessions had tended to become less of a means of promoting new companies and more an end in themselves, being most attractive to persons on high taxable incomes. In such cases, the government provided up to two-thirds of the share subscriptions, and the scale of losses to the exchequer could be a function of the strength and frequency of waves of speculative fever’.

The concerns over the flow-through shares mechanism need to be placed in the context of the incentives created by the personal income tax system during that period. Personal marginal income tax rates that applied in 1972-73 are given in table 11.

The top marginal tax rate was 66.7 per cent which applied to personal taxable income in
excess of A$40 000 in 1972-73 (CCH 1973). In 1971-72, the top marginal tax rate of 66.7 per cent applied to personal taxable income in excess of A$20 000 (CCH 1972). The top personal marginal tax rate was 66.7 per cent throughout the period in which the flow-through shares mechanism was in place.

Although major changes were made to the personal income tax scale in the 1972-73 Commonwealth budget, the additional levy of 2.5 per cent that also applied was not removed (Treasury 1972).

The increase in the maximum marginal tax rate point from A$20 000 in 1971-72 to A$40 000 in 1972-73 occurred in response to bracket creep associated with strong growth in wages, recognition of the impact of rising taxation on incentives, and a decline in consumer spending.

The following is an excerpt from the 1972-73 Budget Speech delivered on 15 August 1972 (Treasury 1972, pp. 23–4).

‘We strongly believe that personal income taxation is now too high and that, without action to cut it, the situation will become progressively worse with the passage of time. The interaction of money incomes rising with inflation and the progressive rate scale is imposing heavy and increasing burdens. This year provides an opportunity to reduce these burdens. Accordingly, we have decided to concentrate our tax concessions in the area of personal income tax. Our reasons are:

• First, the personal income tax burden is becoming more and more severe. The tax bite is being determined, not in accordance with deliberate aims of policy, but by the impact of inflation on a scale basically designed for another level of incomes altogether.

• Secondly, the family man in particular, with all of his other commitments, is finding income taxation looming ever-larger as a problem, and is coming to question the fairness of the burden he bears.

• Thirdly, rising taxation is affecting incentives and encouraging tax avoidance.

• Fourthly, rising taxation adds to pressure for excessive increases in money wages and salaries. We believe our measures will provide grounds for moderation.

• Fifthly, a reduction in personal income tax will put more money directly into the hands of consumers. Their take-home pay and their capacity to spend will be enhanced. There will be a real lift to community and business psychology. That is just what is needed at this time.’

Despite the recognition of the disincentives created by high personal marginal tax rates, there was no reduction in the top marginal tax rate of 66.7 per cent.

The budget deficit was estimated to be A$630 million in 1972-73 (Treasury 1972). The cost to revenue of restructuring the personal income tax scale, effective from 1 September 1972, was estimated to be A$380 million in 1972-73. Gross pay as you earn (PAYE) income tax receipts were estimated to still rise by A$306 million in 1972-73.
Revenue forgone associated with tax concessions relating to moneys paid on shares — including a third of calls on mining or afforestation shares, and moneys paid on shares for the purpose of exploration, prospecting or mining — was estimated to be A$48 million in 1971-72 (Treasury 1972) and A$40 million in 1972-73 (Treasury 1973). Moneys paid on shares in mining, but not afforestation, companies were not deductible if paid after 7 May 1973 (Treasury 1973, footnote b, p. 69).

The taxation environment that is currently in place is substantially different from that which existed in the late 1960s and early 1970s. The much simplified personal income tax scale that applied in 2000-01 is given in table 12. The top marginal tax rate is 47 per cent which applies to personal taxable income in excess of A$60 000 (CCH 2002).

The fringe benefits tax now in place provides a degree of discipline on spending by companies that did not exist under the previous flow-through shares mechanism. Exploration leases are provided to private explorers by state and territory governments that are responsible for monitoring work program commitments. In general, investors tend to be better educated about the risks associated with a range of competing investment options than was probably the case thirty years ago.

Given that the company income tax rate is currently 30 per cent, allowing investors access to tax deductions at the top marginal tax rate implies a maximum premium of 17 percentage points. Under the earlier scheme when the company income tax rate was 42.5 per cent, the implied maximum tax premium was around 24 percentage points. As indicated earlier, an assessment of the extent to which the presence of positive externalities in private mineral exploration activity justifies the tax premium is a matter for further research.

### Table 12: Personal income tax rates, 2000-01

<table>
<thead>
<tr>
<th>Taxable income range</th>
<th>Marginal tax rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>From A$</td>
<td>To A$</td>
</tr>
<tr>
<td>0</td>
<td>6 000</td>
</tr>
<tr>
<td>6 001</td>
<td>20 000</td>
</tr>
<tr>
<td>20 001</td>
<td>50 000</td>
</tr>
<tr>
<td>50 001</td>
<td>60 000</td>
</tr>
<tr>
<td>60 001</td>
<td></td>
</tr>
</tbody>
</table>

a An additional medicare levy of 1.5 per cent applied to taxable income of A$14 927 or more. The levy increases for those without private hospital insurance.

Source: CCH Australia (2002).
overview of environmental legislation

Commonwealth legislation
The major Commonwealth environment legislation is the Environment Protection and Biodiversity Conservation (EPBC) Act 1999, administered by Environment Australia. This act implements a number of the key aspects of the Heads of Agreement (HOA) on Commonwealth/State Roles and Responsibilities for the Environment that was designed to develop a more effective framework for intergovernmental relations on the environment.

Among other things the HOA agreed that the Commonwealth’s involvement in environmental matters should focus on matters of national environmental significance. The act currently identifies six matters of national environmental significance: World Heritage properties, Ramsar wetlands, listed threatened species and ecological communities, listed migratory species, Commonwealth marine areas and nuclear actions.

The administrative guidelines to the act address mineral exploration activities explicitly. They list the specific activities that are, and are not, likely to have a significant impact on matters of national environmental significance.

One feature of the EPBC Act is the provision for bilateral agreements between the Commonwealth and states and territories. Assessment bilaterals allow the Commonwealth to recognise the assessment processes of a state or territory for a certain class of actions. Approvals bilaterals allow the Commonwealth to recognise the approvals processes of a state or territory for a certain class of actions.

For the most part, however, the environmental impact of mining is governed by state and territory legislation.

Western Australia
In Western Australia the environmental aspects of the state’s Mining Act are administered by Department of Mineral and Petroleum Resources. The State Mining Engineer’s approval to mine under the Mining Act requires a Notice of Intention in which the proponent assesses the environmental impacts that may arise from the project. Current guidelines for approval reflect a move toward audited self management by the mining industry as supported and promoted in the Minerals Council of Australia’s Code for Environmental Management. Underpinning the guidelines is an environmental management system for each project.
External technical certification that a Notice of Intention meets the requirements of the guidelines can significantly expedite the process of obtaining State Mining Engineer approval.

There are a number of other important environmental controls:

- The Environmental Protection Authority (EPA) within the Department of Environment and Protection administers the Environmental Protection Act. If a proposed activity is located in an environmentally sensitive area, the proposal will be referred to the EPA, which will require some form of Environmental Impact Assessment.

- The Department of Conservation and Land Management (CALM) administers all lands vested in the ‘conservation estate’ and also the Wildlife and Conservation Act.

- The Water and Rivers Commission (WRC) manages the state’s water resources to support sustainable development and conserve the environment. WRC approvals are required for mining activities that are likely to have an impact the state’s water resources.

It is also a standard condition of all mining tenements issued under the Mining Act that attention is drawn to the provisions of the Aboriginal Heritage Act.

**Queensland**

Acknowledging the importance of clear and responsive regulatory systems in ensuring that Queensland remains attractive for mineral exploration and development, the environmental regulation of mining has been transferred from the Department of Natural Resources and Mines to the Environmental Protection Agency (EPA).

All new mining projects require an Assessment Level Decision by the EPA on whether the project is standard or nonstandard. Projects assessed as nonstandard require an Environmental Impact Statement Decision on whether an environmental impact statement is required.

The EPA is responsible for all aspects of environmental control, including:

- setting levels of environmental assessment for new applications;
- setting environmental conditions;
- monitoring performance, including conduct inspections and audits; and
- ensuring adequate rehabilitation and otherwise enforcing compliance with environmental controls.

**Northern Territory**

The Department of Business, Industry and Resource Development administers the environmental aspects of the territory’s Mining Management Act. Approval for a mining project in the Northern Territory requires the preparation of a Notice of Intent that among other things covers the environmental aspects of the proposed activity. The Notice of Intent is assessed to determine whether the proposal can be managed by the department’s environmental processes or whether it should be referred to the Department of Lands, Planning and the Environment for assessment under the Environmental Assessment Act.
If the proposal is assessed under the act, the proponent must prepare either a Public Environment Report if the project assessed to have limited environmental impact or an Environmental Impact Statement if the project is assessed to have significant environmental impact.
references


PMSEIC (Prime Minister’s Science, Engineering and Innovation Council) 2001, Australia’s Mineral Exploration, Canberra, 28 June.


Resource Information Unit (RIU) 2001, Register of Australian Mining 2001/02, Subiaco, Western Australia (see www.riu.com.au).


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Department of Foreign Affairs and Trade
Department of Industry, Tourism and Resources
Environment Australia
Fisheries Research and Development Corporation
Fisheries Resources Research Fund
Fonterra Cooperative Group Ltd, New Zealand
Grains Research and Development Corporation
Grape and Wine Research and Development Corporation
Land and Water Australia
Meat and Livestock Australia
Murray–Darling Basin Commission
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New Zealand Prime Minister and Cabinet
Office of Resource Development, Northern Territory
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Rural Industries Research and Development Corporation
Snowy Mountains Engineering Corporation
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Woodside Australian Energy
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