AUSTRALIA'S MINERAL EXPLORATION

A PAPER PRESENTED TO THE PRIME MINISTER'S SCIENCE, ENGINEERING AND INNOVATION COUNCIL
PREPARED BY AN INDEPENDENT WORKING GROUP DRAWN FROM INDUSTRY, GOVERNMENT AND THE UNIVERSITIES, WITH ASSISTANCE FROM THE PMSEIC SECRETARIAT AND AGSO

28 JUNE 2001

CONTENTS

****

Executive Summary

The Australian minerals industry is Australia's largest export earner, contributing $43.8 billion to Australia's economy in the year 1999-2000. In the same year, Australia was among the top three producers of ten of the most valuable minerals in the world, including gold, diamond, zinc, tantalum and nickel. The value of the minerals industry is etched in Australian history and identity, and has helped Australia achieve its position as the sixth wealthiest nation, per person. The benefits of the minerals industry to the Australian community extend far beyond export profits. Contributing significantly to the development of regional infrastructure, including railways and roads, manufacturing, and information technology, the Australian minerals industry is the highest value adder to the Australian GDP per person employed.

Although Australia was the top-ranking country in the world for exploration budgets in 2000, it also showed the largest decline of any county or region. Challenges such as accessing deeper mineral deposits, maintaining the intellectual edge and managing changes in social values and expectations are the main issues currently facing the Australian minerals industry. Nevertheless, Australia is considered to be highly prospective for new major mineral discoveries. It has a history of stable government and a history of unique collaboration between government and industry in mineral exploration.

As the world enters a new era of exploration, where minerals are concealed beneath the surface, there is a need for new understanding, new technologies and highly trained specialists to discover the mineral deposits that the world requires. The concepts, technologies and people involved will need to make major contributions to the management of humanity's impact on the natural environment.

There are challenges for Australia if it wishes to build on its existing strengths in the exploration industry and become the global leader in that sector. However, with a competitive business environment, government support for a new phase of regional surveys to stimulate private sector investment, and continuing efforts to develop world-class research and tertiary education establishments, Australia can become the global centre for mineral exploration industry within this decade.

AUSTRALIA'S MINERALS INDUSTRY: NATIONALLY VITAL, GLOBALLY SIGNIFICANT

Australia's largest export earner is the minerals industry. It -

- contributed $43.8 billion in mineral and energy exports to Australia's economy in 1999–2000, accounting for 44.9% of Australia's total merchandise exports or 34.8% of total goods and services,[1]
- contributed $1.9 billion (as a conservative estimate) in high-technology exports in mining services in 1999–2000, which is more than Australia's current wine industry exports;[1]
- was among the top three producers of 10 of the world's most valuable minerals in 1999 (see Table 1),[2,3]
- dwarfs all other sectors in terms of value added per worker - for example, it was more than four times the national average to national income or gross product in 1995–96;[4] and
- accounted for 19% of the value of Australia's fixed assets and natural capital in 1998.[5]

Australia was ranked the sixth wealthiest nation in the world on a per capita basis in 1994,[6] and much of that wealth was due to the minerals industry. Over the past 20 years the resource sector has contributed around $500 billion to Australia's wealth—almost 1.5 times the earnings of the agricultural sector over the same period (see Figure 1).

1999	#1 Producer	#2 Producer	#3 Producer
Bauxite	AUSTRALIA	Guinea	Brazil
Diamond	AUSTRALIA	Russia	Botswana
Gold	South Africa	USA	AUSTRALIA
Iron Ore	China	Brazil	AUSTRALIA
Lithium	Chile	China	AUSTRALIA
Mineral Sands	AUSTRALIA	South Africa	Canada
Nickel	Russia	Canada	AUSTRALIA
Tantalum	AUSTRALIA	Brazil	Canada
Lead	AUSTRALIA	China	USA
Zinc	China	AUSTRALIA	Canada

Table 1. Australia's unsurpassed mineral production rates

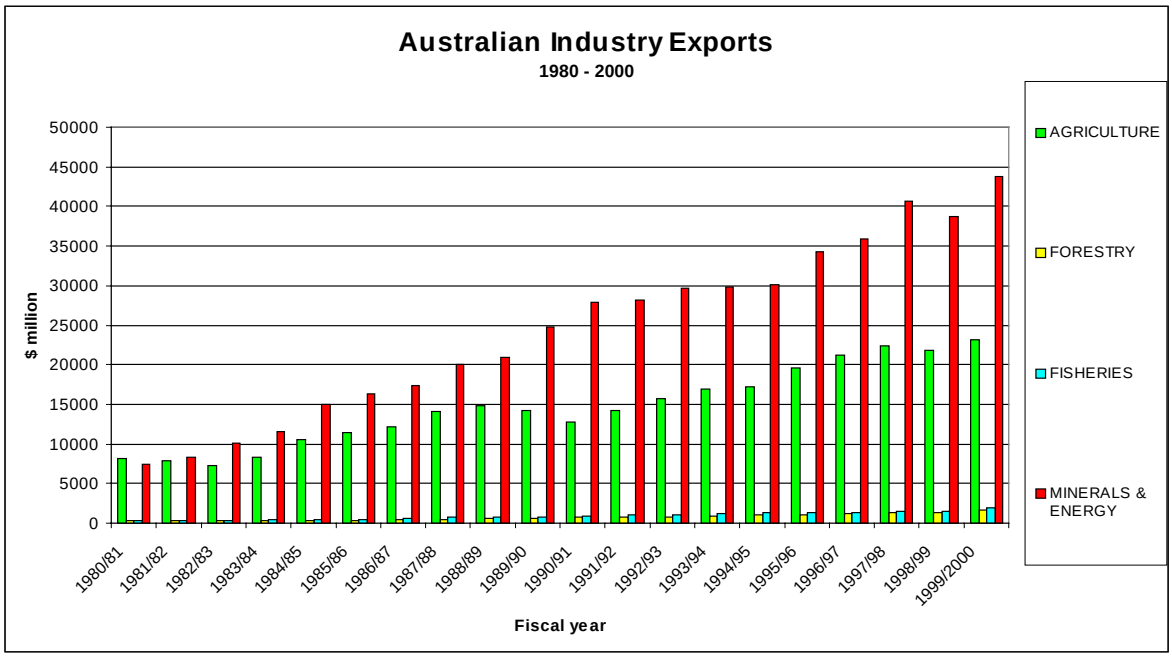

Figure 1: Australian Industry Exports 1980-2000.

In 2000, Australia attracted more than 17% of the world's total budgeted exploration expenditure (see Figure 2a). This was more than any other country, giving Australia the highest exploration expenditure allocated per square kilometre (see Figure 2b).[7] It is no coincidence, therefore, that Australia's national wealth increases at times of increased mineral exploration and mining.

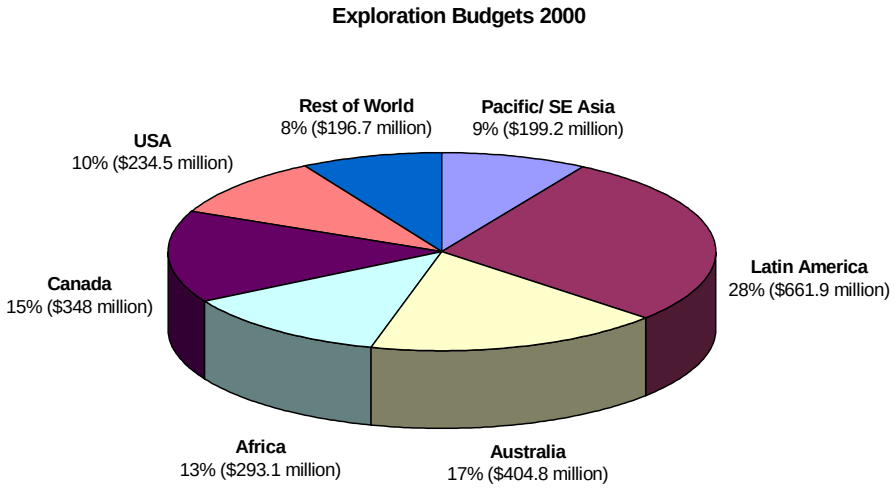

Fig.2a. Distribution of world exploration budgets in US$ by 656 exploration companies

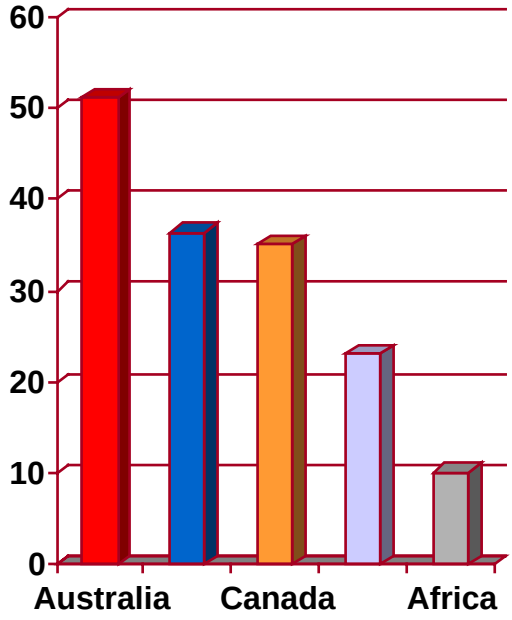

Figure 2b: Projected global exploration expenditure for 2000 normalised by land area (US$/square kilometre)

Nation-wide benefits from mining

The minerals industry has contributed enormously to building the national infrastructure. Mining operations were the impetus for building towns and road and port facilities throughout Australia, and have opened up outback areas that otherwise would have remained isolated and unproductive. Entire towns in regional and rural Australia developed around mines and many, such as Broken Hill, Mt Isa and Kalgoorlie, are recognised as quintessential Australian towns (see Case Study 1). Cities such as Newcastle, Wollongong and Whyalla have prospered indirectly from mining.

Significant benefits flow to other major Australian industries—such as transport, construction and manufacturing—because of the minerals industry. The early days of the Victorian gold rush encouraged Cobb & Co and Australia's first railway (established in 1854) to expand beyond Melbourne to service the Ballarat goldfields and the new rural populations of Victoria. Today trains up to 2.6 kilometres in length, daily transport iron ore across the Pilbara region in Western Australia to ports for export.[5]

In 1999–2000, total payments to government from mining were $4.75 billion, consisting of $3.52 billion in taxes and royalties and $1.23 billion in transport levies.[8]

Mining spawned some of Australia's major companies (such as BHP and WMC) and led directly to new industries such as ore smelting and refining and steel making. In addition, industries that supply mining companies have developed, and now earn export dollars in their own right (e.g. mining and engineering contractor, Henry Walker Eltin). The flow-on effects from mining to other sectors of the Australian economy include goods and services expenditure in excess of $15 billion (1999).[5]

Case Study 1: Irish luck gave Australia untold wealth

In June 1893 three Irishmen, Paddy Hannan, Tom Flanagan and Dan Shea were travelling from Coolgardie to a prospect at Mount Youlle, when one horse threw a shoe and they had to make camp on the slopes of Mount Charlotte. Like every good prospector, Hannan kept his eyes down and fossicked around the camp site. As luck would have it, he picked up lumps of gold and triggered the richest gold rush in Australian history at what became known as Kalgoorlie. But the real treasures were not on the slopes covered by Hannan. They were far below in the rich lodes known as the Golden Mile—the richest square mile of gold ore in the world.

For Australia, Kalgoorlie was a golden milestone; the greatest since Ballarat and Bendigo. Like the Victorian discoveries, it changed the course of Australian history. Within 10 years the population of Western Australia quadrupled (from less than 40 000 people), and a water pipeline was constructed from Mundaring Weir near Perth to Kalgoorlie in one of the great feats of Australian engineering. The continuing productivity of the goldfields made possible the transcontinental railway that linked Australia from coast to coast.

Early prospectors moved on. They were replaced by miners who designed or improved the best of the world's mining machinery to extract gold from the rich underground deposits. Gold from Kalgoorlie helped sustain the nation's fortunes through major depressions in the 1890s and 1930s. Over the past century, Western Australia has produced more than 70% of Australia's gold, with more than 43 million ounces coming from the Golden Mile—the richest single goldfield in Australian history.

Australia's first-class, international reputation

Internationally, Australia's reputation in the minerals industry is unsurpassed. Many Australian technological and scientific innovations have contributed directly to better exploration, mining, environmental and land practices.[9] One such innovation—a collaborative effort by the mining industry, communities and government—is Australia's Best Practice Environmental Management in Mining program. Through a series of booklets written by experts in their field, it promotes an integrated approach to managing environmental issues through all phases of mineral production, operation and eventual closure/rehabilitation. This program is recognised world-wide as a benchmark.

> *"The world's first [Australia's Best Practice Environmental Management in Mining program]: the best example of cooperation between the private sector and government I have ever seen."*
>
> (Mr Robert Goodland, President, International Association on Impact Assessment, World Bank, 1995[10])

Public reporting on environmental and social issues is now widespread under a Code for Environmental Management developed by the Australian minerals industry. It commits the industry to -

- sustainable development and integrated environmental management;
- the application of risk-management techniques;
- setting environmental targets, rehabilitation and decommissioning; and
- reporting to governments and the community.[11]

GOVERNMENT–INDUSTRY COLLABORATION: SUCCESS IN EXPLORATION

> *"…mines formed probably the most efficient industry in Australia, by international standards, but a big section of the public and many politicians came to think that the dazzling procession of mineral discoveries had depended more on luck than on effort and ingenuity."*
>
> (Geoffrey Blainey, historian, 1993[13])

Exploration is the lifeblood of mining. The industry would be unsustainable were it not for the new deposits discovered through exploration. Successful exploration involves skill, innovation, commitment and perseverance. It also involves great risk with the potential for creating great wealth.

> *"WMC attributes its growth entirely to successful exploration which, in turn, is attributed to the successful application of geological science."*
>
> (Roy Woodall, former Director of Exploration, WMC , 1983[12])

Exploration investment requires a perception of prospectivity and an investment climate that is stable and financially competitive—features that Australia has traditionally demonstrated. It also requires a huge research and development effort on geoscientific concepts, and exploration methods and technologies. Australia's proud record of mineral exploration success is due in no small part to the particularly strong collaborative research and development effort between industry and government (see Figure 3).

The impact of this collaboration is highlighted by past successes (see Case Study 2). Private-sector risk taken within a knowledge framework supported by government is now commonly cited as 'world's best practice'—a practice other countries that have not realised their mineral potential are attempting to emulate.

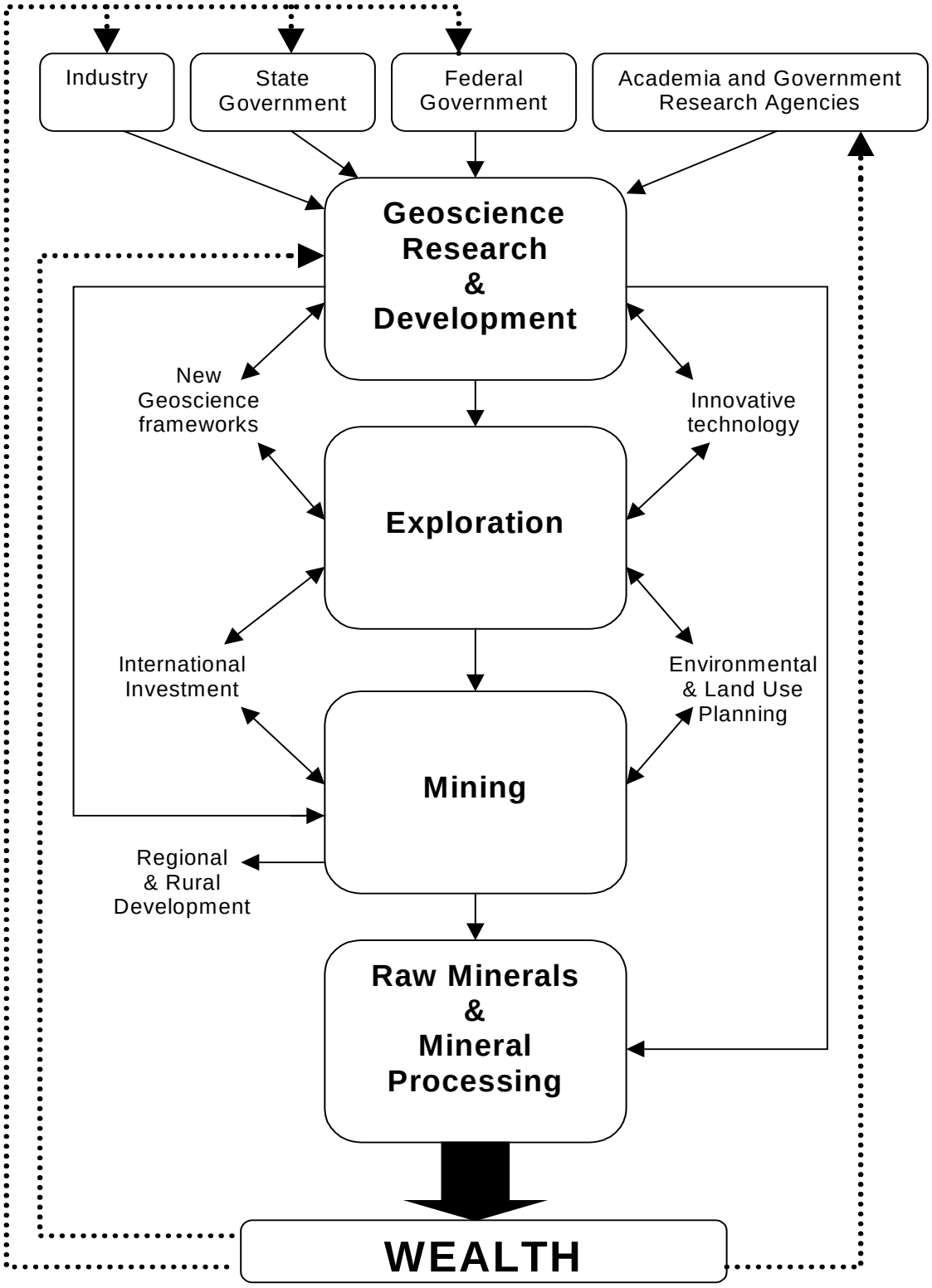

Fig.3: The Australian Minerals Industry – one of the most efficient and successful in the world

Case Study 2: Salt bush cover conceals mineral riches

In 1975 Western Mining Corporation (WMC) drilled an area of salt bush and native pines 200 kilometres north of Adelaide because company geologists noted an anomaly on AGSO's magnetic and gravity survey maps that fitted an exploration model they were testing. It was risky because the company was drilling where there was no surface evidence for minerals. But WMC's borehole intersected a giant lode some 300 metres below the surface. At this depth, copper, uranium, gold and silver ore-bodies had formed a mineralised zone more than five kilometres long and three kilometres wide. It is now known as Olympic Dam—a truly world-class deposit. It:

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

The origin of Australia's strong industry–government collaboration in mineral exploration research and development not only lies in the strong historical and economic importance of our minerals industry. It also lies in the fact that the geology of each part of the globe is unique in detail, and geological research therefore requires a strong element of local geological knowledge.[25] The necessary research needs to be indigenous and cannot be imported. Given the high public good element of such research, the result has been a large number of government-funded research agencies that elucidate Australia's unique geology, develop exploration techniques appropriate to Australia, and appropriately educate and train personnel.[25]

Details of the agencies involved in Australia's mineral exploration research and development are provided in Appendix A. Within the broad spectrum of research and development our universities are focussed on basic research into geological processes and Australia's geology, with some strategic research on mineral exploration models built on an understanding of the genesis of our mineral deposits. The Australian Geological Survey Organisation (AGSO), in collaboration with the State and Northern Territory geological surveys, undertakes strategic research that produces pre-competitive geoscience data and information on the nation's mineral prospectivity. CSIRO's focus is on the applied end of the research and development spectrum, including in particular the development of exploration tools and techniques that are most appropriate to the unique Australian geological environment.

Various mineral-exploration focussed CRCs bring these agencies together with industry partners to solve particular problems, and some of the most important recent breakthroughs and innovations have come from the CRCs. A good example is the TEMPEST airborne electromagnetic exploration system that is not only an important exploration tool, but also a new technique for environmental management (see Case Study 3).

Case Study 3: Mineral exploration and environmental management - TEMPEST

The recently completed airborne system, known as TEMPEST, was developed by CSIRO and World Geoscience Corporation (now FUGRO) through the Cooperative Research Centre for Australian Mineral Exploration Technologies (CRC AMET). It represents the culmination of more than six years collaborative research and development by private and public sector scientists and engineers. It was developed for world-wide exploration for minerals such as gold, diamonds, nickel, copper, lead and zinc buried at depths up to 300 metres. Its ability to detect underground water and groundwater salinity also makes it a valuable environmental management tool.

TEMPEST is installed in a Trislander aircraft and uses an ultra-sensitive receiver towed below the aircraft in a "bird" to detect minute magnetic fields induced in the earth by TEMPEST's powerful electromagnetic pulse generator. This information is processed by computer to produce three-dimensional images of the earth which help geologists map sub-surface geology and determine the best locations to drill.

The former Director of CRC AMET, Dr Brian Spies, said the TEMPEST system, and other new technology developed by the Centre, would play an important role in maintaining the viability of Australia's minerals export industry. "Minerals are our largest commodity export, but our existing mines are largely based on surface discoveries made many years ago," he said. "Because much of Australia is covered by silt and rubble, new ore bodies are becoming harder to find and local explorers are increasingly looking offshore. Australia urgently needs this new technology which is cost-effective, has minimal environmental impact, and is optimised for local conditions. TEMPEST will help us find new world-class deposits and so protect our export income. The system's sensitivity, wide range of applications and the high quality of the data it produces mean that Australia now leads the world in the development of airborne electromagnetic (AEM) mineral exploration systems."

CRC AMET was established in 1992 under the Commonwealth Government's Cooperative Research Centres Program to deliver to industry dramatically improved electromagnetic methods for mineral exploration in Australian conditions. With the successful development of TEMPEST, CRC AMET had fulfilled its mission and it was wound up in 2000.

Although industry supports public-sector research and development, usually through the Australian Minerals Industry Research Association, individual companies, where appropriate, undertake their own in-house applied research. The results of such work generally remain within the company, but there are some notable exceptions. One in particular is the breakthrough made by BHP in developing the first airborne gravity surveying system having a sensitivity sufficient enough for mineral exploration. The system is known as FALCON and its development is presented as Case Study 4.

Case Study 4: Project FALCON – Reducing time, cost and land impact

FALCON is a recently developed mineral exploration tool that minimises environmental impacts usually associated with mineral exploration activities. For the first time, FALCON has enabled BHP to perform high-resolution gravity gradiometer surveys from the air. The radical new airborne exploration system is based on technology designed for use in the US Navy's Trident submarines and developed by Lockheed-Martin. In Australia and North America, BHP has two fully operational airborne gravity gradiometer (AGG) systems in use.

Project FALCON was the result of a strategic vision of a small group of BHP Research and Minerals Discovery employees in the early 1990s. Following a worldwide search for suitable gravity technologies, BHP initiated a feasibility study into the most appropriate technology in 1993. The manufacture of two operational systems commenced in 1995 and the first airborne gravity mapping system entered operational service in late 1999.

BHP Research managed the development and construction of the airborne gravity gradiometer and the development of data processing and interpretation software. This new tool significantly reduces the time and cost of identifying mineral resource targets and improves the efficiency of exploration programs, providing a significant competitive edge. The benefits of FALCON for mineral exploration are provided by -

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

From an environmental perspective, FALCON reduces the need for ground surveys, which may involve constructing access tracks, and drilling or digging trenches to extract rock samples.

A deployment program developed by BHP Minerals Discovery is being implemented to evaluate brownfield (expansion of an existing facility or site) and greenfield (development of new operations from the ground up) opportunities. However, the benefits of FALCON may be more widely extended in the future, with potential applications in the discovery of oil and gas.

INNOVATION IN EXPLORATION: THE KEY TO FUTURE SUCCESS

An important spin off of Australian mineral exploration research and development has been the growth of exports of exploration and mining services. Through the development of remote sensing exploration technologies like TEMPEST and FALCON, and, before them, various space-borne and other airborne platforms, Australia has been at the forefront of imaging, 3D-modelling and interactive geology software development. These developments have extended to mine planning and production and today Australia supplies between 60% and 70% of all the mining software used worldwide.

One of the leading Australian companies in 3D-modelling and interactive geology is Western Australian based Fractal Graphics. Its innovations are applied internationally and it is now recognised as a world leader (see Case Study 5).

To maximise Australia's influence in the global mining services industry, more than 100 companies have formed Austmine—a collective dedicated to the promotion of Australia as a source of innovative technologies, equipment, products and services for the mining industry throughout the world. Austmine had combined exports exceeding A$1.5 billion in 1999–2000.[22]

To improve competitiveness, Australia needs to continue investing in innovation in exploration by developing -

- new data-acquisition tools that allow geoscientists to probe further under the Earth's surface;
- better analytical methods to interpret both existing and new geoscience data;
- new exploration models that overcome the predictive weaknesses of current models.

With the strength and support of government–industry collaboration, Australia is well positioned to enter a new stage of successful exploration.

Case Study 5: Australian ingenuity wins lucrative international prize

Early in 2001, GoldCorp offered US$500 000 prize money to exploration experts anywhere in the world to help find the next six million ounces of gold at its high-grade gold mine at Red Lake, Ontario, Canada.

Through the Internet, GoldCorp provided a geological database and software to visualise and analyse data. Within a week, the web site had more than 475 000 hits. Some 1400 corporations, consultants, agencies and universities from 50 countries registered for the challenge.

In April 2001, Fractal Graphics unanimously won GoldCorp's prestigious international prize. In a media statement announcing Fractal Graphics' win, Senator Richard Alston acknowledged the uniqueness and success of Australian innovation.[23]

He said, "Australian IT companies are building an impressive reputation for their ingenuity, demonstrated by companies like Fractal Graphics winning international competitions.

"Fractal Graphics is an excellent example of the state-of-the-art capability of Australian companies and is also testament to the application of cutting-edge technology to more established industries such as mining.'

Fractal Graphics evolved in the late 1990s from a collaboration between a geology consulting group and the CSIRO Division of Geomechanics (now incorporated in the CSIRO Division of Exploration and Mining). Describing itself as a 'fusion of scientists and engineers', Fractal Graphics is the world's leader in 3D geoscience and mining technology. At present, Fractal Graphics focuses on two domains -

- geoscience—involving the synthesis of geoscientific maps and data into 3D geological models from terrain to mine scale; and

- technologies—developing 3D geoscience visualisation and information management software, and diversifying into other areas of visualisation such as ecology and medicine.

Through collaboration (with CSIRO, the Australian Geodynamics CRC, the Advanced Computational CRC, Monash University and the University of Western Australia), the Western Australian-based Fractal Graphics has developed geoscience software that is sought after by the world's leading exploration companies.

21ST CENTURY CHALLENGE: MAINTAINING THE EDGE

> *"Over the next 50 years we will need to find and mine up to five times all the metal produced to date."*
>
> (Professor Brian Skinner, Yale University, 2000[16])

The global demand for minerals will continue to increase. Australia is well situated to encourage the ongoing growth of the minerals industry—provided it remains a competitive location for research, exploration, discoveries and mining development.[17]

Australia is a leading mineral resource nation. It has the world's largest economic demonstrated resources of lead, mineral sands, nickel, silver, tantalum, uranium and zinc. It is in the top six countries for bauxite, black coal, brown coal, copper, cobalt, gold, iron ore, lithium, manganese ore, rare earth oxides, gem/near gem diamond and vanadium.[2] However, Australia faces increasing competition from other nations.

Many other factors besides mineral endowment determine a country's attractiveness for investment. These include political, social and economic stability, land access, and access to geoscience knowledge and innovative technology. The importance of these factors is constantly changing, with global issues and trends affecting the level of exploration investment. As well, some countries previously closed to international exploration are now becoming significant areas for exploration and mining investment. Attracting foot-loose risk capital for investment in mineral exploration and mining is now a highly competitive process. Even stronger collaboration between industry and government is required, therefore, if Australia wants to remain an effective player in the global minerals industry.

The tyranny of depth

> *"The [Australian] regolith, which consists of 100–200 metres of rocky rubble deposited by eons of weathering, is the greatest single impediment to continued success in mineral exploration in Australia."*
>
> (Dr Bruce Hobbs, CSIRO Deputy Chief Executive, 1999[18])

Mineral deposits in Australia are becoming harder to find. Gone are the days when prospectors stumbled over gold and iron deposits, because most economic mineral deposits close to the surface have already been discovered. More giant mineral deposits undoubtedly exist in Australia, but they are likely to be buried beneath surface cover and hard to locate. Recognising this problem as a challenge, CSIRO has developed a new initiative termed 'The Glass Earth', which aims to find the next generation of economic mineral deposits by being able to 'see' through the top kilometre of the Australian continent.[5]

However, even with advanced exploration concepts and new technologies, exploring the Australian continent will not be easy and mining companies cannot confront the task alone. The private sector relies on government regional geological maps and data sets to select prospective areas for exploration. Without this information, the risks associated with mineral exploration are much greater. Experience shows that private exploration increases when new government maps and data sets are released.[19]

Recommendation 1

That Australia continues to provide high-quality, pre-competitive geoscience data to encourage exploration investment. This requires that the continent be mapped with new technologies, such as FALCON, so scientists can 'see' further into the Earth to locate new regions with potential or large mineral deposits. Such techniques will be faster, non- or less invasive, and more efficient than previous mapping efforts. Pre-competitive data compiled by AGSO and the State/Territory geological surveys will ensure that Australia remains competitive in the global minerals industry.

Maintaining the intellectual edge

> *"Australia's minerals education system, in its current form, is fragile … due to an acute shortage of talented academic staff, under-resourcing of minerals departments, low industry intake of new graduates."*
>
> (Back from the Brink: Reshaping Minerals Tertiary Education, Minerals Council of Australia, 1998[20])

In 1946 the Commonwealth Government established the Australian Geological Survey Organisation (formerly the Bureau of Mineral Resources, Geology and Geophysics) to assist in the national development of resource industries. It was recognised that a comprehensive understanding of Australia's geological framework was essential if there was to be a meaningful assessment of Australia's mineral potential. In conjunction with the State and Territory surveys, a series of geological and geophysical maps were developed as a basis for future exploration and assessment. This contribution has had a major impact on the development of the Australian minerals industry.[15]

Today, CSIRO, AGSO, State/Territory surveys, Cooperative Research Centres and universities are Australia's main agencies for minerals research and development and innovative exploration technology. Geology, geophysics, geochemistry, information technology and engineering are some of the disciplines now required to identify and delineate Australia's mineral resources. Although Australia is at the forefront of mining software and mine-site technology, there are major challenges and opportunities in areas of exploration technology and geoscience concepts. These must be broached if Australia is to achieve world leadership and remain internationally competitive in these fields.

Recommendation 2

That Australia's research efforts be structured to provide better resourced and integrated minerals R&D centres, so that they can provide the next generation of exploration techniques needed to strengthen and support the Australian minerals industry. As well, as outlined by the Minerals Council of Australia's National Tertiary Education Taskforce report, further select mineral research schools be established so Australia can compete with the USA, UK and European elite schools in these disciplines.

Changing social values and expectations

With the spread of globalisation and the need for sustainable development, communities increasingly are identifying social and environmental issues that need to be addressed. For this reason, mining companies are attaching greater importance to their environmental and social responsibilities before committing to new developments.

Major mining companies throughout the world have committed themselves to the Global Mining Initiative (GMI) to provide leadership in the areas of economic, social and environmental performance. They see this as fundamental to the future of the minerals industry. They realise that by contributing to sustainable development and performance, they can build community trust and promote a better understanding of the positive role of the mining and minerals industry in society.[21]

There is also an increased emphasis on the minimisation of waste in mining and mineral processing. Through life-cycle assessment, there is the potential to distinguish materials, processes and possibly resource producers that are environmentally superior. Minimising greenhouse emissions and an increased emphasis on recycling are also growing in importance.

The Australian minerals industry has to address issues related to land rights and land access, endangered species, and the social impacts of exploration and mining. The development of new exploration methods and technologies is particularly relevant to the issues of land access and land use for exploration. Remote sensing techniques such as the airborne FALCON and TEMPEST systems require minimal, if any, immediate land access. Direct access to land is only required for areas identified for intensive exploration and, ultimately, mining if discoveries prove economic. Future economic mineral deposits in Australia are likely to be at depth, requiring underground mining with relatively limited impacts on the surface environment and ecosystems.

Recommendation 3

That land access, a major concern to the exploration industry in Australia, is addressed by a collaborative effort between government and industry.

Innovation in both exploration technology and mining practices continuously addresses environmental, heritage and indigenous issues. Therefore, a positive approach to land access issues involving industry and local communities needs to be encouraged by government.

Opportunities for Australia

The Australian minerals industry operates in a global marketplace. This extends from the commodities produced, the technical services used and the research conducted in support of the sector, through to the educational facilities provided for the sector and the skilled professionals produced in those establishments. Australia is currently a major player in the global industry and has the opportunity to play an even larger role.

The future market for mineral commodities will be immense as developing nations move towards a higher material standard of living. This drive will create opportunities not only for minerals, but also for the discovery, delineation and development of new ore deposits. Australia has the breadth of resource production and a good foundation for expanding its high technology, research and education services to the point where it could become the world leader in this sector. But to capitalise on current strengths, Australia needs to foster high-technology exploration and the government–industry collaboration that made it a significant player in global terms.

Global market changes influence economic outlook which, in turn, drives exploration investment. The economic contribution of exploration is frequently overlooked. Yet the discovery of an economically viable mineral deposit provides the industry's largest value-added component.

Experience has shown that junior exploration and service companies are an essential element in the high risk–high reward area of mineral exploration investment. Furthermore, the location of the exploration headquarters of major mining companies is important in determining where they direct their investment in research and development, and their choice of service companies.

Recommendation 4

That government provides an environment which facilitates exploration investment by junior companies and encourages larger companies to base their global investment exploration operations in Australia.

CONCLUSIONS

> *"Australia is well positioned to continue to prosper, provided it remains a competitive location for [exploration] investment and development."*
>
> (Barry Cusack, Managing Director, Rio Tinto, 2001[24])

Australia was the top-ranking country in the world for exploration budgets in 2000. But in the same year, exploration in Australia showed the largest decline of any county or region.[7] Nevertheless, Australia is considered to be highly prospective for new major mineral discoveries. It has a history of stable government and a history of unique collaboration between government and industry in mineral exploration.

As the world enters a new era of exploration, where targets are concealed beneath the surface, there is a need for new understanding, new technologies and highly trained specialists to discover the mineral deposits that the world requires. The concepts, technologies and people involved will need to make major contributions to the management of man's impact on the natural environment.

There are challenges for Australia if it wishes to build on its existing strengths in the exploration industry and become the global leader in that sector. However, with a competitive business environment, government support for a new phase of regional surveys to stimulate private sector investment, and continuing efforts to develop world-class research and tertiary education establishments, Australia can become the global centre for the mineral exploration industry within this decade.

APPENDIX A

AUSTRALIAN MINERAL EXPLORATION RESEARCH AND DEVELOPMENT: WHO'S WHO

Australian Universities

Schools and Departments of Earth Sciences throughout Australian universities are researching various processes and applications of geoscience. Because research provides the basis for understanding and locating mineral deposits, both industry and government have invested heavily in Australian academic institutes. As a result of this investment many centres of geoscience involving universities, industry and Cooperative Research Centres have developed. They specialise in fields such as the study of ore deposits, geodynamics and geochemical evolution. Some of these collaborative centres of academic excellence and research are -

- **CODES** (Centre for Ore Deposit and Exploration Studies, University of Tasmania). Industry–government participation includes: ARC, AMIRA, BHP-Billiton, MIM, WMC, Goldfields Exploration, Newcrest, Homestake, AngloAmerican, Western Metals and Pasminco.

- **EGRU** (Economic Geology Research Unit, James Cook University). Industry–government participation includes: the CRC for Predictive Mineral Discovery, Queensland Land Department, Queensland Department of Resources and Industries, ESSO Australia, MIM, BHP-Billiton, Equigold, Pasminco, Rio Tinto and WMC.

- **GEMOC** (Geochemical Evolution & Metallogeny of Continents, Macquarie University). Industry–government participation includes: AGSO, CSIRO Division of Exploration and Mining, WMC, BHP-Billiton, GeoDiscovery, Rio Tinto, Kennecott Canada, Pasminco, Phelps Dodge, ANU, University of New England, Queensland University of Technology, University of Newcastle, University of New South Wales, Hewlett Packard, New Wave Research, AMIRA.

- **CGM** (Centre for Global Metallogeny, University of Western Australia). Industry–government participation includes: ARC, AMIRA, Mining and Energy Research Institute of Western Australia (MERIWA), Department of Commerce and Trade Western Australian Government, AngloGold, BHP-Billiton, Datamine Australia, Earth Resource Mapping, Goldfields Exploration, Homestake, LionOre Australia, Maptek, Normandy, Perilya, Placer Dome, Sons of Gwalia, and WMC.

It is estimated that the total university R&D expenditure (including both government and industry contributions) relating to mineral exploration in 1999-2000 was ~$30 million.

Australian Geological Survey Organisation (AGSO)

AGSO is Australia's national geoscience research and information organisation. It is a prescribed agency within the Department of Industry, Science and Resources. Through the application of first-class geoscientific research, AGSO provides information (from continental to regional scale) that benefits Australia's onshore and offshore exploration investment opportunities, improves resource management, and contributes to community safety.

By adapting and applying modern technology, AGSO provides pre-competitive data and analysis of Australia's geology and resources. The geoscientific data gathered and enhanced by AGSO is maintained in national databases. This information provides insights into Australia's geological framework and is used to promote Australia's attractiveness globally to exploration companies.

AGSO's appropriation for 1999-2000 was $62.1m, of which $17.1m was spent on minerals related work.

State/Territory geological surveys

Each State in Australia and the Northern Territory has a geological survey that is an agency within the mines department. In terms of the mineral resources sector, the main function of the department is to promote, manage and support the sustainable development of the minerals industry in the best interests of the particular State or the Northern Territory.

The geological survey collects and disseminates geological data and information (mainly geological, geophysical, geochemical and resource information) that will assist exploration and development activities of the mining industry. Data from the State and Northern Territory governments encourages private sector exploration by reducing exploration risk and thereby contributing to a more efficient and effective exploration process.

The State/Territory surveys are -

- Mineral Resources Tasmania (Department of Infrastructure, Energy and Resources)
- Geological Survey of Victoria (Department of Natural Resources and Environment)
- Geological Survey of New South Wales (Department of Mineral Resources)
- Geological Survey of Queensland (Department of Natural Resources and Mines)
- Northern Territory Geological Survey (Department of Mines and Energy)
- Geological Survey of Western Australia (Department of Minerals and Energy)
- Geological Survey of South Australia (Primary Industries and Resources South Australia)

In 1999/2000 the States/Northern Territory collectively spent ~$57.5million on mineral-exploration related activities.

AGSO and the State/Northern Territory geological surveys coordinate their research through the National Geoscience Agreement which defines the complementary roles of the Commonwealth and the States/Northern Territory in stimulating exploration interest and investment in Australia. AGSO's contribution is to provide key specialist geoscience activities such as geophysics, regolith, geochronology, national information management standards and national data sets.

The geological, geophysical and geochemical data and information developed by AGSO and the State/Northern Territory geological surveys has underpinned many major mineral discoveries, including -

- Kambalda area, Western Australia—several nickel mines;
- Olympic Dam, South Australia—copper-uranium-gold-silver mine;
- Century, Queensland—zinc mine;
- Boddington, Western Australia—gold mine;
- Groote Eylandt, Northern Territory—manganese mine;
- McArthur River, Northern Territory—lead-zinc-silver mine;
- Gove, Northern Territory—bauxite mine; and

- Ranger, Northern Territory—uranium mine.[14,15]

CSIRO Division of Exploration and Mining

CSIRO Exploration and Mining is the largest supplier of applied R&D to the Australian exploration and mining industry. Focussing on research aimed at increasing the competitive advantage of the industry, the Division has an established track record in the delivery of innovative science and engineering to the exploration and mining sector.

Priorities are set in close consultation with industry. In addition, research initiatives are supported by a wide network of collaborative interactions with federal and state government agencies, universities and other research institutions, including Cooperative Research Centres.

CSIRO's research has produced significant results for the exploration industry, including -

- New geophysical tools such as the SIROTEM ground electromagnetic system, the TEMPEST airborne electromagnetic system (see Case Study 3), the PIMA field portable mineral mapping system and new airborne hyperspectral sensors;

- New geochemical exploration techniques including highly sensitive surface geochemical methods for gold exploration in the regolith and the use of Pb isotopes as a discriminator of anomalous geochemistry;

- Continuing development of methods for processing and interpretation of spectral data from satellites and aircraft, which was recognised in 1995 by the award of the Australia Prize.

An important new venture for CSIRO is the Glass Earth initiative. Glass Earth projects are designed to make the top kilometre of the Australian continent, and the processes operating within it, transparent with the aim of discovering the next generation of giant ore deposits.

In 1999-2000 CSIRO's appropriation budget for mineral exploration was $9.4 million, an amount that was supplemented by a further sum of $7.4 million from industry and other sources.

Cooperative Research Centres (CRCs)

Cooperative Research Centres bring together researchers from universities, the public sector and private industry. CRCs cover long-term, collaborative research and development efforts of very substantial quality and size that contribute to national objectives. The objectives of the CRC program are -

- to enhance the contribution of long-term scientific and technological research and innovation to Australia's sustainable economic and social development;

- to enhance the transfer of research outputs into commercial or other outcomes of economic, environmental or social benefit to Australia;

- to enhance the value to Australia of graduate researchers; and

- to enhance collaboration among researchers, between researchers and industry and improve the efficiency of Australia's research effort.

CRCs that were or are involved in mineral exploration research include -

- *CRC AMET (Australian Mineral Exploration Technologies)*—Brisbane, Perth, Sydney. This CRC was focussed on the development of technologies, particularly airborne methods, for the discovery of concealed ore bodies. The AMET CRC was successfully concluded after developing several new airborne electromagnetic exploration systems including the state-of-the-art TEMPEST system (see Case Study 3). The core participants were CSIRO Division of Exploration and Mining, AGSO, Macquarie Univeristy (School of Earth Sciences), Curtin University (Department of Exploration Geophysics), the Geological Survey of Western Australia, and AMIRA.

- *AG CRC(Australian Geodynamics)*—Melbourne, Perth, Brisbane, Sydney. This CRC was established to elucidate the structural and dynamic processes within the Earth's crust using the techniques of structural geology, geochronology and seismology as tools for determining the characteristics of the Australian crust, with an emphasis on evaluating its economic potential. It was successfully concluded after developing new concepts for the geodynamic evolution of Australia, as well as new software for interpreting geophysical and geological spatial data sets (see Case Study 4). The core participants were CSIRO Division of Exploration and Mining, AGSO, LaTrobe University (Department of Geology), Monash University (Department of Earth Sciences), Melbourne University (Department of Geology), and DEC Computing Australia.

- *CRC LEME1* (*Landscape Evolution and Mineral Exploration)*—Perth, Canberra, Sydney. This CRC successfully developed new insights into geochemical exploration techniques in important Australian mineral provinces and has just evolved into CRC LEME2. The core participants were CSIRO Division of Exploration and Mining, AGSO, the Australian National University (Department of Geology), and the University of Canberra (Division of Science and Design).

- *CRC LEME2 (Landscape, Environment and Mineral Exploration)*—Perth, Canberra, Sydney. This new CRC extends CRC LEME1's research into the area of environmental management, particularly land degradation management in Australia's rural environment. In addition to the core participants from CRC LEME1, new core participants are the Bureau of Rural Sciences, the NSW Geological Survey, Primary Industries and Resources South Australia, University of Adelaide (Department of Geology & Geophysics), Curtin University of Technology (School of Applied Geology), CSIRO Division of Land and Water, and the Minerals Council of Australia.

- *PMD CRC (Predictive Mineral Discovery)*—Melbourne, Perth, Canberra, Sydney, Townsville. This new CRC proposes to create a predictive environment for mineral discovery since the highest impact issue facing mineral exploration is the location and quality of ore deposits. The CRC will resolve key areas of uncertainty in existing exploration models and build 3D and 4D images of mineralising systems using the latest developments in airborne geophysics, seismic imaging, geoscience and isotope systematics. The core participants are CSIRO Division of Exploration and Mining, AGSO, AMIRA, the Victorian Institute of Earth & Planetary Sciences, James Cook University (Department of Earth Sciences) and the University of Western Australia (Department of Earth Sciences).

In 1999-2000 Government funding of mineral exploration CRCs totalled some $6.7 million.

Australian Minerals Industry Research Association (AMIRA)

AMIRA is an industry association that manages collaborative research for its members from the global minerals industry. By taking a partnership approach to research and development, which AMIRA manages, its members enhance their competitive position through access to leading-edge technology.

Based in Melbourne, AMIRA comprises more than 80 companies from Australia, Asia, Europe, North Africa and South America. It encourages local research institutions in several countries to collaborate in the global minerals industry.

AMIRA operates by developing and managing jointly funded research projects on a fee-for-service basis on behalf of its members. It currently manages 58 projects attracting approximately $40 million of industry funding. Of this amount some $10.8 million is directed annually towards mineral exploration research.

Minerals industry

As well as funding mineral exploration research and development through AMIRA, individual minerals companies may undertake significant amounts of in-house research and development, particularly when the benefits of this effort can be captured internally to give the company a competitive edge.

Sometimes a return on in-house R&D investment is realised through the commercialisation of discoveries, and one of the most significant recent examples is the FALCON airborne gravity gradiometer system developed by BHP (see Case Study 4).

CITED REFERENCES

1 ABARE. 2000. Australian Commodity Statistics 2000. Canberra: Australian Bureau of Agricultural & Resource Economics; 4, 148.

2 AGSO. 2000. Australia's identified mineral resources. Canberra: Australian Geological Survey Organisation.

3 United States Geological Survey. 2001. Mineral commodity summaries. Washington DC: United States Department of the Interior.

4 Centre for International Economics. 1997. Value adding in the minerals sector. Canberra: Minerals Council of Australia.

5 Stoeckel A. 1999. Minerals: Our wealth Down Under. Canberra: Centre for International Economics; i, 11, 47, 32.

6 Kunte A, Hamilton K, Dixon J & Clemens M. 1998. Estimating national wealth: Methodology and results. Washington DC: World Bank, Environment Department, environmental economics series paper 57.

7 Metals Exploration Group. 2000. Exploration decline slowing down. The Mining Journal; Nov 10; 372.

8 Pricewaterhouse Coopers. 2000. Minerals industry survey report. Canberra: Minerals Council of Australia; 24.

9 Soker M, pub. 1995. Tomorrow's world: The Australian initiative. Sydney: Associated Publishing Corporation; 160–181, 184, 193.

10 Goodland R. 1995. Speech given at the 15th Annual Meeting of the International Association for Impact Assessment, Durban, South Africa, Jun 26–30.

11 Minerals Council of Australia. 1996. Code for Environmental Management. Canberra: MCA.

12 Woodall R. 1989. The keys to successful corporate mineral exploration. South African Journal of Geology; 92(2):148.

13 Blainey G. 1993. The rush that never ended. Carlton: Melbourne University Press.

14 Woods AJ. 1988. Review of the Bureau of Mineral Resources, Geology and Geophysics: Appendix 1—a report to the Minister for Resources. Canberra: Australian Government Printing Service.

15 Williams N & Huleatt M. 1996. The importance of regional geological mapping in minerals exploration. Outlook 96: Minerals & energy; 3:51–59.

16 Skinner BJ. 2000. Perspectives for mineral exploration in the 21st century. Keynote presentation to the 31st International Geological Congress, Rio de Janeiro, Aug 7.

17 Lambert IB. 2001. Sustainable development: Strategic issues for Australia's minerals sector. AusIMM Bulletin; in press.

18 CSIRO. 1999. Seeing right through Australia. Media release 1999/159, Jul 21 (Mineral Exploration & Mining at www.csiro.gov.au).

19 Day RW. 1995. Geomap 2005 program: The key to unlocking Queensland's mineral wealth. Queensland Government Mining Journal, Sep; 20–31.

20 National Tertiary Education Taskforce. 1998. Back from the brink: Reshaping minerals tertiary education. Canberra: Minerals Council of Australia, discussion paper.

21 McNeilly RJ. 2000. The Global Mining Initiative: Changing expectations—meeting human needs and aspirations. Speech to the 2000 Minerals Industry Seminar, Minerals Council of Australia, Jun 7.

22 Broome AJ. 2001. In: Unearthing the Future. Exporting Australian Mineral Innovation to the World. Minerals Council of Australian, Annual Seminar, Canberra, June 2001.

23 Alston Senator R. 2001. Australian company wins international IT competition. Media release, Apr 6.

24 Outlook 2001. Export records, consolidation and competition. Media release, Feb 28 (www.abareconomics.com/conferences/ol2001/mediarel/mr_20.HTM).

25 Towards 2005: A prospectus for research and research training in the Australian Earth Sciences, 1992. ARC, Canberra, pps 5 and 59