Exploration is the first stage to generating mineral wealth; if exploration stalls today the future will be poorer, much poorer.

Imagine being the Federal Treasurer in 10 years time. The largest single contributor to the economy, the minerals industry, is declining year by year in gold, base metals, diamonds. The future is bleak because reserves are continuing to decline. In order to re-start the exploration industry you have to entice back to Australia all those companies that went offshore and found their metals in Chile, Peru and the Pacific islands. It will be a difficult case to argue. Much of the human infrastructure, the expertise that had built Australia's mining industry and mining support industry, particularly geoscience, has been forced to follow the explorers off-shore.

Regaining Australia's global leadership in exploration

Australia's minerals industry, in particular gold and base metals, has reached a fork in the road. It could take the path where it accepts that most of the easy and most economic discoveries have been made in Australia, and leaves it at that. Some gold and base metal discoveries will continue to be made, but most of the future revenues will come from coal, iron ore, and alumina. As existing gold and base metal resources are exhausted and not replaced by new discoveries, our GDP will decline. This scenario has already begun as shown by a decline in gold production over the past three years. Most affected will be regional Australia, with the reduction in indirect and direct benefits being the economic equivalent of a drought each year.

The alternative path is for Australia to accept the challenge and to find a practical solution to the problem of declining reserves. The magnitude of the problem is such that it can only be tackled through a 'whole of Australia' combined financial and intellectual effort: in effect, a national task force to maintain exploration, a critical factor in Australia's most important industry. The main beneficiary will be the nation, so it is appropriate to seek substantial investment from the government to develop the next generation of technical and scientific tools and expertise to reinvigorate Australia's exploration industry. In return, industry will be in a position to make new mineral discoveries that will allow Australia to maintain its standard of living, education, healthcare and defence.

The difference between market forces and the national good

- Global markets have forced industry to focus on finding extensions of existing mines ('brownfields exploration') rather than locating new deposits ("greenfields exploration").
- Market forces reduce the times when explorers can extend into the geologically unknown or speculative.
- Great national benefit will come from major discoveries in new areas.

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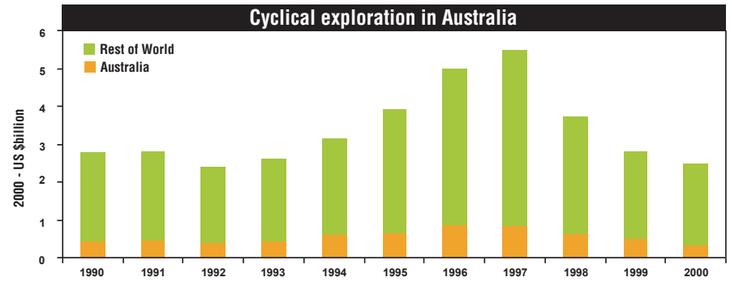
Australia is the sixth wealthiest country per capita. The proportion of this wealth derived from minerals and fossil fuels is 2.5 times the corresponding proportion of that for the other 20 wealthiest countries. For this reason Australia is exceptionally vulnerable to cyclical demand for commodities, and must take strong action in the national interest to protect its economic future.

In order to produce Australia's largest export income, the minerals industry involves an interdependent supply chain that begins with exploration and discovery of mineralization and ends with mining, processing and transportation.

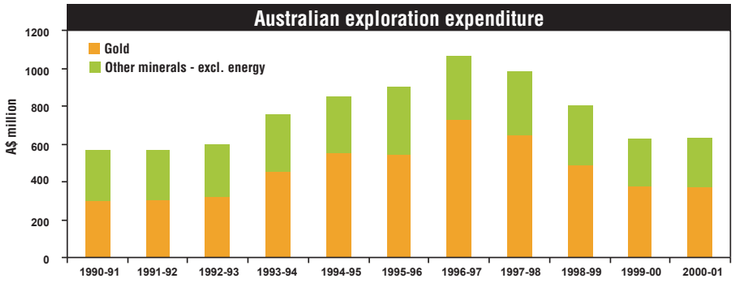
The front end, exploration, is in danger of stalling, threatening the long-term viability of the mining industry. If the country's biggest export industry is significantly reduced, as it will be unless the problem is solved, the implications for Australia's economic future will be severe.

For the past decade until last year Australia has led the world in exploration expenditure. But global expenditure has declined by 50%, and Australia's exploration expenditure has declined from $1.2 bn to $600 million. Moreover, Canada has now replaced Australia as the industry's favourite exploration destination.

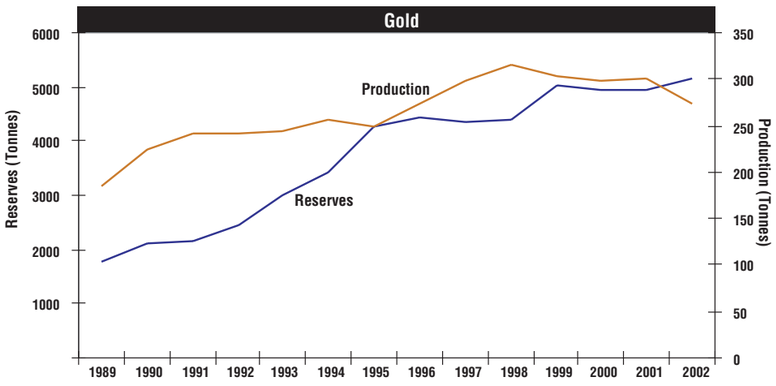
Closer scrutiny shows more disturbing trends. On expenditure per unit area (sq km), Australia is investing at less than half that of Chile and Peru. Further, Australia tends to focus its expenditure in the relatively small areas of outcrop with historical production. Many of these areas are considered mature in the upper 100-200 metres until new techniques are discovered to provide a different basis for exploration. On the other hand the majority of Australia is under-explored. This highlights some of the problems and opportunities unique to Australia. Undoubtedly massive ore bodies are there to be found once we provide the resources for the exploration industry to overcome difficult geological conditions.



Australia's share of global exploration expenditure



Gold as a proportion of Australian exploration expenditure



Production has increased on the back of increased reserves over the last decade but is now in decline

Mining faster than finding

Meanwhile, we are mining gold, nickel, copper and base metals faster than we are finding new reserves. Some other high-value commodities, such as platinum and chromium, are yet to be found in commercial quantities in Australia. Almost certainly they exist.

If we don't replenish reserves and push into the new metals, the economic consequences will be severe.

The dilemma is this: traditionally the biggest explorers have been the major mining houses. For a variety of reasons, major mining houses have made strategic decisions to severely reduce their exploration effort. Several have publicly expressed their lack of success as explorers over the last decade. Many of the second-tier companies have been taken over by multinationals. That leaves the small and medium size explorers (SMEs) who have also reduced their exploration expenditure. They are severely disadvantaged because their limited funding restricts their access to research and the latest technologies.

The dilemma

- Multinationals that have the money to develop the technology are reducing their research effort, because they prefer to acquire resources rather than find them.
- Those who wish to explore do not have the money to afford the research that will lead to breakthrough discoveries.

They simply can't afford the research which will lead to breakthroughs.

The minerals industry is inherently cyclical and the markets will inevitably strengthen and drive renewed interest in exploration. The *Business Review Weekly*, February 5, 2003 issue (see copy of story in folder) announced that mineral resources are already entering a new growth cycle. But will Australia be positioned to benefit from this?

The implications for Australia will depend on our ability to attract explorers and deal with the unique challenges of the Australian landscape and geological architecture.

Catching the wave

This is the first growth cycle under the new mining paradigm. In the past market forces and national good have been reasonably congruent, but this is no longer true. Even with increased exploration activities, it is unclear whether limited multinational interest and under-resourced SMEs can meet Australia's national need for more discoveries. Will companies focus their activities on countries that do not face Australia's geological challenges and potentially offer cheaper and quicker rewards in the form of mineral discoveries?

Australia's unique environment

Many of the challenges facing explorers in Australia are unique. Approximately 70% of the Australian continent is covered by sediments that hide critical subsurface features. In many other areas, strong weathering of mineral deposits has radically changed the tell-tale expression of mineralization in the near-surface environment, impeding the detection of mineral deposits from the surrounding barren rock mass. These factors are major impediments to exploration and will remain so.

This situation, both the perception and reality of the difficulties, won't change unless there are major breakthroughs in technology and geology.

Despite these challenges, there is also widespread recognition of the significant potential for additional discoveries in Australia. Large deposits of gold, iron ore and diamonds in Western Australia, and of copper, lead, zinc and uranium in Queensland, South Australia and the Northern Territory attest to the mineral endowment of the Australian continent. Nevertheless, many of Australia's premier exploration and mining districts are now considered mature in comparison with essentially virgin mineral districts in less developed countries around the globe.

Given Australia's geological history and framework, potential exists under areas of cover to host mineral deposits equivalent to the greatest mineral sites in the world. For example, South Africa's Witwatersrand gold deposits, which produce $10 billion per year, would stretch across an arc from Sydney to Canberra if projected onto Australia. Such a find would have the potential to transform the regional Australian economy, putting economic and social options before Australia barely imaginable now.

The implications are clear: there is outstanding potential for the discovery of new mineral deposits under cover in Australia, but exploration for these deposits is confronted by challenges requiring tailor-made solutions to meet Australia's unique geological conditions.

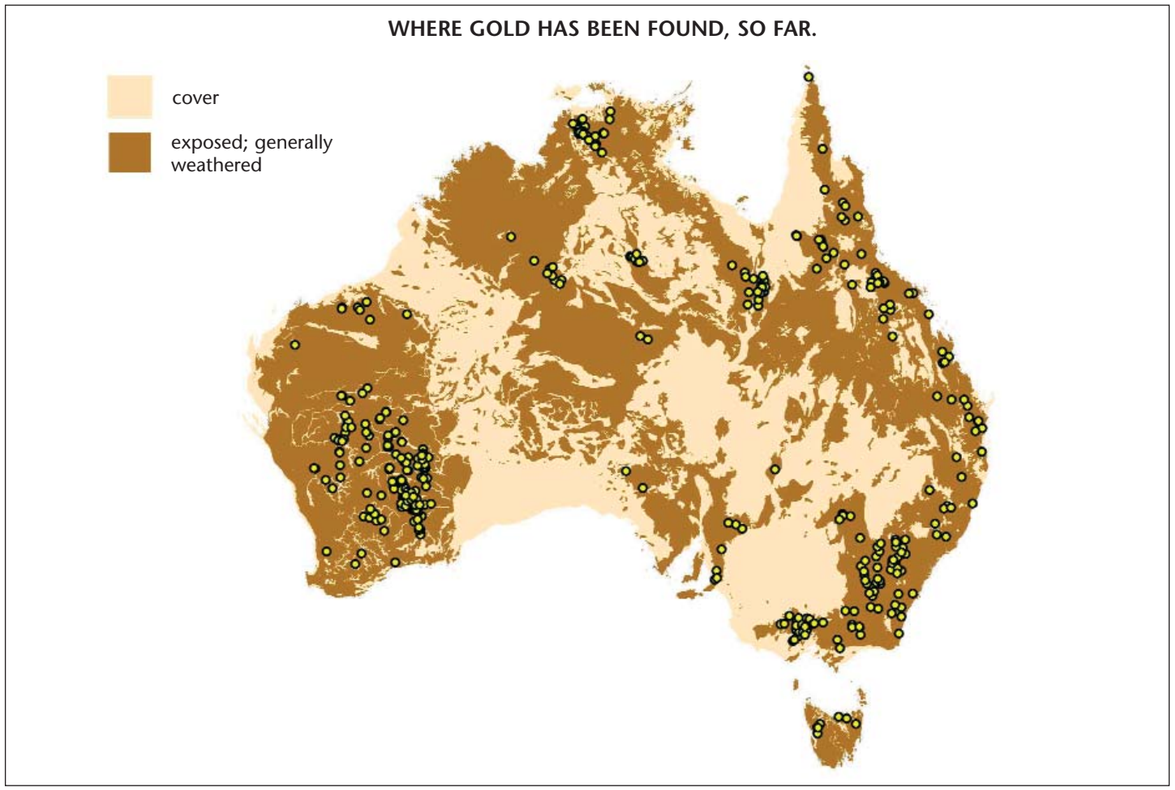
The Centre for International Economics, Canberra (Stoeckel, 1999) has neatly summarized the dilemma- "*The danger in the trend to short-term R&D is that the level of technology available over the long term will fall significantly. The problem is that the benefits of long term R&D come at a cost to short term performance. All mining*" (and exploration) "*companies may act in their own interests and reduce R&D spending in the belief that they may buy R&D 'off the shelf' if they need to. But the collective result of all companies doing this is that the pool of knowledge is not there to draw on.*"

Persuading explorers to explore

We believe there are four main issues which determine where exploration money is spent:

- **Risk and regulation**
- **Access to information**
- **Prospectivity**
- **Uniqueness of geology**

RISK AND REGULATION: Table 1 shows the risks attached to investment in various countries independent of perceived geological prospectivity. Four countries top the list, reflecting the lowest risk: Australia, Canada, United States and Chile. If an Exploration Manager were assessing



Gold deposits have mostly been found in the exposed areas. It is probable that there are similar number of deposits currently inaccessible because they are under cover.

Ranking/Country	Sovereign Risk	Land Access	Green Tape	Land Claims	Red Tape	Social Risk	Infrastructure	Civil Unrest	Natural Disasters	Labour Relations	Weighted Totals
	Investment Risk Categories										
1. Australia	1	3	3	3	2	1	1	0	1	2	11.1
2. Canada	1	2.5	3.5	3	2	1	2	0	1	2	11.6
3. USA	1	3	4	2	3	2	1	1	1	2	12.9
4. Chile	2	2	2	2	2	2	2	2	2	2	13.2
5. South Africa	3	2	2	2	3	3	2	3	1	2	15.7
Risk weighting 0 = least important, 5 = most important											
19. PNG	4	3	3	4	3	4	4	4	3	3	23.5
20. Zimbabwe	5	4	2	5	3	5	4	5	2	3.5	26.7

Table 1 *Source: Resource Stocks*

where to spend his/her global exploration budget. Australia's ranking amongst the world's top four countries would certainly be a positive factor. We need to be vigilant in retaining this status, a task that science can do little to help with. Risks being equal, the decision on where to explore will be made on other issues.

ACCESS TO INFORMATION:
Whether an exploration manager is sitting in Denver or Perth it is extremely helpful if they are easily able to access comprehensive geological information about Australia from their desktop. Quite apart from the information benefits, this sends a very clear signal that this country is open for business and understands the needs of the mining industry. This proposal contains a web-based information tool that will set new benchmarks for services of this type.

PROSPECTIVITY: Investment in exploration is based on the expectation of success. Australia is vulnerable to perceptions that it has been searched out, and that searching the regolith is too hard. New areas of prospectivity and new techniques for exploring areas already explored are needed to change this perception. This comes from new knowledge and new tools.

UNIQUENESS OF GEOLOGY:
Most scientists agree from our existing knowledge that we have found less than half of the major mineral deposits in Australia. As our knowledge increases, so will the potential finds. But the next generation of explorers in Australia will face major problems. They need to have far better insight into what is beneath the regolith before they invest the major sums involved with drilling. This is an extraordinarily complex business and the solution will involve insight which requires new or improved technologies and concepts.

What Australia needs

- **New mines in places never searched before.**
- **New mines in places searched before with old technology.**
- **New mines for commodities not currently mined in Australia.**
- **Extensions of existing mines.**
- **New mineral districts to drive future growth.**

How Australia will do it.

National Task Force

The present decline in exploration investment is a national problem with the potential to do great harm to Australia. A national problem requires a substantial, national solution.

The solution is to form a consortium of the best brains in the country from the leading geoscience and mining related organisations to deal with the problem in a comprehensive way that will provide: the best long-term solutions in the national good, some very beneficial information to industry relatively quickly, and provide the technological platform to overcome the exploration difficulties inherent in Australia.

What is needed is the financial support to bring these people together with a sense of national purpose and the critical mass to make the major breakthroughs needed to give Australia a competitive edge.

Australia is a world leader in geoscientific research and the provision of geoscience information. The mineral sector has been particularly proactive in developing strong collaborative alliances between industry, research agencies, universities, CRCs, State and Territory Surveys and Geoscience Australia. These agencies provide critical support to industry but have all been affected by declining revenue for Research & Development as exploration budgets decline and pressure increases to channel resources into short-term programs **with immediate impact on industry** at the expense of medium to longer-term strategic initiatives. Incremental gains made so far have more than justified the expenditure on these organisations, verified by the value of the mineral industry to the Australian economy.

However this is a new and very challenging situation. Australian geoscience organisations have the platform of knowledge and expertise to achieve these national goals but are they adequately resourced and positioned to deal with this challenge?

Australia's Exploration Future will build a coalition of the geoscience organisations to deal with the critical questions raised in this document in a focussed and urgent way.

Australia's Exploration Future

- National Task Force
- Comprehensive and focussed program
- Best available people
- First results 2004

What can Australia's Exploration Future deliver?

- At the end of six years we believe this approach will make accessible an additional 30% of Australia's mineral resources currently "invisible" beneath regolith.
- New techniques, knowledge, methods and concepts to re-examine areas previously explored.
- New techniques, knowledge, methods and concepts to search for minerals not currently found in commercial quantities in Australia.
  - For example, platinum: the global platinum industry is worth $4.6 billion of which Australia currently has a negligible share. The discovery of a new major platinum deposit in Australia could launch an entirely new industry.

The immediate effect of Australia's Exploration Future would be to provide several hundred high-level, science based jobs. From year one there would be a flow-through effect to Australia's mining services industry leading to many more jobs. Increased exploration leads to even more jobs, many regionally-based. This is before we have found anything. Once the mining process begins investment generates jobs across the economy starting at the mine itself and spreading into transport, infrastructure, food and services and then increased manufacturing.

Andrew Stoekel from the Canberra-based Centre for International Economics estimates that if Australia made new discoveries (equivalent to a 10 percent increase in productivity in the minerals and fossil fuels industry), national wealth would increase by $42 billion in ten years. National wealth in this instance is measured using a full range of factors both positive and negative. This does not include the value of the land or mineral assets.

Investment required

Current funding levels for national priority strategic R&D projects are probably only sufficient for the delivery of incremental gains in the medium-term. In order to make a difference to the exploration industry within a realistic timeframe (2-5 years), it will be necessary to increase spending on strategic R&D tailored to solving the key exploration challenges. Total spending by the Commonwealth and the States / Territories on pre-competitive mineral exploration-related R&D in 1999-2000 was of the order of A$120 million.

To meet the national need will require an increase in expenditure by the participating agencies of the order of 50% per annum, or A$60 million per annum, over 3 - 5 years. Of this amount, A$20 million per annum should be allocated to R&D directed towards developing new and improved technologies and geoscientific concepts, with the remaining A$40 million per annum allocated to using these technologies and concepts on behalf of the exploration industry.

Australia's exploration future: the scientific foundation

Major exploration issues in Australia include the level of perceived prospectivity and the selection of areas to explore, the availability of data and its interpretation; coping with unique aspects of the Australian landscape and improving the cost-effectiveness of exploration tools and strategies (Table 2). These issues are widely recognised by the mining industry as key to future exploration in Australia. The people with expertise to address these issues are in Australia, but they are located in a number of geoscience organisations: including Geoscience Australia, CSIRO,CRCs, Universities, State Geological Surveys and others. Bringing these people together with a sense of national purpose will bring substantial national benefit through:

- Major new finds in Australian geological conditions generally only accessible through scientific breakthroughs.
- New technologies focussed on Australian conditions providing a competitive edge over other countries
- New technologies to supporting Australia's fastest-growing manufacturing and service industry.
- Optimising existing technologies to find high-priority, high-value commodities.
- Providing maximum assistance for Australian small to medium explorers.

What influences the perceived prospectivity of a terrain? Ultimately, nothing is better than proof by the discovery of a major ore deposit. A thorough understanding of the geology and, hence, the potential mineral endowment of geological terrains, coupled with the best **exploration models and targeting tools**[a], can also greatly enhance, or rejuvenate, the perception of prospectivity. Furthermore, first use of a new approach has the potential to lead to major discoveries, demonstrating the attractiveness of a country to exploration. A high level of understanding of the **signatures of targeted ore systems**[b] will help prioritising exploration targets. The pmd*CRC and associated partners aim at developing these kinds of tools. This approach could be widened and accelerated to cover key geological terrains for a number of strategic commodities and to outline the most prospective areas within.

The effective analysis of geological terrains requires high quality geophysical, geological and geochemical information. The acquisition, archiving and evaluation of this information are largely the domain of Geoscience Australia and the State Geological Surveys. New data sets are also required and the collection and evaluation of surface geochemical data is a high priority through the development of **geochemical maps of key Australian mineral provinces and other prospective areas**[c]. These maps will not only facilitate more effective modelling of the bedrock potential for mineralisation, but also enable direct targeting of geochemical trends and anomalies, and serve as a baseline for company data. **The Glass Earth Map of Australia**[d] is planned by CSIRO Exploration and Mining to be a common portal and platform for this information together with all other public domain datasets across Australia.

Whereas surface geochemical methods are effective in exposed areas and drilling is possible where cover is thin, the cost of exploration in areas of medium to thick cover, i.e., 40 to 200 m, becomes prohibitive unless in the vicinity of known ore deposits. The former CRC AMET and the current CRC LEME together with their partners, developed special expertise in dealing with these settings, and these should be expanded to further develop and apply these technologies to key exploration districts as part of a major research program, **exploration under transported cover**[e]. Any survey of this kind must include a balanced approach incorporating geology, geochemistry and geophysical components. New **deep sensing geochemical**[f] techniques should also be developed or optimised (including gas & vapour, partial extraction and hydro geochemical techniques).

Having highlighted prospective terrains in Australia and provided information and methods to assist with area and target selection, it is equally important to provide companies with instruments and techniques for cost effective exploration for specific commodities. Technology developments that would have a major impact on exploration as parts of national surveys are **airborne geophysical systems**[g]. Significant cost savings could also be achieved through the development of cheaper **deep rock sampling methods**[h] as drilling currently constitutes a significant part of all exploration costs.

EXPLORATION ISSUES	RESEARCH RESPONSE	IMPACT
Prospectivity	a) Regional terrain studies and new or alternative exploration models and targeting tools b) Signatures of targeted ore systems in bedrock and regolith including thick transported cover c) Geochemical maps of key Australian mineral provinces and new prospective areas	New mines in places previously explored Recognition and delineation of new prospective districts
Access to information	d) Web-based delivery platforms for information and knowledge through the 'Glass Earth Map of Australia'	Full access to information and knowledge for integration and interpretation Industry wide access to the best data to support discovery
Uniqueness of Australia	e) Open up areas of transported cover to exploration using airborne and ground geophysics, drilling and geochemistry in selected areas with 40-200m of cover f) Deep sensing geochemistry and geochemistry based upon deep sampling	New mines in places previously unexplored or with unrecognised potential
Cost effective tools and strategies	g) Continued development of principal geophysical techniques such as tensor magnetics, electromagnetics and gravity gradiometry. Investigate other airborne and ground-based geophysical methods (e.g., radar and acoustic methods) h) Development of cheaper deep rock sampling methods	New mines in places previously explored using old technology More cost effective exploration in new areas

Table 2 *Note:* more information on each research response is outlined in appendix 1.

Appendix 1

Exploration models[a]

The exploration potential of a region and the choice of the most appropriate exploration techniques largely depend on the prevailing exploration models. These models may change as new data become available and geological thinking evolves. They can ultimately renew the exploration potential of an entire region. Recent examples are the nickel sulphide finds in the Musgrave Province of Western Australia, the discovery of mineral sands in the Murray Basin and the discovery of gold mineralisation in the Gawler Craton. The discovery of diamonds in the Kimberleys in Western Australia in the 1970s radically changed perceptions of the prospectivity of the region. Similarly, in Canada, diamond finds in the Northwest Territories in the 1990s, led to a boom in diamond exploration and mining with an estimated value to the Canadian economy of $27 billion.

In the unique Australian environment, mineralisation can easily go unnoticed due to regolith and sediment cover that obscure geophysical or geological signatures of prospective areas. Although the identification of exploration models generally is regarded as the industry's domain, few small companies, who play a pivotal role in Australian exploration, have the resources to do significant in-house research. Collaborative research between government organisations, universities and industry could therefore play a greater part in the development of new concepts and strategies that can be tested by industry. Linking these new exploration concepts to specific geological terranes in Australia could drive new exploration booms and, ultimately, the development of new mining districts.

Research solution:

- Study Australian terrains for application and development of new or alternative exploration models, notably, for sediment-hosted gold, zinc oxides, platinum group elements, chromium in layered complexes and volcanogenic massive sulphide-hosted base metals. Use geological information, regional geochemistry, geophysics and drill data to identify prospective target regions.
- Provide background information (geophysical, geochemical, drill data) to underpin new exploration models.

Impact:

New exploration models may change the exploration potential of existing districts and open up new areas to exploration. The Canadian example shows this approach can have a significant impact on industry and the economy at large. It is a high-risk, high-reward strategy that therefore is not available to most small exploration companies. A positive result has the capacity to strongly focus exploration onto Australia as it did in Canada a few years ago.

Signatures of targeted ore systems[b]

There have been a very large number of detailed geological and, latterly, regolith and/or geophysical studies of mineral deposits in Australia. Rarely, however, have studies of all aspects been completed, linked and synthesised on either a site or regional scale. In complex exploration environments, however, such integration becomes a necessity. An understanding of how geochemical and geophysical anomalies and mineralogical alteration halos form and can be recognised in bedrock, and how these, in turn, manifest themselves in the regolith would greatly assist in targeting specific styles of mineralisation. They may also help determine the size and grade of a deposit from its surface or near surface expression. Such integrated information will not only have a major impact on successful exploration for concealed targets in greenfields areas, but will particularly benefit exploration in more mature terrains. In the latter, shallow drilling has mostly exhausted the potential for near surface deposits but great potential remains for large ore bodies at depth. This situation applies to many mining districts in Australia, and will continue to pose a major challenge to exploration in the future.

Research solution:

- Document and model the processes leading to geochemical, mineralogical and geophysical signatures of ore deposits in bedrock and regolith for different commodities.
- Integrate studies of primary ore deposits with their regolith-landform expression and geophysical characteristics
    a. Nickel-copper platinum group element deposits
    b. Gold deposits
    c. Iron oxide copper-gold deposits
    d. Proterozoic base metal deposits
    e. Tasman copper-lead-zinc
    f. Diamond deposits
    g. Seafloor exhalative mineralisation and application to terrestrial exploration
- Develop practical exploration parameters that allow recognition of integrated geological, geophysical and geochemical signatures of ore deposits in the regolith and provide vectors towards mineralisation.

Impact:

Results of this study will greatly increase the effectiveness of exploration in Australia and will benefit small and medium size companies that are unable to conduct such comprehensive research in-house.

Glass Earth Map of Australia[c]

Modern geoscientific surveys generate a vast amount of geophysical, geochemical and geological data that is difficult to access, process and interpret, even for well-equipped large companies. Small explorers are not able to utilise this information and therefore are severely disadvantaged. Overseas companies wanting to explore in Australia also face the problem of not having easy access to relevant information. This creates major problems for Australia not only because exploration is less effective but also in terms of lost opportunities. An easy-to-use and readily accessible system that allows integration and manipulation of various data sets would therefore provide a substantial competitive advantage for Australia and significantly improve the level playing field for small and medium size explorers.

Research solution:

"GlassEarth Australia" aims to capture and deliver knowledge to all stakeholders about the earth under Australia and the mineral resources that it contains. The objective is to create a national consortium of geoscience agencies, with the core partners CSIRO and Geoscience Australia, to build a knowledge-rich, multi-dimensional map of Australia that will be delivered through a highly visual and extensible web service portal. The portal will provide transparent access to knowledge, information and data, and a new, pre-competitive geological framework from which to facilitate mineral discoveries. Successful implementation requires support from data suppliers such as the federal and state agencies, from small to medium consultancies that provide knowledge transfer and utilisation, and from CSIRO who provides the technologies for data integration.

Impact:

The GlassEarth Map of Australia, together with State and Federal databases, will significantly improve access and availability of geoscientific data to explorers. This will lead to substantial cost savings for companies, increasing Australia's competitive advantage worldwide. New interpretative tools will facilitate discoveries.

Geochemical maps of key Australian mineral provinces and new prospective areas[d]

Despite extensive geochemical exploration for gold and base metals in areas of subcrop, outcrop and thin transported cover in the last three decades, poorly exposed parts of the Australian landscape, covered by thick residual weathering, may not have been adequately explored and therefore continue to be prospective. Currently, explorers and Government organisations use a range of geochemical procedures to locate anomalies, mainly at 1:50,000 to 1:250,000 scale. To identify major geochemical trends and potential new mineralised provinces, however, the area of investigation has to be significantly larger - i.e., at a geological province or craton scale. This may have been done for some areas by large mining companies, but the data remain confidential and unavailable to smaller companies. There is also uncertainty as to the sampling and analytical procedures. Since most publicly available geochemical datasets are at local scale and generally use different and incompatible sample media, sample preparation, analytical techniques and element suites, they generally cannot be combined and collectively interpreted. It follows that a uniform and regional approach to geochemical exploration is needed. This approach has been accepted and adopted in Europe and North America where regional geochemical maps are used for exploration and environmental applications. These maps will produce a data set to guide exploration within and adjacent to areas of known mineralisation and may identify new mineralised districts in areas of cover. The data integration and delivery platform will be the Glass Earth Map of Australia.

Research solution:

- Sample the Australian continent at an ultra-low spacing, for example, one sample per 2500 square kilometres, for a total of approximately 3000 sample locations, and sample selected areas, e.g., the Yilgarn Craton, at a nominal 9x9 km spacing.
- Use soil as a primary sample medium and develop specific approaches based upon ferruginous sample media because of the demonstrated ability to delineate chalcophile trends important to exploration. Utilise and integrate existing databases from State Surveys, industry and Geoscience Australia where available.
- Interpret the geochemical data together with the geophysical coverage (gravity and airborne electromagnetic surveys). Expand the geophysical coverage where necessary.

Impact:

The research may potentially identify new mineralised districts or trends and provide the exploration industry with a set of high quality background data that will enable far superior interpretation and, perhaps, integration of local geochemical data sets. The data will also serve as a national baseline for environmental surveys for monitoring of changes into the future.

Exploration under transported cover[e]

Approximately 70% of the Australian landmass has a regolith cover that includes transported overburden and/or continental sediments. Even areas without cover that have weathered bedrock or residual regolith exposed at surface, show complex geochemical, mineralogical and physical characteristics that can differ significantly from those of fresh rock and require highly specific exploration techniques. Where overlying sediments are preserved, however, even when only 10 m or less thick, any evidence of mineralisation beneath may be completely obscured. Successful and cost effective exploration in these environments requires sophisticated and integrated interpretation of geology, geochemistry, geophysics and remote sensing. Significant progress has been made in the understanding of the regolith in Australia over the past two decades, including focussed effort through work by CSIRO EM, CRC AMET and CRC LEME. Results have enabled industry to explore successfully in, for example, the Yilgarn Craton and have contributed towards finding ore reserves worth more than $10 billion.

Such regions of exposure and thin cover remain prime exploration targets worthy of continued research. The new frontiers, however, are those areas having moderate to thick sedimentary cover (40-200m). These include sediment-filled river channels and shallow basins on and marginal to highly prospective terrains of the Broken Hill-Curnamona Block, Mt Isa Inlier, Tanami Block, eastern Gawler and Yilgarn Cratons. Few attempts are made to identify large regional trends and mineral provinces that may continue beneath these sediments. An evaluation of the exploration potential and of suitable strategies will require integrated geophysical and geochemical surveys and a significant amount of core and/or percussion drilling along traverses across prospective areas in order to assess the use of geochemical samples from the surface and subsurface.

Research solution:

- Collaboration between the State and Territory Geological Surveys, Geoscience Australia, CSIRO, CRCs and industry to identify highly prospective covered areas marginal to, and underlain by, the Broken Hill-Curnamona Block, Mt Isa Inlier, Tanami Block, eastern Gawler and Yilgarn Cratons and other priority areas.
- Airborne and ground geophysics, subsurface geochemistry and drilling in selected areas with 40-200 m of cover.
- Mapping and modelling bedrock and regolith geology by drilling traverses across areas of cover and demonstrate the principal prospectivity of these terrains.
- Develop suitable geophysical, mineralogical and geochemical methods to locate mineralisation under cover.

Impact:

The project has the potential to open up new districts to exploration and provide industry with a set of parameters and techniques to explore these areas successfully.

Deep sensing geochemistry[f]

Timely and cost-effective discovery of covered or otherwise blind mineral deposits, without extensive resort to deep drilling, is a critical exploration issue. In Australia, deep *in situ* or transported regolith and/or basin sediments, are barriers to exploration. Surface geochemical techniques have had the greatest success in areas of exposure or shallow burial, but have proved largely ineffective where there is thick cover. Nevertheless, the potential remains that chemical dispersion from a substantial source, such as an orebody, will give some near-surface expression. Various methods of deep sensing geochemistry, including soil extractions, gas geochemistry, isotope studies and hydrogeochemistry, have been tested in recent years. However, results have been ambiguous, with the techniques sometimes poorly understood, and the influence of bedrock structure, the regolith and soil commonly ignored. In addition, some techniques such as isotope geochemistry have been costly and required selective application to exploration problems. Despite this, the potential advantages of such deep sensing geochemical approaches continue to generate interest, especially in combination with modern geophysical techniques. Advances in hardware show potential to reduce the cost of isotopic analysis significantly and analytical procedures for trace gases and vapours have improved markedly. There is a strong requirement to further investigate these methods, in the context of an understanding of the regolith. An effective understanding of the utility of these methods would be of major advantage as companies are increasingly forced to explore for minerals either under cover or in regolith-dominated terrains, in Australia.

Research solution:

- Investigation of varying deep sensing geochemical techniques in well characterised regolith environments.
- Development and optimisation of innovative new deep sensing techniques.
- Development and testing of practical exploration methods in different geomorphological, geological and climatic environments.
- Modelling the role of soil and regolith in influencing geochemical anomalies.

Impact:

New or optimised deep sensing geochemical techniques will allow cost-effective evaluation of large prospective areas and provide the exploration industry with a valuable tool for target selection.

Airborne geophysical systems[g]

Airborne geophysics has played a pivotal role in mapping Australian geology for almost 50 years. Airborne magnetics and radiometrics have been the primary techniques and, over the last few decades, most of the Australian continent has been mapped with these methods by the Commonwealth and State surveys.

As technology has improved, so has the resolution and accuracy provided by airborne data. In consequence, prospective areas are often re-flown with each new generation of sensors. The advent of high-resolution aeromagnetic mapping in the 1980s, and demonstrations of its potential in Western Australia, highlighted the use of this technique to map under cover; it rapidly became standard practice for the industry and government alike.

More recently, development of new airborne electromagnetic systems to detect conductors under regolith, such as TEMPEST by the CRC AMET, and the Falcon airborne gravity gradiometry system developed by BHP to measure density variations, have added new capabilities to the exploration toolbox which have yet to be fully demonstrated or exploited. These systems are useful for seeing through thin regolith, but need to be markedly improved to be able to probe to depths of 40 to 200 m needed to radically improve the prospectiveness of Australia's covered and deeply weathered landscape.

Research solution:

- Continue development of tensor magnetic methods, higher-powered airborne electromagnetics, and gravity gradiometry to improve the depth and resolution of subsurface mapping and orebody detection.
- Conduct detailed TEMPEST airborne electromagnetics surveys over prospective areas at the fringes of known mineral provinces in several Australian States (see also Exploration under transported cover[e]).
- In combination with GlassEarth Australia, integrate the airborne EM data with other data sets using advanced data processing methods to translate of geophysical signatures into geologically realistic models of the subsurface environment.

Impact:

The next generation of airborne geophysical systems capable of seeing deeper into and under the regolith will open up new regions to exploration that would otherwise remain hidden. New orebodies in Australia will undoubtedly be discovered in areas under cover.

Development of cheaper deep rock sampling methods[h]

Despite advances in remote sensing, geological understanding and surface geochmical techniques, drilling has been, and will continue to be, a primary exploration technique for most explorers. There is always a need to obtain sub-surface samples in order to more fully assess exploration targets, and to determine the size and quality of any mineralisation.

Research solution:

1) Investigate existing drilling methods and establish what incremental improvements can be made to costs.
2) Investigate other advanced or novel deep rock sampling methods that have the potential to result in cost reduction breakthroughs.

Impact:

Given the large amount of money spent on drilling in Australia, even incremental improvements in drilling costs associated with existing technologies have the potential to make significant funds available for additional drilling or exploration work.

References

Stoeckel, A. (1999). *Minerals – Our Wealth Down Under*, pp. 45 (Centre for International Economics, Canberra).