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Geoscience Research and Education

The Exploration Challenge

5.1 "Modern mineral exploration is scientific inquiry and research. First there is the idea, the vision, or the intuitive thought, then the experiments follow".[1] The testing of the idea for a deposit can employ some combination, and often repeated phases of a variety of geological, geophysical, geochemical and other methods.[2]

5.2 Those valuable resources concentrations that crop out or produce surface expressions, in the main, have already been discovered. "Basically all the easy ones have gone".[3] The challenge now is to find concentrations of minerals and hydrocarbons that "are statistically forecast to be available but are undetected to date", generally at greater depths and under cover.[4]

5.3 The task of finding new resources is becoming increasingly difficult. No major mineral deposit discoveries have been made since the early to mid 1990's.[5] The CSIRO Division of Exploration and Mining advised that the next generation of explorers in Australia will:

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1 Earthsearch Consulting Pty Ltd, *Submission No. 108,* p. 1575.

2 Minerals Council of Australia, *Submission No. 81,* p. 1142.

3 Economic Geology Research Unit, *Transcript, 7 March 2003,* p. 367.

4 John Anderson, *Submission No. 31,* p. 418.

5 John Anderson, *Submission No. 31,* p. 417; Dr David Mackenzie, *Submission No. 69,* p. 938; Queensland Mining Council, *Transcript, 7 March 2003,* p. 331.

> need to have far better insight into what is beneath the regolith [surface material] before they invest the major sums involved with drilling.[6]

5.4 Seventy percent of the rocks forming the Australian continent that are prospective for large deposits are hidden beneath cover sequences that hide critical subsurface features.[7] One experienced geologist observed that:

> We have over the last 35 years developed techniques which allow companies and organisations to look through that cover. We also have had, during that time, enormous developments as a result of research in the understanding of how these very large deposits form.
>
> The consequence of that is that it is clear now that these giant deposits occur in very special places for very special reasons. It needs a very disciplined approach to have scientific teams… focusing on where those special places are and [the reasons why they are there].[8]

5.5 The scientific discipline of finding resources deposits, therefore, involves a number of inputs:

- **intellectual**: "Exploration success often comes as a result of very smart science or intellectual activity,[9] embracing superior scientific and technical skills;[10]
- **cultural**: "A poorly recognised cultural aspect of success present in [the great ore finding period post-World War II but] largely absent today, [is] hands-on leadership in the exploration industry and its beneficial effect in focussing, encouraging, mentoring and inspiring the professional ore finders on the ground";[11]
- **technical**: "The future success of the petroleum industry in Australia will depend…on the maintenance of the technical edge relevant to the specific exploration and production problems encountered in Australia;[12] and

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6 CSIRO Division of Exploration and Mining, *Submission No. 102,* p. 1547.

7 Eduard Eshuys, *Submission No. 32,* p. 432; CSIRO Division of Exploration and Mining, *Submission No. 102,* p. 1546.

8 Eduard Eshuys, *Transcript, 12 May 2003,* p. 473.

9 Eduard Eshuys, *Transcript, 12 May 2003,* p. 471.

10 Earthsearch Consulting Pty Ltd, *Submission No. 108,* p. 1575.

11 Dr David Mackenzie, *Submission No. 69,* p. 937.

12 CSIRO Division of Petroleum Resources, *Transcript, 12 May 2003,* p. 464.

- **managerial**: "Exploration success [is] reliant on a chain of confidence…running from the directors to the field geologists, and from the field geologists to the directors".[13]

5.6 This chapter addresses the role that conceptual R&D plays in resources exploration and future research direction settings, the issue of geoscientific education, and the character of a positive exploration mindset. These issues were not specified in the Terms of Reference for the inquiry. Nonetheless, the Committee notes the high level of concern expressed during the inquiry relating to research and education and believes that these matters amount to significant impediments to investment in resources exploration.

Knowledge Needs

5.7 The Committee recognises the critical importance of conceptual thinking that must go into the process of establishing geoscientific targets. If the intellectual input to the exploration challenge lacks creativity and rigour, the probability of exploration success is reduced. More importantly, however, successful R&D of new exploration concepts and methods may ultimately lower ore body discovery costs and hence reduce exploration risk.[14]

5.8 It is clear to the Committee that any constraints placed on the flow of knowledge into the resources exploration process, by commission or omission, amount to a severe impediment to potential resources discovery.

Research and Development

Global Ranking

5.9 Australia is a world leader in the field of geoscientific research and the provision of geoscientific information.[15] Australia's public sector geoscience research institutions are world-class and their research scientists are held in high esteem globally. CSIRO commented that "[t]oday, Australia's fastest growing mineral export is knowledge".[16]

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13 Earthsearch Consulting Pty Ltd, *Submission No. 108,* p. 1575.

14 Eduard Eshuys, *Submission No. 32,* p. 429.

15 CSIRO Division of Exploration and Mining, *Submission No. 102,* p. 1548.

16 CSIRO Division of Exploration and Mining, *Submission No. 72,* p. 984.

5.10 The level of Commonwealth government support for R&D is high in international terms.[17]

Spending on Research and Development

5.11 The petroleum sector is a technology intensive industry, which has driven significant scientific advances and is a voracious consumer of new science and technology.[18]

5.12 Both private and public spending on the R&D of technologies and concepts to innovate resources exploration in Australia (rather than routine exploration itself), had declined to half what it was in the mid-1990s.[19] A senior minerals exploration manager believed the reason why corporate exploration and R&D always faced funding volatility was because companies "have learned quite quickly that you can make quite a big difference to your profitability by cutting your exploration right down—and your R&D… as well"[20]. Other witnesses pointed to the cuts to the budgets of the leading public sector R&D agencies in recent years, and considered such cuts limited the contribution those agencies could make to the industry.[21]

5.13 The CSIRO Division of Exploration and Mining explained that public sector agencies and universities:

> …provide critical support to industry but have all been affected by declining revenue for Research and 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.[22]

5.14 The increasingly complex exploration challenge faced by Australia to achieve future exploration successes, will be dependent on quantum changes in conceptual thinking drawing on higher levels of both short-term and long-term geoscientific research activity, geoscientific education and the adoption of a rigorous resources discovery culture; and a quantum change in funding.

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17 House of Representatives Standing Committee on Science and Innovation (2003), *Riding the Innovation Wave: The Case for Increasing Business Investment in R&D*, Commonwealth of Australia June 2003, p.21.

18 CSIRO Division of Petroleum Resources, *Transcript, 12 May 2003*, p. 464.

19 CSIRO Division of Exploration and Mining, *Submission No. 72*, p. 985.

20 Dr Ian Gould, *Transcript, 12 May 2003*, p. 441.

21 Victorian Minerals and Energy Council, *Submission No. 63*, p. 868.

22 CSIRO Division of Exploration and Mining, *Submission No. 102*, p. 1548.

Research and Development Providers

5.15 Public sector R&D is undertaken by a range of Commonwealth and state geoscientific research organisations, discretely and through Cooperative Research Centres (CRCs). Universities throughout Australia also have specialist geoscience research units. These organisations are listed in Appendix D. In addition, many resources industry corporations, especially the majors, have in-house research units or use AMIRA International, an industry association which manages collaborative research for its members in the global minerals sector.[23]

5.16 The Tasmanian Minerals Council saw the need for closer cooperation between universities and CRCs to invent and innovate better approaches or innovative technologies that could be handed on to explorers involved in the discovery of mineral deposits in Australia.[24]

Impacts of Globalisation on R&D

5.17 In parallel with exploration spending, globalisation and associated consolidation has also led to declining exploration R&D spending. In Australia, R&D funding has declined by 60 percent over the three years to 2001. Anecdotal evidence suggests that the trend is continuing.[25]

5.18 One unfortunate downside of resources industry globalisation has been that corporate R&D units have tended to co-locate with their corporate head-offices.[26] Because the globalisation of Australia's resources industry entailed foreign majors acquiring leading Australian companies, many of the corporate geoscientific R&D facilities had been transferred to, or consolidated at foreign head-office locations and in the view of one senior minerals manager:

> We have seen far too many research organisations… fade from our landscape in the last 10 years.[27]

5.19 The CSIRO Division of Exploration and Mining (CSIRO) submitted that the current corporate dynamics in the resources industry generated a research dilemma. Multinationals that have the money to develop the technology are reducing their research effort because they prefer to

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23 http://www.amira.com.au/ accessed 2 September 2003.

24 Tasmanian Minerals Council, *Submission No. 88,* p. 1389.

25 Davidson, Alex (2003) *Speech – PDAC 2003 International Convention*, Barrick Gold Corporation, Toronto, Canada.

26 Hugh Morgan AC, *The Business Show*, SBS TV, 20 June 2003, http://www.sbs.com.au/business/archive.php3?contentID=720&month=6&year=2003, accessed 2 September 2003.

27 Dr Ian Gould, *Transcript, 12 May 2003,* p. 443.

acquire resources rather than find them. However, those who wish to conduct innovative exploration cannot afford the initial research effort that might produce new techniques for application in the field by their exploration team aimed at breakthrough discoveries.[28]

5.20 CSIRO believes that Australia's response should be to promote the uniqueness of Australia's exploration and geological environment:

> There are two ways to look at that; one is to educate the world to handling regolith types of environment and the other way is to make available a pool of people here [that] can go out and work for companies and understand the environment in Australia and how to explore here. [29]

5.21 The tendency of the large multinational petroleum operators to rely on and fund overseas research and development is seen as depriving local small operators of access to local competence. Strategic alliances between small companies and technology providers need to be encouraged. The Committee was advised that:

> Dominance by multinationals is not healthy for the development of new exploration concepts and technology in Australia. The low rates of return available to multinational oil companies, and their successive mergers, has seen the market implode over the past decade. ExxonMobil has a limited exploration portfolio in Australia, Shell is showing signs of preferring NE Asian opportunities, Chevron is not expanding here, BPAmoco has no exploration activity, and Woodside is technologically supported for the time being by Shell, but this may not last much longer.[30]

5.22 The Committee concludes that globalisation of the resources industry has impacted fundamentally on the private sector structure and culture necessary to support minerals and petroleum R&D. Some R&D functions have been redistributed away from Australia. Despite this, Australia's innate strength in resources exploration R&D should continue to be driven by domestic requirements and local researchers.

Research and Development Priority

5.23 A major impediment to further resources exploration success (greenfields petroleum and ore discoveries) was the low level of commitment to R&D by Australian business generally and by the Australian resources industry

28 CSIRO Division of Exploration and Mining, *Submission No. 102,* p. 1546.

29 CSIRO Division of Exploration and Mining, *Transcript, 3 March 2003,* p. 312.

30 Cedric Griffiths, *Submission No. 37,* p. 465

specifically.[31] Inadequate R&D is seen as a barrier to future exploration success particularly at a time when the task of finding new commercial resources is becoming increasingly more difficult because of cover sequences, and water depth.

5.24 The national research priorities announced by the Prime Minister in late 2002 included deep earth resources.[32] The Committee endorses this priority adding that adequate and appropriate geoscientific research was a vital precursor to the earliest component of the actual exploration carried out in the field.

5.25 CSIRO considers that current funding levels for national priority strategic R&D projects is probably only sufficient for the delivery of incremental gains in the medium-term. The magnitude of the problem, of declining minerals reserves can only be tackled through a "whole of Australia" combined financial and intellectual effort.[33]

Research Directions

5.26 CSIRO has developed a plan entitled *Australia's Exploration Future*, to regain Australia's leadership in exploration. The plan involved drawing together a consortium of experts from the leading geoscience and mining related organisations to deal with the problem of the decline in exploration investment.[34]

5.27 The plan's proponents believed that the initiative could develop or produce signatures of targeted ore systems; a multi-dimensional digital map of Australia's geology and resources; conventional geochemical maps and deep sensing geochemistry; and techniques for exploration under transported cover as well as deep rock sampling.

5.28 The Tasmanian Minerals Council believed that any geoscience research plan should contain the following elements:

- a co-operative network of universities and CRCs to work on state-based mineral discovery techniques;
- each state to follow a similar approach; and
- research to target the respective state's geologic framework.[35]

31 Australian Petroleum Cooperative Research Centre, *Transcripts*, p. 75.

32 Prime Minister of Australian, *Research Priorities for Australia's Future Prosperity*, Media Release, 5 December 2002.

33 CSIRO Division of Exploration and Mining, *Submission No. 102*, p. 1545.

34 CSIRO Exploration and Mining, *Regaining Australia's Global Leadership in Exploration: Australia's Exploration Future*, 2003. *Submission No. 102,* p. 1548.

35 Tasmanian Minerals Council, *Submission No. 88,* p. 1389.

Research and Development: An Assessment

5.29 The Committee supports the CSIRO initiative encapsulated in *Australia's Exploration Future* to address Australia's declining exploration activity. This initiative meets the requirements of seeing through the regolith that covers much of continental Australia. It is expected to cost $60 million per annum over 3-5 years with one third directed at new concepts and technology development and the remainder to testing.[36]

5.30 The Committee also acknowledges that there are a number of private and publicly funded research centres that have the capacity to achieve a much greater breadth and depth of geoscientific research.[37] In addition to accessing Commonwealth grant programs designed specifically to encourage company R&D[38], these research centres may require increased funding to provide an incentive to initiate high quality geoscientific research and to attract talented researchers.

5.31 Geoscientific research should also have a national focus for maximum impact, although the states should host their fair share of projects. The Committee makes the following recommendation.

Recommendation 10

5.32 **The National Task Force proposed by the CSIRO Division of Exploration and Mining be supported financially and charged with the task of implementing the proposal entitled *Australia's Exploration Future* to provide (in its words) breakthrough concepts, knowledge methods and techniques for transfer to minerals explorers.**

3D Seismic: A Case Study

5.33 CSIRO's Division of Petroleum Resources described the onshore use of three dimensional seismic surveying (3D seismic) as an example of an emerging exploration technology with great potential 3D seismic is currently used with great success for identifying offshore petroleum accumulations.[39] More research needs to be done, however, to optimise 3D seismic for onshore petroleum exploration and lower its costs. If this occurs, then the new technique is expected to have the same significant

36 CSIRO Division of Exploration and Mining, *Submission No. 102,* p. 1548.

37 Eduard Eshuys, *Submission No. 32,* p. 434

38 House of Representatives Standing Committee on Science and Innovation (2003), *Riding the Innovation Wave: The Case for Increasing Business Investment in R&D*, Commonwealth of Australia June 2003, p.29-35.

39 CSIRO Division of Petroleum Resources, *Transcript, 12 May 2003,* p. 466; International Association of Geophysical Contractors (IAGC), *Submission No. 120,* p. 1675.

impact onshore as it has had on offshore petroleum exploration. Accordingly, the Committee recommends.

Recommendation 11

5.34 **CSIRO Petroleum, through its membership of the Australian Petroleum Cooperative Research Centre, encourage research into cost-effective innovation of petroleum exploration technologies such as three dimensional seismic imaging technology, for onshore petroleum exploration.**

Geoscientific Education

5.35 The top Australian university Earth Sciences departments have produced and are still producing some of the best exploration geoscientists in the world.[40] However, the closure of geology schools and diminishing interest in the sciences generally and the geoscience discipline in particular, will seriously limit the numbers of geoscience professionals available to carry out the necessary resources exploration functions in the future.

5.36 The Economic Geology Research Unit from James Cook University warned that undergraduate geoscience student numbers are likely to reduce and postgraduate student numbers are also falling.[41] The Unit further believed that the average quality of the earth science graduates has declined.[42]

5.37 The perceived highly volatile resources industry career paths and currently poor job prospects in the resources industry are the major causes for the decline.

5.38 Some rationalisation of tertiary geosciences schools has taken place. The Committee considers that a network of geosciences schools across Australia should remain viable through the current exploration downturn and be in a position to expand with the recovery of the resources industry, and the likely increase in student interest in geosciences courses. The Committee recognises and supports the peak bodies' and professional associations' longstanding stakeholdings in tertiary education, and notes studies such as the Minerals Council of Australia's 1998 discussion Paper,

40 Earthsearch Consulting Pty Ltd, *Submission No. 108,* p. 1575.

41 Economic Geology Research Unit, *Submission No. 35,* p. 455.

42 Economic Geology Research Unit, *Transcript, 7 March 2003,* p. 367.

Back from the Brink which addressed reshaping minerals tertiary education.[43]

5.39 The issue of falling enrolments in geoscience courses at universities, however, is a sub-set of the broader issue of declining interest in studying the hard sciences. Some educators believed that greater effort needed to be exerted to upgrade the quality of geoscience teaching at secondary schools, through teacher training and curriculum review.[44] Others considered that high schools should focus more on teaching "the fundamentals of science – chemistry, physics and mathematics".[45] Then:

> …you have to create an environment out there where people in universities, doing the hard sciences early on in their university, see the job opportunities, see the salaries which are being offered. There will not be any problem about attracting them to geology in second year and third year, and then geology at doctorate level.[46]

5.40 The Committee concludes that, in the present environment, any attention to teaching should best be directed at improving geoscience education at tertiary level. The Committee agrees that a thorough grounding at secondary school in the core science subjects would serve interested students well for when they reached university and considered taking geosciences studies. Informing high school students of resources industry career opportunities was a responsibility best handled by the geoscience professional associations and the industry peak bodies which already had the infrastructure to continue this role.

Exploration Culture

5.41 A number of submissions and witnesses advised that geoscientists needed to possess, in addition to formal education qualifications, an inquiring exploration culture to enhance their chances of participating in resources discovery. In a landmark 1976 paper, Dr Leo J Miller identified that successful geoscientists needed to be physically fit, creative, intelligent, optimistic, persistent, non-meek and non-humble, and adventurous.[47] Others said that commitment and perseverance were essentials to making

43 Minerals Council of Australia, *Back from the Brink*, MCA, Canberra, 1988.

44 Economic Geology Research Unit, *Submission No. 35,* p. 456.

45 Earthsearch Consulting Pty Ltd, *Transcript, 12 May 2003*, p. 479; Cotopaxi International Pty Ltd, *Submission No. 34,* p. 446.

46 Earthsearch Consulting Pty Ltd, *Transcript, 12 May 2003*, pp 470-80.

47 Miller, Leo J. (1976), '*Corporations, Ore Discovery and the Geologist', Economic Geology*, Vol. 71, 1976, Mount Pleasant, Mich., pp 836-847.

discoveries[48] and that explorers should be entrepreneurial professionals with economic motivation who are dedicated to discovering economic mineral deposits.[49]

5.42 An experienced consulting geologist submitted that successful explorationists are few and far between:

> Exploration is at a low ebb and it has few local champions… and it has a serious cultural dysfunction between the leadership and the troops.
>
> The few explorationists now in senior positions are usually remote from the action…. The largest companies are increasingly directed from overseas headquarters – a further removal from the front line.
>
> We can not roll back the reality of globalisation and mining company mergers. They are driven by short term benefits such as economies of scale. Exploration, by contrast, is a long term exercise in which quality counts for more than quantity. Successful exploration teams are dedicated, consistent, persistent, flexible and innovative.[50]

5.43 The Committee concludes that the attributes of a successful exploration culture need to be nurtured in the Australian geoscientific community so that internationally competitive Australian professionals can drive successful exploration in Australia and overseas. Accordingly, the Committee makes the following recommendation.

Recommendation 12

5.44 **The Department of Industry, Tourism and Resources in conjunction with the Department of Education, Science and Training discuss with appropriate peak bodies and professional associations to develop, in collaboration with universities, tertiary-level short courses to encourage excellence in minerals and petroleum exploration management culture, innovative operational approach and optimisation of the national geoscientific knowledge base.**

48 Geoscience Australia, *Submission No. 53,* p. 645.

49 Earthsearch Consulting Pty Ltd, *Submission No. 108,* p. 1575.

50 Dr David Mackenzie, *Submission No. 69,* pp 938-9.