AusIMM Submission on the Economic, Social and Environmental Returns on Public Support for Science and Innovation in Australia

Who Are We?

The Australasian Institute of Mining and Metallurgy ('The AusIMM') is the preeminent organization representing professionals in the minerals sector in the Australasian region. Our members are spread across industry, university, research organizations and government. As professionals, they have an ethical commitment to apply their expert knowledge in the fields of mining engineering, metallurgy and geoscience towards the benefit of the industry and community. As a corollary of their professionalism, they have a strong commitment to the sustainability of the minerals sector in the Australasian region, and maintaining the benefits that flow from it to our economy.

Many of our members are involved in minerals related R&D, either through universities, CRCs, CSIRO, AMIRA, consultancies or in mining companies. They have first hand experience of the application of policy measures aimed at stimulating R&D. Consequently they have a unique insight into the measures that have proven successful, generating R&D that 'makes the difference' and a strong awareness of impediments to the effective functioning of our engines of innovation.

Broader Social Objective: The Sustainability of the Minerals Sector

In the current climate, Australia cannot afford to take our strong positioning in the minerals sector for granted. In a truly global industry competition for investment between countries for exploration and mining investment is fierce. In the last five years Australia has slipped from second to fifth place for exploration spending by region.[1] Many global players perceive Australia to be mature exploration terrain, and are increasingly preferring to face higher sovereign risk in more prospective locations such as Asia and Latin America. This has not gone unnoticed by professionals in the industry; a recent survey of our members indicated that 91% of respondents agreed that insufficient investment in exploration could lead to a downturn.[2]

There are a number of key factors that we can influence to improve Australia's attractiveness as a location for greenfields exploration investment, such as sovereign risk, infrastructure, skills capability and red tape. However one of the major factors that influences our competitiveness is the relative likelihood of making a discovery, or prospectivity.

Prospectivity is a composite concept that is largely determined by the state of science. A significant innovation in a technology or process can have a radical impact on the prospectivity of a particular region. For example gold production in

[1] Metals Economics Group, 'Worldwide Exploration Budgets Reach $5.1 Billion in 2005-Just Shy of 1997 Peak', (10 November 2005) at http://www.metalseconomics.com/frame_press_releases.html ; Metals Economics Group, 'Exploration Spending Nearing Bottom of Cycle,' (2 November 2000) at http://www.metalseconomics.com/frame_press_releases.html .

[2] Centre for Social Responsibility in Mining at The University of Queensland, 'Macquarie Securities, The AusIMM Survey of Minerals Industry Professionals', (2005) at http://www.ausimm.com.au/2005survey_minerals_industry_professionals.pdf .

Australia jumped six fold in the past 20 years to $5 billion, driven by a range of new exploration and processing technologies. Consequently, we can improve our prospectivity by coming up with new ideas and technologies for deep exploration and mining, developing new minerals processing techniques that allow previously uneconomic deposits to come online, and advancing mining methods to increase efficiencies and bring down costs.

Australia has a strong history of university, industry and government collaboration that has worked effectively in the past. However a number of structural changes to the industry have challenged historical trends in innovation. Consequently we need policy settings that are appropriately adapted to the shape of the industry today, which will foster innovation in mining and increase our prospectivity for the future. Otherwise our $100 billion dollar a year export industry is set for an inevitable decline, notwithstanding that we are entering a period of sustained minerals demand.[3] We would miss out on a unique opportunity to benefit from our generous natural endowments. This would also adversely affect emerging downstream industries, supporting services, and associated information technologies that are positioned to benefit from the sustained boom.

With the rapid industrialization of India and China, the world economy is rebalancing and we have an opportunity to benefit from that. However we need to increase our competitiveness, through R&D, as a top ranking destination for exploration and mining investment. This requires a strategic commitment to education to produce the next generation of innovators, as well as to policy settings that will maximise their ability to generate the innovations that will help ups lift our game.

With global mining companies no longer investing in Australia as a matter or necessity, or having any physical or emotional incentive to conduct research that will add a competitive advantage to our particular terrain, we cannot leave it up to industry to facilitate collaboration on its own. Privately funded research tends to focus on incremental low risk innovation as opposed to the disruptive breakthroughs that revolutionize prospectivity. With global players seeking to increase their search space, they will either go where the R&D is better, or where the discoveries are easier. At present they are favouring the latter strategy. We need to recognise that strong industry performance and higher living standards do not happen by accident, but rely on forward thinking and long term decision making in the national interest. In a global knowledge economy, the focal point of decision making must be proactive support for research infrastructure for our leading industries. Unless we address capacity constraints in minerals R&D now, Australia will become an unsustainable quarry for the rest of the world.

Key Terms of Reference

The AusIMM would like to comment on five specific issues that fall within the second term of reference:

2. Identify impediments to the effective functioning of Australia's innovation system including knowledge transfer, technology acquisition and transfer, skills development, commercialisation, collaboration between research organisations and industry, and the creation and use of intellectual property, and identify any scope for improvements;

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[3] ABARE, 'Record Commodity Earnings in Prospect,' (26 June 2006), at http://www.abareconomics.com/corporate/media/2006_releases/26june_06.html

These issues are as follows:

i. Sustainability of minerals related tertiary education
ii. Alignment of public and private research priorities through research assessment
iii. Impediments to SME participation in the innovation process
iv. Impediments to commercialization of step-change technologies in major companies
v. The importance of junior explorers and classifying new exploration as R&D

i. Sustainability of minerals related tertiary education

It is disturbing that in a global knowledge economy, Australia is below the OECD average in expenditure on educational institutions as a percentage of GDP.[4] Moreover a recent study by Monash University showed that domestic engineering commencements in Australia have been flat since 1996.[5] Meanwhile, the number of mining engineering, metallurgy and geoscience departments has been steadily declining. Small and capital intensive, these engineering courses have been disadvantaged in the current user pays funding environment that favours large, generalist courses. In many cases it is not financially viable for Universities to run them. As a result, since 2000, eight minerals departments have closed, three are marked for closure and four have been merged into other degrees.[6]

The undersupply of graduates from these key disciplines has exacerbated the current skills shortage. The AusIMM Survey of Minerals Industry Professionals indicated that 73% of respondents agreed that the skills shortage had left their company short staffed.[7] Also, whilst 9% of respondents intended to move out of the industry in the next two years, only 5% of respondents had moved in to the industry during this same period.[8] The rate of replacement is clearly unsustainable.

Companies have implemented a range of alternative measures to plug the skills gap, such as increasing sponsorship of skilled migrants, upskilling their workers, recruiting from generalist engineering disciplines, and recruiting students who have not yet finished their degrees into full time professional roles. Not surprisingly, the AusIMM survey found that over 53% of respondents agreed that the skills shortage had resulted in inexperienced or unsuitable candidates being called upon to fill more senior roles.[9]

The shortage of graduates from minerals related disciplines and their hurried induction into industry has serious ramifications for our capacity to innovate. The inevitable declining quality of professionals will adversely affect the ability of companies to innovate their processes, as people who lack in depth technical knowledge are unlikely to develop new and more efficient ways to do things. They

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[4] Australian Industry Group, 'Manufacturing: Achieving Global Fitness,' (April 2006) at http://www.aigroup.asn.au/aigroup/pdf/publications/reports/general_reports/Manufacturing_futures_full.pdf , p 70.
[5] Birrell, B., Sheridan J., and Rapson, V., 'Why No Action on Engineering Training?', *People and Place*, vol 13, No. 4 (2005) pp 34-47, p 38.
[6] Galvin J. and Carter R., 'Strategic Review of Minerals Council of Australia Tertiary Education Initiatives,' *Minerals Tertiary Education Council of Australia* (May 2003) at http://www.minerals.org.au/__data/assets/word_doc/4328/MTEC_Review_FINAL.doc .
[7] Centre for Social Responsibility in Mining at The University of Queensland, above n 2.
[8] Ibid.
[9] Ibid.

will merely perpetuate the processes into which they are inducted. Moreover, as there are fewer graduates who undertake postgraduate studies, there will be a smaller number of professionals available to both industry and public research institutions with advanced research skills.

It has been suggested that business is the most important generator of innovation, receiving over 88% of royalties and licensing fees for new patented inventions in 2003.[10] If businesses are to continue to generate value adding innovations we will need to be able to supply them with graduates with in depth technical knowledge from adequately supported courses.

The skills shortage has also threatened the sustainability of an important emerging industry - mining technology services sector. Last year the mining technology services sector accounted for $1.3 billion dollars worth of exports. Australia currently produces more than 60% of the world's mining software.[11] A recent study on 'Knowledge Management and Innovation in Service Companies', reported that mining technology service firms were particularly likely to rely on in-house expertise for innovation and employed high proportions of tertiary qualified technical staff. The report also showed that at present these firms are having "a great deal of difficulty in finding suitable staff."[12] As the skills shortage worsens the ability of the service sector to develop will be effectively hamstrung.

One of the key purposes of tertiary education is to generate the human intellectual capital to meet the skills needs of the economy and drive innovation. The current funding structure is failing to do that. The Australasian Institute of Mining and Metallurgy has submitted to DEST that minerals related courses in the Science and Engineering should be funded at the same level of Agriculture courses in cluster 10, for a much needed additional $4000 per student.[13] Minerals related courses face similar disadvantages to Agriculture in that they are small and capital intensive; they also contribute significantly to rural and regional Australia. To put this figure in perspective, the average annual contribution to GDP per employee in the minerals sector is $337,000 compared with an average for the economy per employee of $72,600.[14] The additional cost of supporting these students in their chosen disciplines is less than 2% of the value they bring in to the economy annually. Surely this represents a worthwhile return on education investment

Recommendation:

- **Minerals related courses in the Science and Engineering should be funded at the same level of Agriculture courses in cluster 10, for a much needed additional $4000 per student**

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[10] Quirk, T., 'Science in the Service of the Nation State,' *Policy*, Vol 21 No. 3 (2005)
[11] ABARE, 'Mining Technology Services: A Review of the Sector in Australia,' (8 April 2005) at http://www.abareconomics.com/publications_html/minerals/minerals_05/er05_mining_tech.pdf .
[12] Thorburn, L., 'Knowledge Management and Innovation in Service. Companies –. Case studies from Tourism, Software and Mining Technologies,' Study for the Department of Industry, Tourism and Resources (February 2005) at http://www.oecd.org/dataoecd/58/39/34698722.pdf , p 41.
[13] The AusIMM, 'The AusIMM Submission in Favour of Increasing Funding for Minerals Related Courses to Cluster 10 Level,' (4th December 2004) at http://www.ausimm.com/policy/sub_inc_funds0405.pdf .
[14] Australian Bureau of Statistics, 'Key Facts Australian Industry 2004-05,' (2006)

ii. Alignment of public and private research priorities through research assessment

Minerals research in Australia is spread out across a range of public research bodies, collaborative centres and industry. Public research organisations include CSIRO, Geoscience Australia and Universities. The CRCs bring together public and private organisations to solve particular problems. Meanwhile AMIRA International is a private organisation established for collaborative research by minerals related companies, often in consort with public institutions. Mining companies also undertake their own R&D in house.

Industry investment tends to be mainly focused on applied research and experimental development whereas government investment tends to focus on basic and applied research. For example, the ABARE report into research and development in mining indicated that in 2000-01, of the $147 million allocated by government to mineral resources R&D, 40% was spent on basic research, whereas of the $456 million spent by industry on minerals R&D, only 5% was spent on basic research.[15] Thus the relationship between public research bodies and industry research is mutual supporting. Public research tends to focus on the pre-competitive stage of research with commercialisation taking place largely within companies.

The consolidation of the industry has resulted in a more concentrated resource base for industry funding of R&D, meaning that industry investment in public research and participation in the commercialisation process in Australia can no longer be taken for granted. Recent research into the internationalization of R&D shows that companies are locating their R&D according to qualitative motives, such as technological excellence, advanced markets and close and dynamic interactions between firms in the value chain. They are choosing to have a very selective focus on a few locations and concentrating their innovation activities in worldwide centres of technological excellence.[16]

Today's research institutions need to be more effective in meeting the needs of industry and communicating the value of their research to potential investors. This means looking closely at the obstacles to effective collaboration. At the 5th Biennial Exploration Manager's Conference held by AMIRA industry complained of differential timelines between research institutions and their exploration clients, owing to institutional pressure on researchers for work standards that were not necessarily relevant to industry.[17] Another issue was "mission creep" as poorly managed projects lost focus and sponsorship funds were tapped to support non-core avenues of enquiry.[18] More generally industry felt frustrated at the lack of control over research

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[15] ABARE, 'Research and development in exploration and mining: Implications for Australia's gold industry', (2004) at http://www.abareconomics.com/publications_html/minerals/minerals_04/er04_gold.pdf , p 14.

[16] Dodgson, M., and Vandermark, S., 'The Challenges and Opportunities of Globalisation and Innovation in the Minerals Industry,' *Innovation: Management, Policy & Practice*, (September-October 2000) 3, p 11.

[17] *5th Biennial Exploration Conference*, 'Maximising Exploration Efficiency and Success in a New World:Global Support for Research', (March 2003, WA).

[18] Bavinton, O., 'Improving exploration efficiency through collaborative R&D', *5th Biennial Exploration Conference*, 'Maximising Exploration Efficiency and Success in a New World: Global Support for Research', (March 2003, WA).

objectives, a frustration that was exacerbated by secretive and defensive positions adopted by both researchers and industry representatives throughout negotiations.[19]

The AusIMM supports the use of a research assessment methodology that will better align priorities of researchers in the minerals sector with those of their end users along the lines of the Research Quality Framework. A standardised ranking can also be used as 'scorecard' to promote local capability to overseas investors. By assessing 'Quality' of research, meaning intrinsic merit, as well as 'Impact', meaning successful application by end users, the methodology has the potential to bring researcher and industry partners closer together by recognising individual but complimentary measures of strength. The inclusion of end users in adequately constituted, cross disciplinary assessment panels for minerals related research is also appropriate.

The AusIMM has one major reservation regarding the Preferred RQF Model. Namely, the allocation of a single ranking based on aggregate scores for 'Quality' and 'Impact'. This is confusing, as these different measures protect interests which are of varying relative importance for different kinds of research. 'Quality' protects the integrity of the process of investigation and knowledge formulation, recognising that this may have unforeseen consequences significant in time. 'Impact' recognises the need for some kind of return on science investment within a finite time frame.

For the more technical, applied disciplines such as the minerals related disciplines of Geoscience, Mining Engineering and Metallurgy, there is a concern that an aggegate RQF score may result in a downgrading of 'Impact,' and that this will lead to staff in these disciplines focusing on more on academic outcomes at the expense of engagement with industry. Conversely, at a recent Stakeholder Forum held at Melbourne University, academics from enabling sciences such as Chemistry, Mathematics and Physics expressed concern to the effect that an aggregate score will obscure the 'Quality' of their research. That is, the lack of discernible 'Impact' will lead to a poor ranking even when they are producing world class research according to their peers.

In its initial submission to the RQF Inquiry The AusIMM proposed differential weighting for 'Quality' and 'Impact' depending on whether the research could be classified as Mode 1 or Mode 2.[20] Mode 1 research is identical with what is traditionally meant by science. Its problems are set and solved, largely by the academic community. In contrast, Mode 2 research is transdisciplinary, carried out in a context of application and includes a wider set of practitioners collaborating on a particular problem defined in a specific and localized context.[21] Both kinds of research are vital for ensuring a thriving and innovative minerals sector. That is, the transformative leaps of science from Mode 1 research can become the basis for innovations to processes created at the Mode 2 level.

The industry would be best served by assessing Mode 2 minerals related research with a significant weighting for 'Impact,' so as to recognize the excellence or

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[19] Finlayson, E., 'Is Australia a mature exploration destination or are there still opportunities: can collaborative R&D help?', *5th Biennial Exploration Conference*, 'Maximising Exploration Efficiency and Success in a New World:Global Support for Research', (March 2003, WA).
[20] The AusIMM, 'Submission to DEST RQF Issues Paper,' (May 2005) at http://www.dest.gov.au/NR/rdonlyres/CA13B5BA-0657-42F8-8BC4-77D520B535B9/6104/RQF010158AusIMM.pdf .
[21] Gibbons, M. (1997) 'Factors Affecting the Valance Between Teaching and Research in the Twenty-First Century', *Higher Education in Europe*, 12(1), pp 21-30.

researchers who have achieved their goal in solving a specific problem. Mode 1 research at the more fundamental range of the spectrum, whether in minerals departments or the enabling sciences, should be valued for its integrity and consequently its potential to be the springboard for innovations as yet unforeseen, and valued primarily for 'Quality.'

Recommendations:

- **'Quality' and 'Impact' rankings to be reported separately**
- **Recognise that 'Quality' is of primary importance in Mode 1 research, and 'Impact' is of primary importance in Mode 2 research**
- **The term Research Quality Framework is a misnomer (implies that 'Impact' is a subset of 'Quality') and should be reconsidered**

v. Impediments to SME participation in the innovation process

Small to Medium-size Enterprises (SMEs) are an important and dynamic part of the innovation chain. They can often act as disseminators of innovation as well as generating innovation in their own right. Therefore public support for innovation must ensure that SMEs do not miss out on access to R&D grants or the opportunity to participate in the collaborative process. The AusIMM has received a number of submissions from its members which indicate that at present SMEs face a number of obstacles in obtaining innovation grants, such as the prohibitive costs of putting together tender applications. Meanwhile the dollar for dollar nature of some of the grants is inappropriate for some companies that cannot raise a significant proportion of the start-up capital themselves. Consequently these companies cannot capitalise on the grants that they receive.[22]

SMEs have also reported some exclusion from participating in some of the collaborative research institutions and CRCs, largely due to concerns about dilution of intellectual property from larger investors.[23] To some degree CRCs have sought to overcome this hurdle. For example CRC Mining has utilised its 'SME Club' to successfully engage with some SMEs working in the mining technology sector. This has involved putting together a specific process to assess the relevance of SME interests to CRC Mining research and to then get them involved. The last CRC Mining Annual Report indicated that there were 20 SME Club members in mid 2006.[24] Measures such as the SME Club are to be applauded, but a strategic assessment of impediments to collaboration that can recommend best practice measures is needed.

Recommendations:

- **Streamline grants application process for SMEs**
- **Review effectivess of grant programs that require SMEs to match industry funding**
- **Review impediments to SME collaboration in CRC program**
- **Disseminate best practice programs implemented by CRCs to involve SMEs**

[22] Graham, A., 'No Room for Small Players in Collaborative R&D', *The AusIMM* Bulletin, March/April (2006) pp 52-53 at http://www.ausimm.com/policy/no_room_small_players.pdf .
[23] Ibid.
[24] CRC Mining, 'Annual Report 2004-05,' pp 13-31 at http://www.crcmining.com.au/dynamic_page.php?page_id=71 .

iv. Impediments to commercialization of step-change technologies in major companies

Given that mine to mill is an integrated system with significant sunk costs and a long operation life, the risks of implementing a step change technology for a major company are significant. Moreover even if the technology proves commercial, it will take a long time to integrate it across an entire operation.

For example, at present there are two disruptive technologies in steelmaking at the commercialisation stage. They are the HIsmelt iron smelting process which has had its first commercial application at Kwinana, Western Australia supported by a joint venture of Rio Tinto, Nucor, Mitsubishi and Shougang, and the Castrip strip casting technology that arose from development work done by then BHP Steel, with IHI of Japan at Port Kembla, NSW. The total cost of bringing these technologies to commercialisation has been somewhere between half billion to a billion Australian dollars, with both technologies having been in gestation for over two decades.[25]

The benefits that flow to Australia from successful large scale commercialization on our shores is significant. We not only gain a reputation for R&D excellence, we also build our local capacity and potentially increase our prospectivity. However in order to maximize the attractiveness of Australia as 'the place' to implement a new process or technology at scale, we will need to ensure that we offer companies the best return on their long term risk. For most companies the most affective incentive we can offer them is a generous tax concession. This would need to be specifically targeted towards commercialization of disruptive technologies in industries with significant sunk costs.

Recommendation:

- **Review whether existing R&D tax incentives are sufficient to ameliorate risks of commercialization of new technologies in capital intensive industries with high sunk costs**

v. The importance of juniors and classifying new exploration as R&D

The exact contribution of junior explorers to Australian greenfields exploration and discoveries is difficult to measure. On a global scale, the Metals Economics Group reported that in 2005 junior company exploration budgets rose almost 57% to $2.3 billion, with juniors accounting for more than 63% of the overall $1.3 billion increase in exploration spending worldwide.[26] In Australia, it is believed that junior explorers play a major role not just in finding new orebodies, but in developing geological ideas that drive exciting new finds.

Greenfields exploration is a high risk activity which has significant value adding potential, not unlike mainstream R&D. However at present, whilst the development of new or vastly improved methods of data acquisition, processing and interpretation is classified as R&D, the activity of searching for minerals using existing methods is not. This means that greenfields exploration activity does not attract the 125% tax concession available for mainstream R&D activity. This is notwithstanding the fact

[25] Farr, I., 'Fundamental Technology Change in the Iron and Steel Industry,' in *The AusIMM New Leaders Conference Proceedings 2006: Riding the Boom,* (April 2006) p 39.
[26] Metals Economics Group, 'Worldwide Exploration Budgets Reach $5.1 Billion in 2005-Just Shy of 1997 Peak', (10 November 2005) at http://www.metalseconomics.com/frame_exploration_reports.html .

that the process of drilling increases geological knowledge of a region, and gives rise to 'disruptive' ideas that have the capacity to revolutionise the industry.

There are a number of historical examples where exploration work by juniors has completely revolutionised the prospectivity of particular terrain. For example, the reclassification of Western Australia from 'mature terrain' to 'exciting exploration frontier' was brought about by a number of converging breakthroughs which came from studies based specifically on the Yilgarn Craton by juniors. Of the breakthroughs, three concerned the primary geology of gold deposits (structural control, role of host rocks and alternation haloes) and three were related to the regolith environment (metal dispersion, sampling media, and regolith landforms). These were assisted by the right tools: aeromagnetic and hyperspectral maps revolutionized the way explorers could look at large parts of the Yilgarn Craton.[27]

Each of these breakthroughs was developed further and disseminated to the industry through publicly funded research centres, most notably the Key Centre for Strategic Mineral Deposits at the University of WA, and the CRC LEME. They were major contributors to the outperformance of gold in WA after 1979.[28]

Given the critical role of juniors in developing the science that determines the prospectivity of our terrain, they should be eligible for the same tax concession as mainstream R&D. Moreover, for the greater part new geological ideas and understanding is not subject to any intellectual property protection, therefore even the most cutting edge and innovative juniors will not be rewarded for their efforts unless they find an economic deposit.[29] This is clearly a significant risk for a small private entity to bear for an activity that has the potential to contribute significantly to the long term well being of one of our leading industries.

An alternative financial incentive that has been suggested to encourage greenfields exploration is a tax credit scheme, similar to the ITCE that has been operating in Canada since 2000. Under this scheme a percentage of investment expenditure in greenfields exploration can be applied against a taxpayer's income tax. In the most recent budget the Federal Government once again knocked back the tax credit proposal put forward by mining industry groups. Consequently, the problem of finding incentives to support and promote the high risk activity greenfields exploration remains unresolved, with ongoing ramifications for exploration levels in Australia.

Recommendation

- **Greenfields exploration activity to be classified as R&D to attract 125% tax concession**

[27] Phillips, N., 'Australia's Declining Exploration Share: the Problem and a Solution, Part 3 – case history: The Contribution of R&D to success in the Australian Gold Industry', *The AusIMM Bulletin*, January/February (2006), pp 39-42.
[28] Roberts, P., 'Mining Innovation Will Pay Handsome Dividends,' *Australian Financial Review* (21st March 2005), p 28.
[29] Phillips, N., 'Australia's Declining Exploration Share: the Problem and a Solution, Part 5 – Tailoring R&D to Support Successful Explorers', *The AusIMM Bulletin*, July/August (2006), pp 11-20, p 18.