

CONFIDENTIAL

FIFTH YEAR REVIEW OF THE CRC FOR LANDSCAPE ENVIRONMENTS AND MINERAL EXPLORATION 19-20 JULY 2006, Australian Resources Research Centre, Perth

1. Executive Summary

Scientific outcomes to date are substantially in accord with the objectives laid down in the Commonwealth Agreement.

There are notable scientific achievements across the range of the CRC's research activities. However, significant deficiencies remain to be addressed.

There are numerous examples of adoption of CRC outputs by stakeholders and a consequent increase in the profile of regolith science within the community.

The Education and Training Program is an outstanding success.

There are few, if any, competitors world-wide with LEME's interdisciplinary approach to regolith science. For this reason the Review Panel strongly recommends that all avenues for the continuation of regolith research be pursued.

2. Review Procedures

The Review Panel were provided with extensive background documentation (Appendix 1 - Support Documentation). Prior to meeting with LEME personnel the Panel met for half a day to reach consensus on major issues and questions to be raised. The Review proceeded by interviewing the Board Chair and CEO, followed by Program Leaders and Key researchers from each of the Programs in succession and finally selected Postgraduate Students. (Appendix 2 - List of participants)

Following the interviews the Panel met to summarise their conclusions and to formulate this report.

3. Scientific Outcomes and Advances

To what extent has the CRC delivered scientific outcomes and advances as set out in Schedule 1 of the Commonwealth Agreement?

Objective 1 in Schedule 1 - *Provide the mineral industry with world leading capabilities leading to breakthroughs in exploration in Australia's extensive areas of cover.*

The Panel recognises that there has been a breakthrough in the widespread investigation of biological processes and the role of biology in geochemical

dispersion. In addition, the establishment in recent weeks of the AMIRA P778 Project (Predictive Geochemistry in Areas of Transported Overburden) represents a vital step towards making geochemical exploration predictive in areas of transported cover. The importance of this is emphasised by the sponsorship of most of the major mineral exploration companies in Australia, viz: Barrick Gold Corporation; BHP Billiton Minerals Exploration; Inco Resources (Australia) Pty Ltd; Independence Group NL; Newmont Australia Limited; SGS Minerals; Teck Cominco Ltd; and Cameco Corporation.

Objective 2 in Schedule 1. Produce the essential multidisciplinary knowledge of Australia's regolith environments / areas of cover, to package this knowledge in readily useable forms, and ensure that it is transferred into practice in the minerals industry and environmental management

There have been considerable advances in understanding and interpreting the Australian regolith. For example:

- recognition of the unexpectedly great age of regolith
- development of the knowledge and technology to allow production of the Northern Territory Regolith Map, its acceptance by stakeholders, and the commissioning of a similar product by the Government of Queensland.
- Development of advanced inversion algorithms to facilitate airborne electro-magnetic (AEM) survey interpretation in catchment scale salinity hazard assessments.
- Recognition of the considerable extent of both coastal and inland acid sulfate soils (ASS), and the development of remediation strategies.

There are numerous cases where States and Territory Governments, NRM Agencies and commercial clients in both mineral exploration and NRM are actively adopting LEME technologies.

Objective 3 in Schedule 1 - Provide high quality, geoscience-based education for those entering the minerals industry, landcare and environmental realms and to provide continuing education for those already involved.

There is absolutely no doubt that CRC LEME has succeeded in providing high quality regolith geoscience based education as outlined in this objective.

Objective 4 in Schedule 1 - Inform and guide decision-makers in the Federal and State policy arenas about the relevance and contribution to Australia's future of the Centre's research.

See response to Objective 2 (above)

4. Science Quality

The Panel has been favourably impressed by numerous aspects of the science program of the CRC. In summary:

- The applications of biology at all scales to the improved understanding of fundamental regolith processes and to important applications in mineral exploration.
- Using the detailed understanding of ASS gained within CRC LEME, researchers have discovered and described previously unexpected, regional-scale occurrences of ASS. This includes important work in acid and saline groundwater discharges as well as applications to management of saline lakes in the Murray Darling Basin.
- The progressive increase in reliable regolith dating is leading to a fundamentally new perception of the antiquity and development of the Australian regolith.
- There is evidence of much increased interdisciplinary collaboration between researchers and the inclusion of specialist services from outside the CRC, all of which are leading to new insights.
- There is also evidence of strong interactions between staff from Core Parties and this is also leading to new synergies and insights.

Some examples of high quality science within LEME are:

- Biogeochemical applications in mineral exploration (leaf litters, river red gum leaves and Spinifex leaves as geochemical sampling media)
- Biozoological applications (sampling of termitaria)
- Microbiological applications for gold exploration
- Definition of the sedimentological history of the Eucla Basin Margins
- Refinement of groundwater geochemical methods
- Speciation of metals in low temperature surficial environments
- Recognition of the world-wide scale of ASS problems, including acid groundwater drainage
- Advances in regolith dating
- Development of improved and targeted inversion algorithms for AEM
- The use of time domain EM for in-situ salinity measurement in rivers (NANOTEM)
- Wetland rehabilitation management
- Landscape-scale salt mapping for NRM including upland salt store evaluation

Notwithstanding the high quality of much of the research, the Panel noted some deficiencies. For example:

- The overall publication record in international refereed scientific literature is poor. CRC staff must be encouraged, wherever possible, to publish their work in high profile journals.

- The panel notes an apparent lack of inter-program integration and synthesis. This may reflect the natural evolution of a seven year CRC, and we anticipate this will be improved upon during the last two years of the CRC.
- The Panel notes a serious lack of collaboration between Programs 1 to 3 with Program 4.
- A paucity of geophysics in Programs 1 to 3

Overall the panel noted a tendency to emphasise tactical work to the detriment of strategic and fundamental science. For example, the problem of mapping the depth component of the regolith remains largely unresolved. This may in part reflect poorly defined strategic objectives in the early stages of the CRC, but its continued presence is detrimental to the overall achievement of objectives.

5. Adoption and implementation of outcomes and technology transfer

There have been a significant number of excellent examples where LEME work has been adopted in both the mineral exploration and NRM industries. LEME can point with pride to numerous documented examples of significant uptake and financial outcomes.

The Panel urges LEME management to make even more of its successes, particularly during the closing phases of the CRC. The Panel notes that there are a number of emerging scientific results which also have the potential to have major impacts on the industries involved. In particular it applauds the efforts and achievements of Program 4 in impacting significantly on NRM throughout Australia, and the Panel encourages those involved to internationalise their achievements.

The adoption of Open File Reports and web based items has facilitated the dissemination of this information to potential end users. However, the Panel notes that this may have been done to the detriment of scientific reporting. Within the CRC there are examples of innovative information delivery such as the web based delivery model in Program 3. CRC management needs to pay careful attention to the commercial potential of this and similar developments and to protect its workers' Intellectual Property.

The Panel suggests that LEME management review the protection and commercial potential of all aspects of the CRC's research, particularly the commercial potential of work in Program 4.

5. Education and Training

The Panel is delighted to note that the CRC's achievements in Education and Training are outstanding in terms of the number and quality of its students and uptake of those students into industry. The number of Honours and

Postgraduate students is on course to exceed significantly the CRC's Key Performance Indicators.

For example, the work by LEME PhD scholar Frank Reith on biofilms on bacterioform gold has achieved world wide scientific and media acclaim. The paper, originally published in Science, was immediately picked up by other major journals (eg Nature) and world-wide media including the New York Times.

In the current environment of active industry demand, there is a risk that not all students will complete their studies. CRC management is encouraged to take whatever steps it considers appropriate to minimise this risk.

CRC LEME is responsible for the only courses in regolith science in Australian universities (CUT, ANU and AU) and conducts widely accepted courses for the minerals and NRM industries through the MCA Minerals Tertiary Education Council. It would be disappointing if the connection between this program and CRC LEME were to be discontinued.

6. Competitive advantage

It would appear that in the area of regolith science CRC LEME has no competitors and therefore occupies a unique niche with particular relevance to the special needs of the Australian mining and NRM industries. Australia is not the only country in which exploration under deeply weathered cover is an important problem and the work done by CRC LEME therefore provides its collaborators with a global advantage.

In pushing into areas applying biology to more traditional geochemical exploration techniques, the CRC has begun to develop an important Australian niche. The CRC has assured the adoption of these techniques by the Australian exploration industry by being the first to apply them systematically in the Australian landscape.

The CRC's work on catchment scale problems in salinity and acid drainage is invaluable and unique. The CRC's work in NRM potentially has enormous international applications.

7. The future

The Panel acknowledges the decision taken by the Board in 2004, with regard to non-continuance of the CRC, but respectfully suggests that the achievements now demonstrated represent a significant change in circumstances. Achievements demonstrated and in the pipeline constitute a case for reconsideration of that decision.

The CRC LEME Minerals Advisory Council reached a similar conclusion at its meeting of 12 May 2006 and its report has been forwarded to the Board.

That report recommended the CRC LEME Board: “**consider the fact that there will be no CRC focussing on mineral exploration after June 2008 and in that light should **strongly encourage** evaluation of all available options for establishment of a new CRC (or similar structure) focussing on research into techniques of mineral exploration, particularly in areas under cover.**”

The Panel draws attention to the fact that we are nowhere near to having definitive answers to exploring through cover, nor are we close to having final solutions to salinity management. CRC LEME has a brilliant, inter-disciplinary team in place. Once disbanded, all the impetus provided by this team is lost.

In any future incarnation, LEME will fill an invaluable and unique role in focussing on strategic pre-competitive regolith research.

RECOMMENDATIONS

1. That LEME management take steps to ensure the highest possible exposure of LEME science in high quality, peer reviewed journals.
2. That LEME management ensure that throughout the delivery process there is a focus on integration and synthesis within and between Programs.
3. Within the constraints of 2. (above) LEME management arrives at focussed strategies in relation to Program priorities.
4. LEME management undertakes regular reviews of commercialisation opportunities and ensures adequate IP protection.
5. Throughout the delivery process LEME management must ensure that achievements are accorded maximum exposure to all relevant audiences.
6. LEME management are strongly urged to investigate all possible options for the continuance of interdisciplinary research into regolith science. Having determined potential niches for such continuance, it will be essential to define clearly the strategic interests of any future entities.

Professor Graham Harris (Chairman) _____

Professor Gerry Govett _____

Dr Nigel Radford _____

Date _____

Appendix 1 - Support documentation

AGENDA AND PERSONNEL

KEY POINTS TO BE ADDRESSED BY REVIEW PANEL

REPORTING CRITERIA

- Schedule 1 Commonwealth Agreement
- Schedule 6 Commonwealth Agreement
- Second Year Stage 1 and Stage 2 Reports, and Board Response

SCIENCE QUALITY ASSESSMENT

1 July 2001 to 30 April 2006 - Life of LEME -

- Examples of Major Non Paper, Non-Patent Scientific Outputs
- Examples of Demonstrable Adoption and Uptake of LEME Science

Performance Measures - Life of LEME

- Objectives of the Centre
- Quality and Relevance of the Research Program
- Strategy for Utilization and Knowledge Transfer of Research Outputs
- Education and Training
 - Students
 - MCA course participants
- Collaborative Arrangements
- Resources and Budget

CRC LEME Annual Report 2001-2002

CRC LEME Annual Report 2002-2003

CRC LEME Annual Report 2003-2004

CRC LEME Annual Report 2004-2005

Statistical Updates 1 July 2005 to 30 April 2006

- Publications
- Collaboration
- High Profile Visitors
- Awards and Appointments
- Communication
- Education and Training
 - Student Breakdown - current and completed
 - Undergraduate Student Courses and Shortcourses

Finances and Research Project Portfolio (covering note from CEO)

- LEME Operating budget 06-07 - Cash (CRC and Core Party funding)
- LEME Operating budget 06-07 - Cash contributions and external funding
- Cash Flow Forecast 06-08

Legacy Products 06-08

Project Summaries P1 to P5 for 2006-2007

LEME Advisory Council Reports

Land Use Advisory Council - Meeting 10 May 2006

Minerals Advisory Council - Meeting 12 May 2006

Appendix 2 - LEME Participants

Mr George Savell - Board Chair

Dr Steve Rogers - CEO

PROGRAM 1:

- Ms Lisa Worrall - Program Leader, Minerals Division, Geoscience Australia, Canberra
- Dr Steve Hill - Senior Lecturer, Adelaide University (and E&T Program Leader)
- Professor Brad Pillans - Project Leader, Senior Research Fellow, The Australian National University, Canberra

PROGRAM 2:

- Dr Ravi Anand - Program Leader, CSIRO Exploration and Mining, Perth
- Dr Matthias Cornelius - Project Leader - Senior Research Scientist, CSIRO Exploration and Mining, Perth
- Dr Bear McPhail - Project Leader - Reader, Australian National University, Canberra.

PROGRAM 3:

- Dr Paul Shand - Program Leader - Landscape Geochemist, CSIRO Land and Water, Adelaide
- Dr Rob Fitzpatrick - Project Leader - Pedologist/Senior Scientist, CSIRO Land and Water, Adelaide
- Dr Steve Rogers - former Program Leader - Principal Research Scientist, seconded to CSIRO EM , Perth from CSIRO L&W

PROGRAM 4:

- Dr Ken Lawrie (per telephone) - Program Leader, Geoscience Australia, Canberra
- Dr Tim Munday - Project Leader - Senior Research Scientist, CSIRO Exploration and Mining, Perth
- Dr Jon Clarke - Research Scientist, Geoscience Australia, Canberra

PROGRAM 5 - EDUCATION AND TRAINING

- Dr Steve Hill - Program Leader - Senior Lecturer, Adelaide University
- Ms Karen Hulme - PhD UA - Thesis: *Biogeochemistry of river red gums (Eucalyptus camaldulensis) in the Curnamona Province and adjacent parts of SA and NSW* (Karen is currently writing up)
- Dr Frank Reith - PhD ANU / CSIRO Exploration and Mining Postdoctoral Fellow - **PhD Awarded** *Interactions of microbes and gold in regolith in moderate, arid and tropical climates*
- Mr Ryan Noble - PhD CUT / CSIRO Exploration and Mining Soil Chemist and Hydrogeochemist. **Thesis submitted:** *Dispersal mechanisms of arsenic and antimony in regolith and surface deposits in the vicinity of buried gold ore bodies, northwest Victoria: implications for gold prospectivity and environmental management*
- Mr Nathan Reid - PhD, AU - Commenced 2005 - Thesis: *Biogeochemistry of regolith associated with Au deposits in the Tanami, WA and NT*