

ONTON

Our vision is of an environmentally healthy, wealthy Australia where regolith geoscience plays a fundamental role in mineral discovery and land management.

Our mission is to create breakthroughs in mineral exploration and environmental management through generating and applying new knowledge of the regolith. In doing so we will develop LEME and its core participants into global leaders in regolith research and its application to mineral exploration and natural resources management.

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GLOSSARY AND ACRONYMS

The objectives of CRC LEME are to:

- Provide the mineral industry with world-leading capabilities leading to breakthroughs in exploration in Australia's extensive areas of cover.
- Provide essential multi-disciplinary
 knowledge of Australia's regolith
 environments, to deliver this
 knowledge in readily useable forms,
 and ensure that it is transferred into
 practice in the minerals industry
 and environmental management.
- Provide high quality, geosciencebased education for those entering the minerals industry, land-care and environmental realms and to provide continuing education for those already involved.
- Inform and guide decision-makers in the Federal and State policy areas about the relevance and contribution to Australia's future of the Centre's research.

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Regolith is the surface blanket of material including weathered rock, sediments, soils and biota that forms by the natural processes of weathering, erosion, transportation and deposition. It has complex architecture, and may vary in thickness from a few centimetres to hundreds of metres. It hosts or hides valuable mineral deposits, we live on it, we grow our food in it, it is the foundation of many major engineering works, and much of our water supplies are stored in it. It underpins our economic, social and infrastructure systems.

The Cooperative Research Centre for Landscape Environments and Mineral Exploration (LEME) is an unincorporated joint venture that brings together groups from the

- The Australian National University
- CSIRO Exploration and Mining and CSIRO Land and Water
- Curtin University of Technology
- Geoscience Australia
- Minerals Council of AustraliaNew South Wales Department of
- Primary Industries
- Primary Industries and Resources South Australia
- The University of Adelaide



















The Centre has been well served by its professional staff and Program Leaders who, collectively, are delivering excellent results. The Centre continues to function in a timely and professional manner.

Mr George Savell



I am delighted to report that this year has seen many of LEME's research initiatives come to fruition. The Centre's research Programs have continued to deliver solid results to our collaborators and end users.

During the year LEME undertook the necessary preparations to ensure the CRC has an enduring Regolith Science legacy before the conclusion of official operations on 30 June 2008.

The full import of the CRC's pending termination became very evident in a number of significant events.

- The official "Wind-up Plan" required by the Commonwealth Government was prepared and signed off by the Managing Board on 28 June 2007.
- PhD programs entered their final stage.
- The Mineral Advisory Council and Land Use Advisory Council held their final meetings in the first half of 2007.
- No new work programs were contemplated or accepted and the corporate focus changed from new research to completion of projects already in progress.
- The "writing-up" of work done achieved heavy emphasis.

Notwithstanding this inevitable time in the Centre's affairs, staff and Executive morale is high and still focussed on outcomes.

All of these events have, however, slowly reoriented the CRC and are, indeed, melancholy factors in its ongoing existence. The effect of the events has affected operations in less obvious ways in that Core Party administrative responses have been less urgent and ultimately reaction times to major issues are much slower than in the past. Apparently this is a syndrome affecting all CRC's coming to a termination date. Board representatives, however, continue to function effectively and efficiently.

Leaving aside these matters, the central concern, which I have expressed "ad nauseum" during my term of office, is the need to ensure that Regolith Science does not fade into the background due to CRC LEME's demise.

During the year the Board authorised a subcommittee headed by CEO Steve Rogers to investigate a way forward for the continuing development of Regolith Science. The CEO was diligent in his approach and reported to the Board on a number of viable options the outstanding one of which was an offer by the Department of Primary Industry and Resources, South Australia (PIRSA) to develop an "Exploration Under Cover" Centre which would continue emphasis and focus on Regolith Sciences. The Chief Geologists' Government Committee (representatives of all States and Federal Government) supported this approach. In addition, some other CRCs are keen to use CRC LEME's work and personnel in an ongoing way.

These developments have improved the chances of Regolith Science continuing to be pursued to the benefit of mineral exploration, natural resource agencies and the farming sector generally. One thing has not changed, however, and that is the need for industry, Government Departments, Agencies and learning institutions to put money and effort into ensuring the success of

PIRSA's offer and thus ensure the flow of Regolith knowledge.

The Centre's Education and Training Program suffered a negative effect as a result of the "mining boom". On the one hand the mining industry talks about the need for higher training in the form of PhDs and other Post Graduates but, when need arises, "poaches" these very same people with offers of huge salaries to fill their immediate work force, a move which can effectively ruin a student's future and often wastes considerable sums of money spent on his or her earlier educational development.

A huge potential wastage of money and talent can result from these actions, which have seriously affected the CRC's potential PhD output at 30 June 2008.

During the past year the Board's two Advisory Councils made major contributions to the Centre's operations. It was, in my humble view, the best example of Advisory Committee input we have experienced. Great praise and thanks is tendered to all those worthy people who comprise those Councils. The Board acknowledges the work, effort and advice provided by Dr David Garnett and Dr Richard George who chaired the respective Councils.

In the past year the appointment of a Communications Officer has paid big dividends. It was a long overdue initiative and has greatly improved CRC LEME's profile in industry and general awareness of the importance of Regolith Science in the community.

The Centre has been well served by its professional staff and Program Leaders who,

collectively, are delivering excellent results. The Centre continues to function in a timely and professional manner.

It is appropriate, at this point in the Centre's existence, to make certain observations about the system under which we operate. It is a system with many advantages, so this is not a criticism *per se*.

The policy/principle under which research is carried out needs some attention. While the Commonwealth's emphasis on pure commercialism has been somewhat lessened, there are many worthy research areas which fall into the area of public good where progress could have profound results. What is needed is for the Government to divide research funds provided in the Federal Budget: one portion for commercial work and one portion for public good issues. Until this is done, many public good CRCs will never be contemplated or get off the ground. Australia is already suffering and will continue to suffer immeasurable loss as a result.

Finally, I would like to thank my fellow Board Members for their unstinting efforts on the Centre's behalf.

The Centre is functioning well and will continue to do so until its job is done.

George Savell

Independent Chairman



Chief Executive Officer's Report



Dr Steve Rogers

In its penultimate year of operation, the clear benefits and impact of the Centre's research are becoming evident as research Programs mature and outputs are delivered to endusers, in both the mineral exploration (MINEX) and natural resource management (NRM) sectors.

The delivery of two outstanding precompetitive geoscience products has had a significant impact on exploration activity in WA and SA.

Following the release of the *Laterite Geochemical Atlas and Database for the Western Yilgarn Craton*, a collaboration between LEME, CSIRO, Geological Survey of WA and the Minerals and Energy Research Institute of WA, a significant increase in exploration license applications (ELAs) in areas covered by the Atlas was recorded. More than 100 ELAs were lodged in the month following the release, compared to 40 in the previous month.

Release of the LEME/PIRSA Palaeodrainage and Tertiary Coastal Barriers Map of South Australia has led to a significant increase in ELAs over palaeodrainage systems in South Australia. Since May 2007, 78 ELAs have been lodged on ground over palaeochannels identified by the map. In July 2007, Diatreme Resources Ltd publicly acknowledged in a MiningNews.net article that its recent Gawler Craton tenement applications were the direct result of a review initiated by the palaeodrainage map.

Both these products were released into the public domain at minimal charge to the enduser. They demonstrate that economic activity does result from the rapid, appropriate release of public-sector funded, pre-competitive geoscience information into the public arena.



It is also pleasing to note that the LEME/NSW DPI Thomson Orogen project is stimulating industry interest in this 'Green Fields' province, with ELAs in the region increasing from three, prior to project commencing, to 32 at the end of the reporting period.

Development of phyto-exploration as an effective exploration-through-cover tool continues to deliver encouraging results. The quality and relevance of this work was reflected in a June 2007 feature article in New Scientist magazine, highlighting the Tanami project phyto-exploration and termitaria research of two of our LEME/UA PhD students - Anna Petts and Nathan Reid. The uptake of uranium and thorium and concentration of these elements in leaves of a variety of native Australian plant species has also been demonstrated by LEME researchers, indicating that phytoexploration is a potentially viable method for uranium exploration.

The Centre continues to deliver on a suite of NRM co-investment projects with State and Federal agencies. Highlights of our Salinity Mapping and Hazard Assessment Program in the past year include: successful delivery of a range of airborne geophysics-based products underpinning groundwater and salinity management in several projects along the River Murray Corridor in South Australia and Victoria, development of a new generation of Groundwater Flow System (GFS) products in collaboration with Dept Primary Industries Victoria (DPI Vic), Murray Darling Basin Commission (MDBC) and Catchment Management Authorities (CMAs) in NSW and Victoria, and new 3D models of aquifer systems in the Ord and Burdekin Catchments for the Irrigation sector. The production of the first national salt accession maps, that allow the sources of salt in the Australian

The delivery of two outstanding precompetitive geoscience products has had a significant impact on exploration activity in WA and SA.



landscape to be identified has been a major achievement.

An announcement made by GA in mid 2006 to adopt the Centre's regional geochemical survey methodology, arising out of the LEME *Low Density Geochemical Survey Project*, to undertake a National Geochemistry Survey of Australia (NGSA), is an outstanding endorsement of Patrice de Caritat's team, who developed this technique. The Survey will be funded under the Australian Government's new *Onshore Energy Security* Program, and involve GA and State geoscience agencies.

Our Education and Training Program has again been outstanding in its achievements. LEME has now graduated 100 Honours students (against a KPI of 60); the majority of whom are being 'snapped up' by the MINEX industry or government geoscience agencies. The E&T Program Leader Steve Hill stood down in early 2007, having gained a lectureship in Regolith Geoscience at UA, the first dedicated regolith lectureship in Australia. Steve was replaced by the equally capable Ian Roach from ANU.

A summary of the Centre's resource allocation during 2006-07 shows \$2.64 million on salaries, \$0.183 million on student scholarships via the E&T Program, and \$2.74 million on research operating. External income tied to projects was \$2.24 million. Although the CRC is in its winddown period, external income in 2006-07 increased by \$0.74 million compared to 2005-06, demonstrating expanding demand from end-users for CRC's regolith geoscience expertise. Our forward cash flow forecast shows research activities and salaries can be resourced to ensure research objectives are met up to the cessation of LEME in June 2008. The development of a Centre Wind-Up plan to ensure resources are in place to achieve stated objectives, is a Commonwealth requirement for CRCs approaching cessation. The LEME Plan was endorsed by the Board and submitted to DEST in June 2007.

Dissemination of research outputs is the number one priority for LEME in its winddown period. In order to increase knowledge transfer and accessibility to a wider audience, it was decided in early 2007 to make all LEME publications digitally available as .PDF files, free of charge, from our web site: http://www.crcleme.org.au. CSIRO will maintain the LEME web-site for five years after cessation of operations in 2008. The remaining Head Office hard copy stock of Open File Reports (OFRs), thematic volumes and other publications will be sent out to Core Participant libraries, LEME students and interested end-users free of charge before the conclusion of Centre operations.

The CRC has entered into a collaborative agreement with AMIRA to transfer all relevant LEME technical reports and mineral prospect data into the AMIRA online database, *Data Metallogenica*, an international geoscience and prospect information repository. This, along with the CRC web site, will ensure the long term legacy of LEME scientific outputs.

LEME staff and students won numerous awards and prizes this year – congratulations to all. Andrew Fitzpatrick received an outstanding award for his paper "*Mapping Salt-loads of the Murray River, Australia, using airborne and in-river electromagnetic methods*" at the Symposium on the Application of Geophysics to Engineering and Environmental Problems, held April 07 in Denver, Colorado. Andrew has been invited to present the same paper at the Near Surface 2007, 13th European Meeting of Environmental and Engineering Geophysics Conference, in September 2007.

In addition to the South Australian proposals for an *Exploration Under Cover Centre of Excellence*, mentioned in the Chairman's Report, I am very pleased to note that, following discussions at the AMIRA Exploration Managers Conference in March 2007, AMIRA has initiated a consultative process to seek support from industry to prepare a bid for submission in the 2008 round for a new *CRC for Deep Exploration Technologies*. This would encompass the regolith geoscience knowledge and expertise of LEME, into a much broader exploration under cover R&D and innovation focus.

The excellent outputs we deliver as a CRC, and the clear impact our work has had on end-users, is only possible through the hard work, commitment and collaboration of the people involved. Therefore, thank you to the researchers, administrators, students. Program Leaders, members of the Executive, the Centre's Advisory Councils and the Board of Management. I also wish to acknowledge the excellent working relationships LEME has with our external industry and government agency collaborators. Thanks to everyone for working together in a professional and co-operative manner, to ensure we continue to deliver quality regolith geoscience that makes a difference to the business of our clients and end-users.

Steve Rogers

Chief Executive Officer

Professional Memberships, Awards and Invitations

Name	International and National Committee Membership	Core Party	Date 2002 onwards	
Colin Pain	Member – National Committee on Soils and Terrain	GA		
Ken Lawrie	Chair, Geological Society of Australia's Environment, Engineering and Hydrogeology Specialist Group	GA 2005 onwards		
Ken Lawrie	Member of International management Committee of IUGS Working group on Communicating Environmental Geoscience	GA	2005 onwards	
Ken Lawrie	Member Steering and Technical Organising Committees – International Salinity Forum 08	GA 2006-08		
Charles Butt	Liaison Committee – Regional Geoscience Mapping and Mineral Resources, Geological Survey of Western Australia	CSIRO 1996 onwards		
Charles Butt	Deputy Chairman – Minerals Research Advisory Committee, Minerals and Energy Research Institute, Western Australia	CSIRO 1997 on (Deputy Chair from 2006 on)		
Brad Pillans	President – Stratigraphy and Chronology Commission, International Union for Quaternary Research (INQUA)	ANU 2003 onwards		
Brad Pillans	Member of Sub-commission of Quaternary Research, International Commission on Stratigraphy	ANU 2004 onwards		
Charles Butt	Board Member, Executive Member and Secretary – Earth Sciences WA	CSIRO 2005 onwards		
Rob Fitzpatrick	President: – Royal Society of South Australia	CSIRO) Oct 04- Oct 06	
Rob Fitzpatrick	Working Group Member – International Geohazards	CSIRO	.O 2005-07	
Rob Fitzpatrick	Soil Mineralogy Commission Member – International Union of Soil Sciences (IUSS)	CSIRO	2003-06	
Colin Pain	Australian Representative – International Association of Geomorphology Working Group on Applied Geomorphic Mapping	GA	2006 onwards	
Richard Cresswell	Member – National Coordinating Committee for Salinity	CSIRO	2006 onwards	
Paul Shand	Member – UNESCO IHP Committee on Climate Variability and Impact on Low and High Flows	CSIRO	2006 onwards	
Graham Heinson	Chair of Earth imaging sub-committee – Auscope NCRIS Facility 5.13 Structure and Evolution of the Australian Continent	UA	2006 onwards	
Graham Heinson	Steering Group Committee Member – Australian National Earth Sounding Facility (ANSIR)	UA	2006-07	
Charles Butt	Convenor, Awards Sub-Committee, Geological Society of Australia (WA Branch)	CSIRO 2006 onwards		
Rob Fitzpatrick	Wellington Weir Environmental Impact Assessment Knowledge Group Member	CSIRO Jun 07		
Kathryn Fitzsimmons	Australasian Quaternary Association Executive Committee Member	ANU 2007 onwards		
John Keeling	President Australian Clay Minerals Society	PIRSA	Dec 06	

These tables illustrate the high regard in which LEME researchers and students are held.



Ravi Anand receiving the Butt Smith Medal. L-R Steve Rogers, Ravi Anand, Graham Carr.

Butt Smith Medal

The biennial CSIRO EM and LEME Butt Smith Medal and monetary grant for *outstanding and sustained contributions linking regolith science to exploration in Australia,* was awarded to CSIRO Principal Research Scientist and CRC LEME Program Leader, Ravi Anand, in acknlowedgement of his long-term dedication and excellence in the development of geochemical mineral exploration techniques for Australia 's deeply weathered landscapes. The announcement was made at the LEME Regolith Symposium, November 2006.

The Butt Smith Medal recognises and honours the significant contribution of Charles Butt and Ray Smith to research and development related to the mineral industry in Australia through their lifelong association with CSIRO and CRC LEME.

Name	Core Party	Award, Appointment or Promotion	From	Date	
Rob Fitzpatrick	CSIRO	Centre for Australian Forensic Soil Science (CAFSS) Director	CAFASS Board	2005-06	
Brad Pillans	ANU	Pullar Award for the most meritorious contribution to tephrochronological research in the New Zealand region	Geological Society of New Zealand	2006	
Charles Butt	CSIRO	Chief Scientist, CSIRO Exploration and Mining, Member of the Divisional Executive	CSIRO Exploration and Mining	2006 onwards	
Ravi Anand	CSIRO	2006 Butt Smith Medal and grant	LEME/CSIRO	Aug 06	
Rob Fitzpatrick	CSIRO	Stream Leader	CSIRO Land & Water	Aug 06 onward	
Rob Fitzpatrick	CSIRO	Best poster at the Salinity/Acid and Communication Symposium	Australia Society for Soil Science	Dec 06	
Kathryn Fitzsimmons	ANU	Executive Committee Member, Australasian Quaternary Association	AQA	2007 onwards	
Keith Scott	CSIRO	Honorary Fellow	CSIRO Exploration & Mining	Jan-Dec 07	
Keith Scott	ANU	Visiting Fellow	ANU	Mar 07 to Feb 08	
Andrew Fitzpatrick	CSIRO	Voted one of the best of four papers presented at the 2007 Symposium on the Application of Geophysics to Engineering and Environmental Problems	SAGEEP	Apr 07	
Patrick De Deckker	ANU	Awarded a Member of the Order of Australia (AM) . For service to science through research and teaching in the areas of palaeoclimate studies, salination and climate changes, and through the initiation and support of international scientific collaboration.	Australian Government	Jun 07	
Dirk Kirste	ANU	Assistant Professor, Simon Frazer University, Canada	Simon Frazer University	2006 onwards	
Name Core Party Editorships and Invited papers		Editorships and Invited papers	Publisher	Date	
Brad Pillans	ANU	Editorial Board – Quaternary Science Reviews	Elsevier	1996 onwards	
Graham Heinson	UA	Sub editor – Pure and Applied Geophysics	Springer	2002 onwards	
Charles Butt	CSIRO	Co-editor – Proceedings of the 22nd International Geo- chemical Exploration Symposium, published in two special issues of <i>Geochemistry: Exploration, Environment, Analysis</i>	The Geological Society	2005-07	
Brad Pillans	ANU	Associate Editor – Encyclopaedia of Quaternary Science, 4 volumes 3365 pages	Elsevier	2004-06	
Keith Scott and Colin Pain	CSIRO/ ANU/GA	Editors – CRC LEME Regolith Geoscience Reference Textbook	CRC LEME	2006 onwards	
Patrice de Caritat	GA	Editorial Board – Geochemistry: Exploration, Environment Analysis	Geological Society of London and Association of Applied Geochemists	2005 onwards	
Brad Pillans	ANU	Invited contributor/paper – Special issue of Journal of Quaternary Science	Wiley	2007	
Charles Butt	CSIRO	Associate Editor – Geochemistry, Exploration, Environment, Analysis	GEEA	2007	
Kathryn Fitzsimmons	ANU	Editor – Quaternary Australasia	Australasian Quaternary Association	2007 onwards	
Colin Pain	GA	Guest Editor, International Journal of Remote Sensing	Taylor & Francis	2007 onwards	
Paul Wilkes	CUT	Co-Editor: Irrigation Insights Number 7: Geophysics for the Irrigation Industry	Land and Water Australia	May 07	

LEME HONORARY FELLOWS

The LEME Board pays tribute to Honorary Fellows of LEME in recognition of outstanding contributions to the development and promotion of Regolith Science. The Awards are in the form of embossed and engraved plaques. Seven Awards have been presented thus far. The inaugural Awards were presented to Emeritus Professor RA (Tony) Eggleton, Dr Ross Fardon and Professor Graham Taylor in 2003. Two more Awards were made in September 2005 to Emeritus Professor Gerry Govett and Dr Raymond Smith. On 6 September 2006, it was the turn of Dr R Dennis Gee and Dr David Garnett to receive the recognition and appreciation of their colleagues and George Savell was pleased to make the presentations at the Annual Board Dinner.



Dennis Gee and David Garnett

A major development during the year was the announcement in May 2007 of the Minerals Down Under Flagship by the Minister for Education, Science and Training, the Honourable Julie Bishop. The Flagship will be developed by CSIRO in collaboration with industry, government geoscience agencies and R&D providers to assist the Australian minerals industry in the discovery and exploitation of new mineral resources.



Context and Major Developments During the Year

To deliver on its objectives, LEME operates within two industry sectors – mineral exploration (MINEX) and natural resource management (NRM).

MINEX industry context

Program 1 and 2 apply regolith geoscience to the challenges facing the Australian MINEX industry. There are many large multinational corporations operating in Australia, but 'grass roots' exploration in Australian is predominantly undertaken by junior or medium sized companies. This is a large and diverse end-user market that presents unique challenges to technology transfer.

According to the Australian Bureau of Statistics, exploration expenditure increased by 28.9% in 2006, a 37% increase compared to the same period in 2005. The Bureau anticipates that MINEX activity in Australia and internationally will strengthen further during 2007 as a consequence of current metal and mineral prices – most of which are at 25-year highs.

An example of end-user adoption of LEME's R&D, is in the development of 'Low Density' geochemical sampling techniques, with the announcement of the Australian Government's Onshore Energy Security Program in August 2006. One of the Program's initiatives, as part of a broader package of energy exploration strategies, is the NGSA, which will use regolith sampling methodologies developed by LEME and GA.

A major development during the year was the announcement in May 2007 of the Minerals Down Under Flagship by the Minister for Education, Science and Training, the Honourable Julie Bishop. The Flagship will be developed by CSIRO in collaboration with industry, government geoscience agencies and R&D providers to assist the Australian minerals industry in the discovery and exploitation of new mineral resources.

Australian NRM context

Program 3 and 4 apply regolith geoscience to environmental issues facing Australia such as salinity risk assessment, and protection of ground and surface water resources from acidification and salinisation and acid sulfate soil (ASS) formation.

The NRM sector comprises a large group of end-users and decision makers such as State and Commonwealth Government agencies, Local Government, CMAs and Landcare Groups. This diverse and complex stakeholder group requires a multi-layered, targeted approach to the delivery of research outputs to ensure adoption.

Procurement and sustainable use of water resources remains high on the political and public agenda in Australia. Drought during 2006-07 in many parts of the country is directing policy and research effort towards strategies to ensure the future supply and quality of scarce water resources. In January 2007, the Australian Government announced it would invest \$10 billion as part of a National Plan for Water Security to ensure rural water use becomes sustainable in the coming decade. Under the Plan, \$585 million will be allocated to reform the governance arrangements of the Murray-Darling Basin Commission. Program 4 activities, in particular, address these issues.

Above: Sampling acid sulfate soils in a salt lake near Tunbridge, Tasmania: part of a national study to map and characterise inland ASS. Left: Drill Rig at Kanowna, WA. Photographer: Ian Robertson



For the last six years, LEME's Program 4 researchers have been developing and applying geophysical methods to map saline environments and define areas at risk of salinity.

> Exposed bed of the Murray River, near Toolybuc.



National Research Priorities

The Centre research outputs address two of the Australian Government's broader 'wholeof-government' National Research Priorities:

- An Environmentally Sustainable Australia.
- Frontier Technologies for Building and Transforming Australian Industries.

An Environmentally Sustainable Australia

Water - a critical resource

LEME's Program 3 and 4 research activities are directed towards water management issues currently facing Australia. The Centre is improving the understanding of groundwater salinity processes in river catchments, such as the Murray-Darling Basin, by employing geophysical technologies to map saline groundwater and groundwater flow systems. The Centre generates and rapidly disseminates scientific understanding of complex regolith systems. This assists decision-makers to assess and implement new management options to reduce salinity and acidity spread, and improve water quality and availability.

Transforming existing industries

The CRC's Commonwealth Agreement identifies a core deliverable:

"To develop breakthroughs in mineral exploration of covered areas which will attract exploration investment in Australia and increase discovery of ore deposits, the development of which will ultimately lead to creation of national wealth."

Centre research outputs have enabled the MINEX industry to operate more effectively in regolith-dominated landscapes through an improved understanding of regolith biological, chemical and physical processes controlling mineral transport and transformation and regolith interactions with underlying bedrock.

The Centre has developed innovative techniques in the areas of phyto-exploration, spectral analysis, regional geochemical sampling and hydrogeochemistry. Phytoexploration (the sampling of plant materials to detect geochemical anomalies) is showing great promise with the identification of Australian native flora that express buried mineralisation in their leaves and other above-ground tissues.

LEME's methodology in conducting regional geochemical surveys will be used as part of the NGSA. The survey is part of the Australian Government's Onshore Energy Security Program announced August 2006 to acquire pre-competitive geoscience information on Australia's onshore energy prospects.

Overcoming soil loss, salinity and acidity

The Centre's research addressing the goal of Overcoming Soil Loss, Salinity and Acidity was highlighted in the Australian Government's Backing Australia's Ability 2005-06 Innovation Report.

It stated that: "Geoscience Australia worked in partnership with State and Territory Governments survey organisations and the CRC for Landscape Environments and Mineral Exploration to produce a range of geoscience information and approaches that are enhancing understanding of the Earth's layers of weathered and transported material (regolith)."

The report also highlighted the Centre's research with Core Participant, CSIRO LW,



drains used to treat dryland salinity in the Western Australian Wheatbelt. The research has identified the extent of acidic ground waters in salinity mitigation drains, and assessed the risk of elevated levels of heavy metals in acid waters which have the potential to cause negative off-site environmental impacts.

assessing the effectiveness of deep, open

For the last six years, LEME's Program 4 researchers have been developing and applying geophysical methods to map saline environments and define areas at risk of salinity.

Developing deep earth resources

LEME's Program 2 Objective Logging Project has developed a practical automatic interpretation tool for the automated logging and categorisation of regolith materials collected as drill chips, or pulps.

Responding to climate change and variability

Program 4 research is generating background science on groundwater flow models for Australian catchments that will assist in the assessment of the extent, quality and sustainability of groundwater resources.

NATIONAL RESEARCH PRIORITIES

Electron mircograph of Gold crystals.

Synchrotron XRF element maps of an iron oxide nodule. Moolart Well. WA.



Frontier Technologies for Building and Transforming Australian Industries

Frontier technologies

LEME has undertaken research through the Australian Synchrotron Research Program, via Rob Hough's (CSIRO EM) work to accurately determine trace element distribution in regolith materials and vegetation, through high energy X-ray analysis, using the CSIRO-developed GEOpixe software. The use of this method allows researchers to determine where metals actually sit in very complex samples at high resolution.

Through access to the Chicago Synchrotron, the Centre has used microtomography technology to examine regolith and plant materials at very high resolution in three dimensions in a similar way to a CT scan image. LEME acknowledges the support of the Australian Synchrotron Research Program.

LEME has produced signal processing algorithms to improve the quality of seismic data generated in areas of high interference. This has applications to the petroleum and NRM industries with BHP Billiton expressing an interest in applying some of the algorithms to their Geoferret array TEM system. LEME/PhD students from CUT, led by Jayson Meyers, have pioneered the use of seismic reflection surveys over the Beverley Uranium Mine. Survey results show seismic techniques have the potential to become exploration tools in the region through their ability to locate palaeochannel systems.





Governance and Management

Core Participants

LEME operates as an unincorporated joint venture between its eight Core Participants. They are signatories to the Commonwealth Agreement and Centre Agreements. Under those Agreements, CSIRO Exploration and Mining is the Centre Agent and assumes administrative responsibility. The Core Participants are:

- The Australian National University
- CSIRO Exploration and Mining, and CSIRO Land and Water
- Curtin University of Technology
- Geoscience Australia
- Minerals Council of Australia
- New South Wales Department of **Primary Industries**
- Primary Industries and Resources, South Australia
- The University of Adelaide

Richard Hillis, Gerry Govett, James Johnson (Alternate for lan Lambert), Kevin Tuckwell, Steve Harvey, Paul Heithersay, David Ellis (Alternate for Tim Brown), David Garnett. L to R seated: Steve Rogers, George Savell, Gary Kong.

L to R standing: Adrian Larking,

Board of Management

The Governing Board is responsible for policy and strategy. It comprises Core Participant representatives, Advisory Council Chairs, and Independent Members. George Savell is the Independent Chair. At the end of the reporting period the Governing Board membership was:

Professor Tim Brown - Dean, College of Science, ANU

Mrs Janet Dibb-Smith - Director, Adelaide Research & Innovation, UA

Dr David Garnett - Independent, Minerals Advisory Council (MAC) Chair

Dr Richard George - Independent, Land Use Advisory Council (LUAC) Chair

Mr Lindsay Gilligan - Director, Geological Survey NSW, NSW DPI

Dr Steve Harvey - Acting Chief, CSIRO EM

Mr Paul Heithersay - Executive Director, Dept Minerals and Energy, PIRSA

Mr Gary Kong - Board Secretary and Business Manager, CRC LEME

Mr Adrian Larking - Independent -Minerals Industry

Dr Ian Lambert - Group Leader, Onshore Energy and Minerals Division, GA

Dr Steve Rogers - Chief Executive Officer, CRC LEME

Mr George Savell - Independent, Board Chair

Mr Charlie Thorn - Associate Director, Research and Development, CUT

Dr Kevin Tuckwell - Executive Director, Minerals Tertiary Education Council, MCA

Our Centre Visitor, Emeritus Professor Gerry Govett, has a standing invitation to attend Board meetings as an ex-officio member.



During the reporting period, Richard George replaced Warwick McDonald as LUAC Chair, and Charlie Thorn replaced Tony Tate as CUT representative.

The Board met on the following occasions:

7 September 2006, Perth - Board Meeting and AGM

9 November 2006, Hahndorf Resort, SA * *

8 March 2007, Canberra

28 June 2007 - Teleconference to approve the 2007-08 Budget

**Board members attended the LEME Regolith Symposium, 5-8 November and held its meeting at the Hahndorf Resort.

These meetings were supplemented by Outof-Session endorsement of contracts and other matters, as necessary.

Board Sub-Committees

The Audit Committee ensures an effective system of financial reporting, internal control and risk management is in place; ensures compliance with statutory responsibilities; reviews the scope of work and reports of external auditors; and assesses adequacy of accounting, financial and operating controls. It comprises Tim Brown, David Garnett, Gary Kong, George Savell (Chair), Steve Rogers. The Committee met prior to the AGM on 7 September 2006.

The Remuneration Committee reviews and makes recommendations to the Board on the remuneration of the Board Chair and other LEME HO Executives as well as undertaking the performance assessment of the CEO. The Committee - George Savell (Chair), Tim Brown, David Garnett, Kevin Tuckwell, Steve Harvey (representing CSIRO as the





employing organisation) and Gary Kong (Committee Secretary) - met after the AGM on 7 September 2006.

The Regolith Futures Task Force was put in place after the Fifth Year Review in July 2006. Its remit was to critically examine various options associated with the future of regolith science. It comprised Tim Brown, Graham Carr, David Garnett, Richard George, Gerry Govett, Paul Heithersay, Steve Rogers (Chair), George Savell, Charlie Thorn, and Kevin Tuckwell. Its task was completed by end June 07.

The Safety Committee, formed in 2001, reviews safety procedures and makes recommendations to the Board on adopting best practice O&HS standards for LEME staff and students. The inaugural members (representatives from GA, CSIRO, UC, an independent member and CEO) were tasked with the production of a field and vehicle safety manual for LEME personnel.

Advisory Councils

The Minerals Advisory Council (MAC) reviews research outcomes and advises on future priorities in line with industry and other user needs, primarily in mineral exploration. It reports directly to the Board through its Chair, David Garnett.

Members at the end of the reporting period were:

Mr Paul Agnew - Rio Tinto Exploration Pty Ltd

Chair: Dr David Garnett - Independent

Prof Bob Gilkes - University of Western Australia

Dr Jon Hronsky - Vertex Exploration

Dr Richard Mazzucchelli - Searchtech Pty Ltd

Mr Christopher Oates - Anglo American PLC, London

Dr Paul Polito - Anglo American Exploration (Aust) PL

Mr Bill Peters - Southern Geoscience Consultants

Dr Nigel Radford - Newmont Australia

Dr Bryan Smith - Bryan Smith Geosciences

Prof Peter Williams - University of Western Sydney

Dr Wally Witt - Geophysics Consultant

The CEO and Board Chair are ex-officio members of MAC and the Centre Visitor participates by invitation

The Land Use Advisory Council (LUAC) provides comment and advice on land use and environmental management issues. Its membership is drawn from government, non-governmental organisations (NGO) and independent user groups, representing a broad spectrum of end-users. It reports to the Board through its Chair, Richard George.

Members at the end of the reporting period were:

Mr Murray Chapman - Rural Plan Pty Ltd

Dr Colin Chartres - CSIRO Land & Water

Chair: Dr Richard George -Independent

Mr Mike Grundy - Dept Natural Resource & Mines Old

Mr Gavin Hanlon - North Central Catchment Management Authority

Dr Mike McLaughlin - CSIRO Land and Water (Waite Laboratories)

Dr Bruce Munday - CRC Plant Based Management of Dryland Salinity

Mr Bob Newman - Consultant, Catchment Management

Mr Colin Simpson - Consultant

Mr Ross Williams - Water Landscape Sciences, NSW

Mr Blair Wood - Land and Water Australia

Mr Ryan Vogwill - Dept Environment & Conservation WA

The CEO, and Board Chair are ex-officio members of LUAC and the Centre Visitor participates by invitation.

The Advisory Councils were consulted at an early planning stage of the 2007-08 Research Portfolio, with project proposals sent to the respective Council Members for their input. The Councils then met in May 2007 to receive presentations from Program Leaders and discuss their plans to wrap up research activities and communicate results, prior to the cessation of LEME in June 2008. Advisory Council input was assimilated prior to finalisation of the operating budget.

Executive Committee

The Executive Committee is responsible for the overall management of research Programs, including the annual assembly of research project portfolios and budgets for Board approval. The Executive Committee comprises CEO, Business Manager, Program Leaders, Assistant Directors whose responsibilities cover the three LEME nodes and, where appropriate, co-opted members for limited periods.





At the end of the reporting period the membership of the CRC LEME Executive was:

Dr Ravi Anand – CSIRO EM (Program 2 Leader)

Assoc Prof Lindsay Collins – Dept Exploration Geology, CUT (Assistant Director, Perth)

Dr Stephen Hill – School of Earth and Environmental Sciences, UA (*ad hoc* UA Member)

Mr John Keeling – Mineral Resources, PIRSA (Assistant Director, Adelaide)

Mr Gary Kong – Business Manager, CRC LEME

Dr Ken Lawrie – Onshore Energy and Minerals Division, GA (Program 4 Leader)

Dr Paul Shand – CSIRO LW (Program 3 Leader)

Dr Ian Roach – Dept Earth and Marine Sciences, ANU (Program 5 – Education and Training Leader)

Assoc Prof Ken McQueen – Dept Earth and Marine Sciences, ANU (Assistant Director, Canberra)

Dr Bear McPhail – Dept Earth and Marine Sciences, ANU (Key Researcher – *ad hoc* ANU Member)

Dr Steve Rogers – CEO, CRC LEME (Chair)

Mr John Watkins – Geological Survey, NSW DPI

Ms Lisa Worrall – Onshore Energy and Minerals Division, GA (Program 1 Leader)

Mrs Susan Game is Executive Secretary and Centre Support Officer Ian Roach replaced Steve Hill in February 2007 as Education and Training Program Leader. Dr Hill accepted a position at UA as a Senior Lecturer in Regolith Geoscience and was no longer able to devote a sufficient percentage of his time to Program Leader duties. Appreciation and thanks are extended to Dr Hill for his excellent job in the role during the last two years.

The Executive Committee met several times per teleconference during the year, more frequently when setting the 2007-08 Research Portfolio and Operating Budget. Also the CEO meets with Executive Committee members on opportunity when he travels and there is continuous email liaison amongst Executive Committee Members.

Program Leaders and local Executive members met to review progress on LEME projects in Adelaide, Canberra and Perth during March 2007. They also met prior to, and attended the Board Meeting in Canberra on 8 March.

Centre Culture

Consistent with the collaborative spitir of a Cooperative Research Centre, LEME develops and delivers multi-disciplinary and multiparty research, addressing stakeholder needs. In planning and executing its research, governance and educational priorities, LEME acts as a cohesive entity in the best interests of the joint venture, whilst recognising the needs for equitable returns for individual participants in the joint venture.



Prof Gerry Govett

CRC Visitor

Since its inception, LEME has received valuable counsel from its longstanding Visitor - Emeritus Professor Gerry Govett. The Board endorsed his continuation in this role during the reporting period. Professor Govett is a mentor and independent advisor to all LEME personnel - administrative staff, students, project staff, project leaders, Program Leaders, Executive and Board members and provides written guidance to the CEO. He is the thread of wisdom and support through the entire CRC. He has a standing invitation to attend all Board and Advisory Council meetings, all project reviews and all scientific seminars and symposia.

Strategic Planning

The LEME Strategic Plan 2002-08, adopted by the Board in March 2003, is consistent with the concepts of the Commonwealth Agreement. Within a framework of strategic priorities, tt sets out objectives, strategies to meet those objectives, and indicators to measure performance. On 28 June 2007, the Board endorsed the Centre's Wind-Up Plan for submission to DEST which describes the processes and policy to ensure LEME delivers on its contractual obligations.



Activities and Achievements

Program Structure

For administrative, management and reporting purposes, LEME activities are organised under four core research Programs:

Program 1: Regolith Geoscience

Program 2: Mineral Exploration in Areas of Cover

Program 3: Environmental Applications of Regolith Geoscience

Program 4: Salinity Mapping and Hazard Assessment

Research within LEME is aligned to different Themes, each of which has its own separate objectives, and often different stakeholders. However, all are linked by a core R&D capability in regolith geoscience.

Program 1: Regolith Geoscience

Progam 1 aims to understand the nature and timing of regolith processes, in both a detailed and regional context. It contributes strategic research in its own right, as well as forming the scientific foundation for other MINEX and environmental projects. It characterises and interprets regolith materials in different environments, develops landscape evolution models, and addresses the architecture and evolution of three-dimensional regolith models. In addition to a spread of regional focus projects, it looks at generic processes such as dating regolith events and history of aridity, as well as geophysical technology developments.

Program 2: Mineral Exploration in Areas of Cover

Program 2 provides new and improved tools for MINEX in areas of cover. This is achieved by understanding the chemical, mineralogical, biological and physical processes involved in metal mobility, and the formation of geochemical anomalies. There is a special emphasis on depositional regolith regimes. It addresses generic processes at a range of scales, involving micron-scale mineral hosts, calcrete genesis, and interactions with microbes and higher plants. Field sites are centred on key styles of mineral deposits. It pursues technology developments in hydrogeochemistry, spectral logging and remote mineral mapping.

Program 3: Environmental Applications of Regolith Geoscience

Program 3 researches environmental applications of regolith science. Themes include: assessment of regional geochemical baseline datasets, geochemistry of acid sulphate and alkaline soils, and microbiological processes in groundwater geochemistry. An important part of Program 3 is the application of microbiological and hydrogeochemical processes in other LEME Programs.

Program 4: Salinity Mapping and Hazard Assessment

Program 4 applies regolith science to the mapping, assessment and prediction of salinity stores and discharges, in both regolith materials and groundwater. The founding objective is to provide specialist geoscientific knowledge, technologies, datasets, interpretations and services to other agencies operating through the National Action Plan for Salinity and Water Quality (NAPSWQ). Research outcomes are applied to engineering mitigation proposals, landuse considerations, and landscape re-design strategies. Projects include both specialist contractual site studies generally funded under the NAPSWQ scheme and commissioned by NRM agencies, and

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strategic research into generic processes such as salinity hazard mapping, salt stores and mobility, aquifer parameters and groundwater flow models. A key component of its research, is the application of electrical and electromagnetic technologies to mapping salt stores in regolith and groundwater

Research Themes

Themes are high-level groupings of multidisciplinary research topics that have broad application, and are unified by a common strategic direction within the overall objectives of LEME. Addressing designated Themes ensures the best integration of research capabilities and resources across all nodes of LEME. All Themes provide a direct focus on stakeholder interests, and many bind the two principal applications of MINEX and NRM. They therefore focus the individual research projects, and enhance their cohesion.

All projects must address one or more of these Themes. Multi-party and multi-disciplinary projects have been cultivated, so the intellectual capital generated is effectively directed towards the needs of our diverse stakeholders in both MINEX and NRM. These Theme statements are:

Theme 1. Understanding regolith processes

Theme 2. Models of regolith-landscape evolution

Theme 3. Acid and alkaline soils

Theme 4. Regional mineral exploration studies

Theme 5. Making geochemistry more effective

Theme 6. Geophysical mapping and modelling

Theme 7. Salinity systems in regolith and groundwater

Theme 8. Regolith geoscience and urban Australia

Theme 9. Environmental geochemistry and the regolith

Program Leader: Ms Lisa Worrall (GA)



Highlights

- Release of the Palaeodrainage and Tertiary Coastal Barriers Map of South Australia results in 78 ELAs over palaeodrainage systems in South Australia
- Significant increase in ELAs over the Thomson Orogen in New South Wales from 3 to 32 since project inception.
- Low-density geochemical sampling of overbank soils and vegetation in areas of thick cover in the Thomson Orogen generates meaningful patterns that relate to geology and possible mineralisation at depth.
- In the Tanami:
 - Groundwater hydrogeochemistry successfully identifies gold mineralisation through cover
 - Spinifex chemistry mirrors groundwater chemistry suggesting that Spinifex roots tap groundwater at depths of over 20 metres.
 - Phyto-exploration and termitaria research features in the *New Scientist* Magazine.
- The uptake and concentration of uranium and thorium in leaves of a variety of native Australian plant species has been demonstrated, indicating phyto-exploration is a potentially viable method for uranium exploration.
- In a possible world first, the feasibility of potassium-argon dating of beudantite, a potassium-bearing lead arsenate mineral that occurs in the oxide zone of base metal deposits in the Cobar region, has been demonstrated.
- Release of Special Volume Regolith Geochronology and Landscape Evolution (OFR 189).

Overview

Program 1 aims to understand the nature and timing of regolith processes in both a detailsed and regional context. It contributes strategic research in its own right, as well as forming the scientific foundation for other mineral exploration and environmental projects. Projects within this Program have been grouped into Regional Focus, Generic Process and Commercial projects.

REGIONAL FOCUS PROJECTS

Thomson Orogen

John Greenfield, Bill Reid, Kingsley Mills, Dick Glen, Steve Trigg, Gary Burton, Steve Hill, Karen Hulme, Robert Dart, Jess Davey, Layla Tucker, Dave McAveney, Lisa Worrall, Patrice de Caritat, Megan Lech, Andrew McPherson, Ken McQueen, Ian Roach, Richard Greene, Tony Eggleton

The Thomson Orogen Project, established 2005, is improving regional prospectivity by developing an effective means of exploring through the cover in the region. This project is part of a major initiative by NSW DPI into the Thomson Orogen that includes regional mapping, seismic surveys, drilling, gas geochemistry and airborne geophysics.

The project has three main components:

- A low-density geochemical survey employing overbank sediment, lag and vegetation samples. Analysis performed using NITON, MMI partial leach, XRF and ICPMS and other techniques.
- Regional regolith mapping to provide a basis for interpretation of surface and near surface geochemistry.
- Detailed regolith mapping and geochemical studies aimed at providing more accurate regional regolith maps by

generating a better understanding of post-Palaeozoic landscape evolution and its influence on geochemistry.

One of the project highlights in 2006-07 was the completion of a low density geochemical survey. Ninety nine sites were visited during this survey and at each site overbank soils, lag and vegetation samples were collected. Preliminary and partial analysis of the data suggests the overbank soils and vegetation geochemistry derived from ICP-MS analysis reflects the underlying bedrock geochemistry. This relationship is not apparent in comparative MMI partial leach analysis of the same soils. Gold, calcium and magnesium in the MMI dataset are moderately to strongly correlated, suggesting the effective use of this technique might be dependent on a good understanding of how regolith carbonate accumulations form. Analysis of lag samples suggests the finefraction could be particularly useful as a lowcost, geochemical vector to mineralisation.

Another highlight was the successful research undertaken by LEME/UA students Layla Tucker and Dave McAveney with their supervisor Steve Hill. Their work has unravelled palaeocurrent vectors and the tectonic history of the gold-bearing Cretaceous units in the western Thomson Orogen, and points to new potential primary gold sources. Geochemical analyses of vegetation and standard soil samples over an area of known primary gold mineralisation at Tibooburra in northwest NSW were compared. Vegetation proved to be a much more sensitive vector for mineralisation under transported cover.

A measure of project success has been an increase in exploration activity in the region. The number of exploration licenses granted in the NSW Thomson Orogen has increased from 3 to 32 since the project began.

Central Gawler Landscapes

John Keeling, Malcolm Sheard, Baohong Hou, Wenlong Zang, Liliana Stoian, George Gouthas, Barry Cooper, Steven Hill, Jack Lowrey

Increased MINEX activity for sandstonehosted uranium in the central Gawler Craton and elsewhere in SA resulted in a strong demand from exploration companies for a map that shows the sedimentary cover in the



region. LEME's collaborative work with PIRSA on palaeodrainage and Tertiary coastal barrier sediments on the margins of the Eucla Basin was used to produce a revised stratigraphy of Tertiary sediments and a GIS of palaeodrainage sediments in the region. These data sources were combined with LEME project studies: Eucla Margins, Curnamona Minex and Mineral Mapping SA to provide a DVD-based, Arc GIS format of palaeodrainage and palaeocoastal sediments of SA. The first-edition GIS was released at the Mineral Exploration Through Cover Conference, held at UA on 22 June 2007.

A marked increase in ELAs over palaeodrainage systems was recorded, with 78 ELAs intersecting palaeodrainage systems submitted in the six weeks following release.

A 1:20,000 regolith map of the Wudinna Area, which incorporates the Barns and Baggy Green gold prospects, was released at the LEME Symposium in Hahndorf, November 2006. Biogeochemical surveys over the Tunkillia Gold Prospect were completed by LEME/UA Honours student Jack Lowrey. The survey results have shown that Casuarina, daisy blue bush and some eucalyptus species accumulate gold in their terminals. which may be useful mineralisation indicators in areas of sand dune cover over weathered basement.

Spectral mapping of muscovite/phengite alteration and spatial association with gold mineralisation at the historic Tarcoola gold mining district has shown that in areas of thin or patchy cover this technique offers a means of recognising alteration even where the bedrock is deeply weathered. A paper describing this research has been accepted for publication in the *Transactions of the Institute of Mining and Metallurgy*.

Collaboration with Professor Luo and students at Guilin University of Technology on the electro-geochemical exploration technique (CHIM) continued during the year. The technique shows potential to refine geochemical anomalies from regional sampling programs and the results of surveys over ore shoot extensions at the Challenger Gold Mine in the Gawler Craton were reported and widely discussed.

A visit by LEME researchers, Baohong Hou and John Keeling, to Guilin University in Palaechannel Dataset Release and Subsequent Exploration – May to July, 2007



September 2006 included field work in the Dachang Tin and Polymetallic Mineral District of southern China where Luo recently completed a series of geochemical surveys.

Curnaminex

Adrian Fabris, John Keeling, Baohong Hou, George Gouthas, Steve Hore, Liliana Stoian, Mark McGeough, Roger Fiddler, Malcolm Sheard, John Joseph, Luisa Ruperto, Joel Brugger, Pierre-Allain Wulser, Steve Hill, Karen Hulme, Jessie Davey, Michael Neimanis, David Baker, Dirk Kirste, Sue Welch, Bear McPhail, Nick Direen

The Curnaminex Project was established in July 2005 to develop comprehensive geochemical and geophysical exploration strategies targeting specific mineral deposit types, primarily copper-gold, lead-zinc-silver and uranium, in areas of regolith cover. The thickness and complex nature of transported cover in large areas of the region provide significant challenges to mineral explorers.

Four prospects were researched during the year: Polygonum (multi-element), Kalkaroo (copper-gold-molybdenum), Goulds Dam (uranium) and Christmas Ball (coppergold). Combinations of traditional and novel geochemical techniques have been trialled at most prospects. These include soil sampling from two depth intervals, the use of a variety of partial leaches, soil desorption pyrolysis and the electro-geochemical CHIM method.

Partial leach soil geochemistry appears to be mapping changes in underlying bedrock, even through 100 m of transported cover. A combination of soil conductivity measurements and partial leach results has given encouraging signs of known mineralisation. Further trials will be conducted to confirm these potentially significant findings. The uptake and concentration of uranium and thorium in leaves of a variety of native Australian plant species has been demonstrated, indicating phyto-exploration is a potentially viable method for uranium exploration.

A further eight line kilometres of TEM data were acquired over the Kalkaroo Prospect as a follow up to the encouraging results encountered by past surveys. The surveys have highlighted the high conductivity of cover sediments in the region. General differentiation of cover sediments has been achieved including quantification of thickness. The basement-cover interface was defined using a 100m-loop configuration. This information will assist with interpreting the phyto and geochemical results.

During the year the Mingary 1:100 000 regolith map sheet was completed. Significant variation in regolith and landform styles became evident during the mapping. A critical understanding of these landforms will be required when planning and interpreting drilling and geochemical survey results.

LEME/UA students, Michael Neimanis and Davey, are studying Jessie the biogeochemical expression of uranium mineralisation, and sub-Mesozoic regolith interfaces and palaeosurfaces respectively. The uptake of uranium and thorium in a variety of native plant species has been demonstrated over a number of known uranium deposits in the Northern Flinders, indicating that phyto-exploration is a viable method for uranium exploration. Future work will use vegetation to detect secondary uranium mineralisation in palaeodrainage systems.

Tanami

Lisa Worrall, Tony Eggleton, Steven Hill, John Joseph, Dirk Kirste, Anna Petts, Brad Pillans, Nathan Reid, Luisa Ruperto, Martin Smith

Sam Elliott and Richard Landford (GSWA) with Lisa Worral (GA) and Anna Petts (UA) posing by an outcrop of fluvial conglomerate at Mushroom Bore, Tanami. Below: Nathan Reid and Tunkilla Spinifex.



The Tanami Collaborative Regolith Research Project was established in 2005 to develop an effective means of exploring through cover in the region. The collaborative partners are LEME, GA, Northern Territory Geological Survey (NTGS), Geological Survey of Western Australia (GSWA), Newmont, Tanami Gold and Anglo American.

Studies demonstrate that regional weathering history in the area extends as far back as the late Carboniferous and long-term erosion rates are of the order of one to four metres per million years. Geophysical investigations have shown that deep weathering (greater than 300m) has enhanced the electrical conductivity contrast of the parent rock, and that electromagnetic techniques may be able to map the regolith expression of key elements of the primary mineral system.

The results of geochemical analyses of termitaria and plant samples are highly



correlated, both detecting anomalies over areas of known mineralisation. Spinifex chemistry mirrors groundwater chemistry suggesting that spinifex roots tap groundwater at depths of over 20 metres. Proximity to gold mineralisation can thus be identified in the groundwater chemistry in areas of thick cover.

A *New Scientist* Magazine feature article (30 June 2007) summarised project research by LEME/UA PhD students Anna Petts and Nathan Reid on detecting gold mineralisation in termitaria and Spinifex grass over known deposits.



Brad Pillans collecting samples in Redback Pit, Tanami, temperature approx 40°C. Picture taken by Simon Bolster, Newmont Australia, August 2006.

GENERIC PROCESS PROJECTS

Geochronology and Quantitative Models of Landscape Evolution

Brad Pillans, Ed Rhodes, David Ellis, Jim Dunlap, Ian Williams, Rainer Grun, Steve Eggins, David Edwards, Andrew Christy, Martin Smith, Kat Fitzsimons, James Hughes

Laboratory analyses were undertaken throughout the year on palaeomagnetic samples from the following sites – Coyote Mine, Balgo and Supplejack Downs in the Tanami region of Western Australia (Tanami Project); Mount Lofty Ranges, South Australia, Harden area; New South Wales (NSW) as part of the Landscape Analysis Project, Murray-Darling Basin; and New Cobar and Mt Boppy mines in northwest NSW (Lachlan Fold Belt Project).

Results from these sites have consolidated the continent-wide data set of palaeomagnetic dates and continue to support the hypothesis (shown in the 2005-06 Annual Report) that major episodes of deep regolith oxidation occurred during Neogene (0-20 Ma), Early Palaeogene-Late Cretaceous (50-80 Ma), and Early Permian-Late Carboniferous (290-320 Ma).

In a possible world first, Jim Dunlap has demonstrated the feasibility of potassiumargon dating of beudantite, a potassiumbearing lead arsenate mineral that occurs in the oxide zone of base metal deposits in the Cobar region.

Macro and micro biotic influences on the solubility of alumina and the formation of bauxite (Weipa)

Tony Eggleton, Graham Taylor

Bauxite is one of the world's most important mineral resources and is generally considered to be the product of long-term weathering in tropical or monsoonal climates on a low-relief landscape. In Australia, bauxite accumulation occurs across the whole continent with mines at Weipa in Queensland, Gove in the Northern Territory (NT) and in the Darling Ranges in WA.

The primary goal of this project has been to understand the formation of the world-class Weipa Bauxite Deposit. Secondary goals



ESEARCH PROGRAMS

include: clarification of the process of pisolith formation, impact of biota on regolith geochemistry, dating the age of the deposit and establishing the history of the Weipa Plateau landscape.

Two field trips to Weipa provided fresh samples and data that allowed mechanisms of pisolith development, and the short- and long-term geological history of the bauxite deposit to be addressed. The visual, chemical and mineralogical characterisation of the regolith profile at Weipa was also completed.

During the year, five papers were prepared for submission to the *Australian Journal of Earth Sciences* and a technology transfer session between LEME and Rio Tinto staff took place at Weipa. Rio Tinto Exploration and Rio Tinto Alumina are acknowledged for their ongoing support of this project.

COMMERCIAL PROJECTS

Queensland Regolith Map and Atlas

Mike Craig, Matilda Thomas, Ian Robertson also Mal Jones and Joanne Morrison (Geological Survey of Queensland and Tessa Chamberlain, and Ben Harms (Queensland Department of Natural Resources and Water).

In mid 2006, LEME commenced a project with the Queensland Geological Survey

Natural Resources and Water (QLD NRW) and GA on the production of a Queensland Regolith Map and Atlas. GSQ is funding the project as part of their \$20 million Smart Exploration Initiative.



Mike Craig in desert terrain, SW Qld.

During the year, the project met its first major project milestone by successfully completing the 7500 km Queensland Regolith Traverse. The purpose of the traverse was to assess the major variations in regolith terrains and landscapes across Qld and use this information to plan the strategy for detailed mapping of three regions. Detailed mapping will provide information about regolith materials, their distribution and associated landscapes which will underpin the preparation and production of the Map and Atlas. During the March Traverse, approximately 20 prospective palaeomagnetic-age determination samples were collected that will form part of a regolith-chronology pilot study. The overall results of the pilot study will contribute to the construction of a broad, but simple, chronology for the observed weathering events across Qld and assist with a wider framework for Australia. A further 100 whole-regolith specimens were also taken for mineralogical, petrographic and geochemical analysis.

Physiographic Regions

Colin Pain, Luisa Ruperto

The National Land and Water Resources Audit, through the Australian Collaborative Land Evaluation Program, continued funding during 2006-07 for work on a new national map of Australian physiographic regions. This map was compiled during the first half of the year, and was then finalised at a workshop with input from State and Territory representatives. Final line work will appear on the Australian Soil Resource Information System (http://www.asris. csiro.au/), where a draft can be viewed. In addition to compilation of national scale landform and regolith information, this project has provided standard lists of landforms, regolith and parent material lithology.

Northern Agricultural Catchment Council (NACC) Coastal Project

Lindsay Collins, Alexandra Stevens

This project has two distinct components: The development of a coastal Geographic Information System (GIS) for the coastal zone of the Northern Agricultural Region of Western Australia, which includes more than 400 km of coastline, and the development of a genetic model for mineral-sand accumulation for the coastline in the Hutt River Region in the Midwest of WA.

Five of the six GIS stages have been delivered to the sponsor, the WA Department of Environment and Conservation, with the concluding stage and synthesis to be completed by December 2007. The GIS will provide a dynamic database that will allow for documentation of on-ground works and coastal remediation.

Mine mapping at Hutt River has established the processes and pattern of mineral sand accumulation within a Holocene highstand barrier complex, and the genetic model being developed will assist mine development and further exploration.

Outlook for 2007-08

In the last year of CRC LEME, Program 1 staff will be winding up research activities and communicating results, most particularly via a number of CRC LEME Legacy Products.

A series of Explorers Guides will be released during 2007-08 that outline MINEX strategies and procedures in regolithdominated terrains, based on state of the art knowledge gained from 13 years of CRC LEME 1 and 2 multidisciplinary research activities. The Guides will provide a userfriendly introduction to the regolith, models of regional regolith landscape evolution, palaeo and contemporary dispersion





processes and information on the most suitable geochemical sampling media and preferred laboratory techniques for identifying anomalies. The Guides will be available as .PDF files for free download from the CRC LEME web site. The Explorers Guides and their planned release dates are summarised below:

- Explorers Guide to the Cobar Region, Lachlan Orogen, NSW. Project Leader: Ken McQueen, ANU. Planned publication/Release – September 2007, Mines and Wines Conference, Orange, NSW
- 2 Explorers Guide to the Tanami. Project leader: Lisa Worrall, GA. Planned publication/Release – April 2008, Annual Geoscience Exploration Seminar, Alice Springs, NT
- 3 Explorers Guide to the Central Gawler. Project Leader: John Keeling, PIRSA. Planned publication/Release – May 2008, South Australian Resources and Energy Investment Conference, Adelaide
- 4 Explorers Guide to the Curnamona.
 Project Leader: Adrian Fabris, PIRSA.
 Planned publication/Release June
 2008, Mineral Exploration Through
 Cover Conference, Adelaide
- 5 Explorers Guide to the Thomson Orogen. Project Leader: Steve Hill, UA. Planned Publication/Release – June 2008, Exploration in the House, Sydney, NSW

A Yilgarn Explorers Guide will be delivered through Program 2, led by Ravi Anand.

In addition, a CRC LEME Guide to Describing and Sampling Regolith Materials, a Guide to Phyto-Exploration and an updated edition of the LEME Guide to Regolith Dating Methods, will be released at key exploration geoscience events during 2007-08.

Modifications to CHIM have been recommended and further CHIM surveys are planned during August 2007 over uranium prospects near the Beverley Mine and the Challenger and Tunkillia gold deposits in the central Gawler Craton, SA.

Progress in the Queensland Regolith Map and Atlas Project will be reported to the public at the "Digging Deeper" forum sponsored by GSQ in November 2007. The final Map and Atlas will be delivered in the second quarter 2008.

Lists of landforms, regolith and parent material lithology have been provided by the Physiographic Regions Project for inclusion in an updated version of the Australian Soil and Land Survey Field Handbook, to be published in 2007-08. A series of Explorers Guides will be released during 2007-08 that outline MINEX strategies and procedures in regolith-dominated terrains, based on state of the art knowledge gained from 13 years of CRC LEME 1 and 2 multidisciplinary research activities. This new knowledge assists explorers determine the most suitable regolith environments in which metal dispersion is possible, and what sample media or techniques are needed to detect metal anomalies.

Program Leader: Dr Ravi Anand (CSIRO EM)



Program 2: Mineral Exploration in Areas of Cover

Highlights

- Significant increase in ELAs in the Western Yilgarn Craton following release of the Laterite Geochemical Atlas and Database for the Western Yilgarn Craton from 40 in the month preceding release to over 100 in the month following release.
- Chilean component of the AMIRA P778 Predictive Geochemistry in Areas of Transported Overburden Project begins.
- Modelling of fundamental nickel sulfide deposit weathering identifies alternative hydrogeochemical reaction pathways for bedrock oxidation.
- Nanoparticulate gold studies suggest rapid evaporation (days-months) is responsible for gold precipitation in sulfates.
- Objective logging research develops effective procedures for determining regolith mineral abundances from spectroscopic data.
- Hyperspectral analysis of surface illite identified as a mineralisation vector
- New theory of groundwater acidification processes in the southern Yilgarn, based on downward leaching of acidity, better explains regolith mineralogy and groundwater geochemistry observations.
- Application of hyperspectral surveys to diamond exploration aids the discovery of two new kimberlites at Pine Creek near Terowie, SA, employing spectral analysis of HyMap data.
- Strong Program 2 representation at the 23rd International Applied Geochemistry Symposium in Oviedo Spain.

Overview

Program 2 provides new and improved tools for MINEX in areas of cover, based on new understandings of metal and mineral transport and transformation processes. This new knowledge assists explorers determine the most suitable regolith environments in which metal dispersion is possible and what sample media or techniques are needed to detect metal anomalies. LEME researchers have applied innovative techniques including analysis of various plant tissues (phyto-exploration), metal geochemistry in the zone of plant roots in relation to plant uptake, mass balance studies, in-house laboratory and greenhouse studies, groundwater geochemistry, microbial genetic characterisation, and isotopic analysis to establish the source of metal in plants and surface regolith materials, and soil desorption analysis to assess potential gas migration mechanisms.

Projects within Program 2 have been grouped into Generic Process, Regional Focus and Technology Development projects.

GENERIC PROCESS PROJECTS

Metal mobility

Bear McPhail, Steve Eggins, Susan Welch, Andy Christy, David Ellis, Ken McQueen, Joel Brugger, Marc Norman, Alistair Usher, Chris Gunton

Significant progress has been made into understanding gold geochemistry in saline solutions as part of the research done by LEME/ANU students Alistar Usher and Chris Gunton. A featured component of Chris' research has been the effect of salinity on metal adsorption on goethite, solubility of hemimorphite, and the effect of salts on measuring pH in brines. NaCl enhances adsorption of copper at low pH (<4.5-5), Na₂SO₄ suppresses copper adsorption and NaNO₃ has little effect. Zinc adsorption was suppressed by both NaCl and Na₂SO₄.

Long-term (>100 day), low-temperature (25° C) experiments were completed to measure



A polished section of a gold nuggett from Salt Lake that shows internal strain. An SEM image of crystallographically controlled internal silver depletion in gold. An SEM image of internal crystal structure in gold that has been etched.



the solubility of hemimorphite (hydrated zinc silicate alteration mineral). Preliminary data shows that hemimorphite solubility decreased with increasing temperature. Predicted zinc concentrations are about 50 ppm in waters at 25°C saturated with hemimorphite and amorphous silica at pH 5.5. These concentrations decrease markedly with increasing pH to less than 0.1 ppm at pH ~ 6.5. A key finding is that in silica-poor environments common in carbonate-dominated terrains in Australian landscapes, zinc concentrations are anticipated to be higher.

Tracing, timing and mechanisms of metal migration (TRIMM)

Rob Hough, Ray Smith, Ryan Noble, Mel Lintern, David Gray, Ravi Anand, John Keeling, Ken McQueen, Charles Butt, Andy Christy

Key sites with very rich occurrence of supergene gold crystals at the Golden Virgin Deposit in the Parker Ranges, WA were examined in detail. The crystals occurred along weathered fractures within quartz veins together with goethite, hematite, clays, sulphates and salt. Scanning Electron Microscopy (SEM) has revealed ultra-thin gold crystals, to the point of transparency, and a nanoparticulate population of single gold crystals on coarse gold crystal surfaces. Nanoparticulate gold occurs within sulphate minerals, suggesting a rapid evaporitic precipitation mechanism over days. *In-situ* microanalyses of samples from Cobar, NSW were undertaken on different regolith mineralogies associated with metal dispersion events, within the weathering history of the gold deposit. By combining this microanalysis with geochronology of the same materials, the project has begun to date important regolith metal migration events.

Assisted by the Australian Synchrotron Research Program, the project has continued to utilise synchrotrons located outside Australia to perform analyses and collect tomography data. Akin to a CT scan of a rock sample, the synchrotron has been able to rapidly reveal the 3D microstructure of regolith materials and vegetation at high resolution. Data generated from the synchrotron analyses totalled two terabytes in size.

TRIMM has continued to study gold nuggets and crystals from the CSIRO Exploration and Mining's Creasy Gold Collection. SEM analyses of nugget surfaces has revealed that primary nuggets found near salt lakes weather and develop a secondary gold crystal coating intermixed with evaporite minerals such as celestite, strontianite, gypsum and halite.

The St Ives Goldfield research has shown that nuggets and nugget patches are significant indicators for primary mineralisation. Further work is needed to examine secondary gold formation at different deposits and climatic environments.

Predictive geochemistry in areas of transported overburden (AMIRA P778)

Ravi Anand, Mel Lintern, Steve Wakelin, Rob Hough, Craig Macfarlane, Brian Townley, Cajetan Phang, Ryan Noble, Steve Rogers, David Gray, Graham Carr, Michael Korsch, Mehrooz Aspandiar, Steve Hill, Siriporn Soongpankhao, Nathan Reid, Tenten Pinchand

AMIRA P778 aims to determine the mechanisms responsible for geochemical anomaly formation in transported overburden and, based on these mechanisms, develop effective and robust geochemical exploration techniques. The project team has begun to innovatively and systematically study the role of chemical and biological mechanisms that form known geochemical anomalies in areas of transported overburden in Australia and Chile. Fourteen mining companies provide sponsorship for this project. The Chilean component of the project is led by Professor Brian Townley, University of Santiago.

The work plan, research sites and priorities were discussed at the first sponsors meeting in October 2006. Four major field study sites, three in Australia and one in Chile, were then selected representing different commodities and mineralisation styles. They were: Jaguar – volcanic massive sulfides (WA): Barns – gold (SA), Miitel North – nickel (WA), Inca del Oro – copper porphyry (Chile).

Work also began at secondary study sites located at the Western Australian gold deposits, Moolart Well, Rose Dam and Gnaweeda.

Field research began at the Codelco-owned, Inca de Oro porphyry copper prospect in the Atacama Desert, Chile in October 2006. A follow up sponsors meeting was held at the Faculty of Mathematical and Physical



Sciences of the University of Chile in Santiago in December, which involved a field trip to determine the suitability of study site locations.

Significant progress has been made in understanding biotic and chemical metal dispersion processes in areas of transported cover. Important conclusions and outcomes from various study sites were integrated and presented at sponsors meetings in October 2006 and May 2007. The resulting field and experimental work will be complied and incorporated into several confidential investigation reports.

An external review of the project by Drs Gwendy Hall (Geological Survey of Canada) and Colin Dunn (consultant biochemist) was undertaken in April 2007 in Perth. A very positive report based on their observations and recommendations was then presented to the AMIRA sponsors.



REGIONAL FOCUS PROJECTS

Yilgarn Laterite Atlas

Ian Robertson, Matthias Cornelius, Paul Morris, Amanda Cornelius

The final output from this project was released in June 2007 as Geological Survey of Western Australia Record (GSWA) 2007/9 Laterite Geochemical Database for the Western Yilgarn Craton, Western Australia. At the same time LEME released this report as

Work in the P778 project will continue the CRC focus in molecular microbiology and bacterial metal mobilisation mechanisms pioneered by Frank Reith and colleagues. Image courtesy of Science www.sciencemag.org

Biomineralization of Gold: Biofilms on Bacterioform Gold

Frank Reith, 1,2* Stephen L. Rogers, 1,4 D. C. McPhail, 1,2 Daryl Webb

Bacterial biofilms are associated with secondary gold grains from two sites in Australia. 165 ribosomal DNA clones of the genus *Ralstonia* that bear 99% similarity to the bacterium *Ralstonia* metallidurans—shown to precipitate gold from aqueous gold(III) tetrachloride—we present on all DNA-positive gold grains but were not detected in the surrounding soils. These results provide evidence for the bacterial contribution to the authigenic formation of seconda bacterioform gold grains and nuggets.

the origin of secondary gold grains is The origin or secondary gota gota and controversial and widely debated in the scientific community; the two main the-are that they are detrital or are formed by

chemical accretion (1). However, there is gro

¹Cooperative Research Centre for Landscape Environ and Mineral Exploration, Post Office Box 1130, Be Western Australia 6102, Australia. ²Department of and Marine Sciences, ³Research School of Biol Microscopy Unit, Aus ACT 0200, Australia. and Water, PMB2, Glen Osr and South Au

nat resident microbiola solutionized up to 55 at % [i.e., 1100 ng per g (dry weight, soil)] of

Pseudomonas fluorescens, Bacterium nitrificans

are able to solubilize several milligrams o gold per liter of medium under in vitro

s (2, 4). A recent microcosm oils from the Tomakin Park G outheastern New South Wales, A

alia (35°48'51.9"S, 150°10'26.4"E)

Mine

dence should be addressed. E-mail

. (D) Detailed view ice in the biofilm, all clusters (in blue) ained interstices. F spreading preuse surface of the bacter old and are not p



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OFR 116, which may be downloaded from its website (http://crcleme.org.au).

The release of the report and associated data met with very positive response from industry, with a significant increase in ELAs in the Western Yilgarn following the release of the Atlas. Applications increased from 40 in the month preceding release to over 100 in the month following release.

Undertaken at sample spacings close enough to recognise regional geochemical trends, major lithologies and dispersion halos around significant bedrock mineralisation, the Atlas has been able to detect increased gold abundances in the northeast of the survey area that extend beyond known gold mineralisation zones. Anomalous arsenic, bismuth, molybdenum and antimony concentrations observed along the south margin of the craton could also be related to gold mineralisation.

A chalcophile element index undertaken for the project has also highlighted gold and base metal mineralisation potential in the western most part of the Yilgarn Craton. Chromium abundances observed in granitic terrain suggest that mafic-ultramafic remnants may be present.

During the year Ian Robertson replaced Matthias Cornelius as joint project leader with Paul Morris (GSWA), following Mathias' appointment as Exploration Manager for Cullen Resources. This collaborative project is funded by MERIWA, GSWA, CSIRO EM and LEME.

RESEARCH PROGRAMS

Hydrogeochemistry for mineral exploration

David Gray, Bear McPhail, Patrice de Caritat, Ryan Noble, Grant Douglas

During the year, laboratory research has expanded upon the results generated from the previous groundwater sampling program along the Leonora-Wiluna Belt. The research has put forward new mechanisms for sulfide alteration observed in these environments. Historial patterns of weathering suggest the sulfide-oxidation front occurred tens of metres below the water table, in a low oxygen environment. Modelling within Geochemists Workbench® (GWB), has demonstrated that deep sulfide alteration, such as pyrrhotite to pyrite and pentlandite to violarite, can occur with sulfate as an oxidant to provide an additional source of sulfide, presumably mediated by anaerobic microbial activity.

 $2\text{FeS} + 0.4\text{SO}_{4^{2*}} + 1.6\text{H}_2\text{O} < - > 0.8\text{Fe}(\text{OH})_3 + 1.2\text{FeS}_2 + 0.8\text{OH}_3$ (pyrhotite) (iron oxide) (pyrite)

By reaction modelling, the project has demonstrated that iron oxides can also be formed as a by product of this conversion process, even in oxygen depleted zones. The reaction modelling results have implications for the interpretation of iron oxide observations at depth. In contrast, oxidation of secondary sulfides to sulphate can only occur in the presence of either O₂ or NO₃.

 $2FeS_2 + 6NO_3 + H_2O < -> Fe_2O_3 + 3N_{2(G)} + 4SO_{4^{2^*}} + 2H^{4^*}$ (pyrite) (iron oxide)

This modelling suggests the shallow groundwaters of the Leonora-Wiluna Belt will be sulfide enriched, nitrate depleted and acidic. The degree of acid production is dependant on mineralogy, with iron-rich systems producing more acidity than nickelrich systems. These predictions for both deep and shallow groundwaters are supported by field observations and provide additional techniques for broad-scale identification of potential sulfide systems.

Groundwater study results for nickel sulfides, volcanic massive sulfides (VMS), and uranium will be combined with previous research on gold deposits in the area, to





develop a generalised model for hydrogeochemical exploration in the study area, as well as similar geological and geomorphological regions. Follow-up research has included applications of these nickel sulfide exploration methodologies along the adjacent Yandal Belt, with the support and partnership of Echo Resources Ltd. This has led to the development of a hydrogeochemical mapping project proposal for the northeastern quadrant of the Yilgarn Craton.

Research in the southern Yilgarn has modelled the pervading groundwater acidification in the area. The project successfully demonstrated that previous hypotheses to explain the acidity, namely oxidation of dissolved ferrous iron released during weathering, has several flaws with no mechanism for the initial release of the iron cations identified. Previous modelling has also had problems in explaining the stratigraphy of acid products such as alunite. However there is a very close correlation on a regional scale between acid groundwaters above the base of the upper saprolite, carbonate soils, and dominance of eucalypt species with rainfall less than 400 mm per year.

In parallel with WA Department of Agriculture and Food colleagues, the project has developed the hypothesis that eucalypt root processes are leading to the slow downward leaching of acid saline soil water, resulting in carbonate formation.

The ability of percolating acid-saline water to dissolve gold and other metals has been identified by the project. When acid-saline groundwater interacts with lower saprolite, research has shown that mineral dissolution processes buffer groundwater pH up to 6.5 with a high amount of dissolved iron in soultion. This buffering, along with high salinity, prevents the further weathering of rock.

A partnership project with Australian Mineral Fields Pty Ltd advanced the exploration potential of hydrogeochemistry in Australian environments during the year. In particular, the understanding of elemental signatures within the Yilgarn and south-east sections of the Albany-Frazer Province.

Research in the southern Yilgarn has demonstrated there is a very close correlation on a regional scale between acid groundwaters above the base of the upper saprolite, carbonate soils, and dominance of eucalypt species with rainfall less than 400 mm per year.

WA Wheatbelt Uranium

David Gray, Grant Douglas, Ryan Noble, Steve Rogers

This collaborative project with Mindax Ltd and Quasar Resources Ltd was formed following the discovery of anomalous uranium and cobalt in the bores, lakes and drains of the Upper Avon River Catchment by LEME's Program 3 WA Wheatbelt Acid Drainage Project.

During the year, the project undertook an infill sampling program over the areas where anomalous uranium concentrations were detected, with some encouraging results up to 700 ppb uranium encountered.

TECHNOLOGY DEVELOPMENT PROJECTS

Objective regolith logging

Tim Munday, Cajetan Phang, Alan Mauger, Amanda Cornelius, David Gray

This project has continued to develop new spectroscopic technologies for the characterisation of regolith materials, through the refinement of the CSIRO/CRC LEME-developed HyChips automated, spectroscopic logging technology. Work has developed new algorithms that predict relative abundance of regolith materials.



Cajetan Phang (CSIRO EM) using the HyChip Logger at Genalysis Laboratories, Perth, along with Helen Waldon and Sarah Williams (Genalysis Laboratory Services Pty Ltd).

A critical part of the work has been the identification of effective procedures to estimate the proportions of regolith minerals in different settings from mixed sample spectra. To achieve this, the project has collaborated with CSIRO Mathematical and Information Sciences to advance the

development of unmixing algorithms that allow the rapid determination of relative regolith material abundance in samples collected from chips or core in the field. The aim of the collaboration is to build a regolith version of the software program The Spectral Assistant now used routinely by the minerals industry for spectral analysis.

During the year, LEME concluded a collaborative study with CSIRO EM and Genalysis Laboratory Services Pty Ltd in Perth. The study investigated whether sample mineralogy determination by spectroscopic methods could be incorporated into an analytical laboratory's workflow. It also examined specific technical issues and potential market demand. Development options for a commercial service built around the most suitable market model are under consideration.

The Centre has worked with AusSpec International in collating spectra that represent materials from the upper saprolite (kaolinite and residual primary minerals), lower saprolite (kaolinite, smectites and residual primary minerals), weathered basement (mafic, ultramafic and felsic units), and transported cover. With the collation now complete, the project has moved on to the development of a methodology for the semi-automated classification of spectra from regolith profiles using the Aux match function found in The Spectral Assistant software program, and to build an associated template file that can automatically calculate a series of spectral indices relevant for regolith and weathered basement materials.

Collaboration between LEME and CSIRO EM to further develop commercial opportunities for HyChips technology has resulted in several mining companies using the system. In several instances, the logger was installed on mine sites in the Eastern Goldfields of WA.

Mineral mapping

Alan Mauger, John Keeling

This project is using HyMap technology, developed by Integrated Spectronics and CSIRO Materials Science and Engineering, to differentiate regolith mineral assemblages associated with mineralisation through the analysis of remotely sensed data.

A major project highlight during the year was a breakthrough in the technologies ability to map alteration using the crystallinity of surface illite as a mineralisation vector, reported in Alteration Mapping of the Tarcoola Goldfield (South Australia) Using a Suite of Hyperspectral Methods. The report also drew together the accumulated findings of mineral mapping studies since 1999.

At the 2006 Australian Earth Sciences Convention, a paper on the application of surveys diamond hyperspectral to exploration presented, which was announced the discovery of two new kimberlites at Pine Creek near Terowie, SA. The discovery was made through spectral analysis of HyMap data, later confirmed by soil geochemistry. Further investigation directly linked three hyperspectral methods over the same deposit. HyLogged, inclined drill core from the Blue Mine Deposit have had their projected surface positions imaged by the airborne HyMap system. By using the Portable Infrared Mineral Analyser (PIMA) surface samples were collected and correlated with HyMap and HyLogger spectra. While the spectral data produced by each instrument differed in amplitude and signalto-noise characteristics, the same mineralogical boundaries could still be identified.



The hugely popular LEME Thematic volume, *Regolith Expressions of Australian Ore Systems*, will be updated through the addition of new case histories that will be available from the Centre's website. These new case histories will expand on what has already become a valuable scientific resource and Centre legacy.

Outlook for 2007-08

All Program 2 projects will focus on the synthesis and delivery of final research outputs through the production of OFRs and LEME Legacy Products, peer-review publications, and conference presentations. The delivery of these outputs to the national and international scientific community is crucial to the Program's success.

The success of the HyChips technology has provided the Objective Regolith Logging Project with further incentive to upgrade the logger's technology and enhance its imaging capability through the addition of an ASD spectrometer. This system, which will be located in Kalgoorlie, WA, will be commissioned in September 2007, and will help promote the benefits of using spectroscopic mineralogy as a MINEX tool to the wider mining and exploration community.

To further define the targets identified in the WA Wheatbelt Uranium Project, Mindax has proposed an aircore drilling program to identify and confine mineralisation and collect water samples for analysis. Additional stream sediment and soil sampling will also be undertaken. This information is expected to further define palaeochannel morphology.

The Predictive Geochemistry AMIRA P778 Project will continue the Centre's generic processes-oriented research into understanding metal dispersion processes in areas of transported cover beyond the life of LEME. Program 2 will produce a summary of its Yilgarn Craton regolith research as part of the Centre's Explorers Guides series. The *Explorers Guide to the Yilgarn Craton*, a pocket size field guide, is planned for release at the final LEME Mineral Exploration Seminar, May 2008.

The hugely popular LEME Thematic volume, *Regolith Expressions of Australian Ore Systems*, will be updated through the addition of new case histories that will be available from the Centre's website. These new case histories will expand on what has already become a valuable scientific resource and Centre legacy.

A Hydrogeochemical Approaches to Mineral *Exploration through Cover* field guide will be released mid 2008.

Program Leader: Dr Paul Shand (CSIRO LW)



Program 3: Environmental Applications of Regolith Geoscience

Highlights

- New mechanistic process models of Acid Sulfate Soils (ASS) formation and oxidation at a range of scales from nano to landscape established (including toposequences, catchments, regions and continental).
- Legend created for the Atlas of Australian Acid Sulfate Soils.
- Loveday Basin flooding successfully curtails noxious smells but high salinity problems remain.
- Advice provided on the environmental risks associated with sulfidic materials to management agencies planning the 'drought response' in the SA Lower Murray.
- Geochemical assessments and modelling concludes that mixing water in receiving environments (rivers, salt lakes) with acid drainage water from drains in the WA Wheatbelt, is insufficient to neutralise acidity.
- Jarosite group minerals and transformations to goethite shown to be key trace element mobility controls in acid sulfate soils.
- Low density geochemical sampling protocol forms the basis for the Australian National Geochemical Atlas, through the National Onshore Energy Security Program at GA.

Overview

Program 3 applies regolith science to environmental problems, with an emphasis on geochemistry and environmental hazards. Using the multi-disciplinary skills of the LEME Core Participants, project outcomes provide robust scientific information upon which land managers can make decisions. Key areas of research include regolith characterisation, ASS process understanding, biogeochemical controls of acidity and metal mobility, and the development of geochemical risk assessment strategies. The projects are multi-disciplinary in nature and involve active collaboration with external research groups, agencies and other end-users.

ACID DRAINAGE IN THE WESTERN AUSTRALIAN WHEATBELT

A study of the geochemistry and hydrochemistry of acidic drains in the WA Wheatbelt, as reported in last year's annual report, has highlighted the need to assess geochemical risks associated with deep drainage. This study has revealed some of the complex processes behind acid storage and release from minerals formed in the drains and other receiving environments. Project research outcomes have been extended beyond the initial Avon Catchment Study with a third project initiated to assess simple treatment technologies.

(1) Acid Drainage – EEI Phase II Wheatbelt Geochemistry Risk Assessment

Brad Degens, Paul Shand, Rob Fitzpatrick, Grant Douglas, Warren Hicks, David Gray, Ryan Noble, Richard George, Adam Lillicrap, Michael Smith

This project expands upon earlier LEME investigations in the Avon Catchment to assess geochemical risks associated with deep drainage in the WA Wheatbelt. Three new regions in WA were targeted for further detailed study: The Yarra Yarra, Blackwood and South Coast catchments.





Deep drainage with alkaline headwaters at Mongers Lake, Wubin.

Program 3 applies regolith science to environmental problems, with an emphasis on geochemistry and environmental hazards. Using the multi-disciplinary skills of the LEME Core Participants, project outcomes provide robust scientific information upon which land managers can make decisions.





Groundwater bore and drain water surveys were completed in the Yarra Yarra Catchment with hydrochemical analysis of a suite of major, minor and trace elements. Soil and sediment samples for detailed mineralogical studies were collected from drain profiles and selected receiving environments. Secondary surface evaporite precipitates and efflorescences, which provide insight into the active evaporation and hydrogeochemical processes, were sampled to assess the variety of evaporite minerals. Sulfidic sediments were well developed in many of the alkalinesaline playa lakes, as well as in deep acid drainage channels. Detailed mineralogical and geochemical analyses of the sediments at each site will be completed and linked in with the regular water quality monitoring. Drain sampling has been completed in the Blackwood Catchment and is currently underway in the South Coast Catchments.

Further model development using the PHREEQC geochemical code was completed. The model's aim is to predict acid neutralisation potential by mixing drain water with waters of known composition in receiving environments. The model takes into account the potential for mineral precipitation and trace element sorption as trace element mobility. Preliminary results indicate buffering capacities of known receiving environment waters are insufficient to neutralise many drain waters with high acidities and remedial engineering action is required to achieve a neutral pH. Laboratorybased evaporation experiments will be completed to support the modelling exercises and determine calibration factors to refine mineral precipitation predictions and trace element behaviour during mixing and neutralisation processes.

(2) Evaluation of Acid Drainage Treatment Technologies

Brad Degens, Warren Hicks, Grant Douglas, Mark Raven, Paul Shand, David Gray, Ryan Noble, Richard George, Adam Lillicrap, Michael Smith

This project forms part of the Avon Catchment Council (ACC) investment in Salinity Management Project. The Project aims to:

- Review and report on available treatment methods for acidic-drainage waters
- Identify feasible treatment methodologies and sites for method evaluation
- Construct and evaluate practical options for treatment of acidic-saline drainage waters, focussing on the discharge point of drains
- Evaluate simple, low cost options for treatment of acidic-saline drainage waters in drains
- Identify, evaluate and demonstrate practical options for treatment of acidicsaline drainage waters by mixing with alkaline surface waters
- Develop a set of best-management practice guidelines for such drainage treatments in the Avon Catchment
- Promote evaluation trials and best management guidelines to the broader Avon River Basin Community
- Contribute to 2006-08 salinity management investment planning for the Avon Region.

During the reporting period, a review of potential acid neutralisation treatments for acid drains in the Wheatbelt was completed (LEME OFR 209). As a result, six on-ground Establishment of a pilot compost treatment wetland for acid drainage alongside an evaporation basin, Beacon

pilot treatment sites were established by the WA Department of Water to investigate lowcost, practical treatment options for acidic drainage waters. These include the use of simple engineering structures using either calcite (calcium carbonate) neutralisation, or sulfate reduction systems that utilised locally available carbon sources.

LOVEDAY BASIN FLOODPLAIN SULFIDIC SEDIMENTS

Studies of the Loveday Basin in the Riverland Region of the Murray Basin are a focus of LEME ASS research. Formerly an ephemeral wetland, the site was subsequently used as a disposal basin between 1970 and 2000. This work, in collaboration with the SA Department of Water, Land and Biodiversity Conservation (DWLBC), provides regolith biogeochemical and hydrogeochemical inputs into the site's rehabilitation. The Loveday Basin was chosen as a test case to assess the impact of reflooding the wetland with the aim of restoring the basin to an ephemeral, river red gum-dominated wetland.

(1) Drawdown Geochemistry

Sebastien Lamontagne, Warren Hicks

The Loveday Disposal Basin flooding experiment was completed during the year. Water quality monitoring in the basin, which began prior to the re-flooding event, was undertaken for almost a year. From a





Changes in electrical conductivity in the Loveday Basin prior to, and following, flooding

management point of view, the experiment was a partial success, as flooding of the basin did curtail noxious smell emissions during the summer of 2006-07. However, due to drought conditions in the Murray-Darling Basin, the delivery of water from the river to basin was curtailed earlier than anticipated by management agencies. As a consequence, salinity was only temporarily lowered and saline conditions returned by March 2007. The final monitoring program report will provide the most detailed evaluation to date of biogeochemical changes in a saline Lower-Murray Wetland during a wetting-drying cycle.

A visiting student, Julie Corriveau from Institut National de la Recherche Scientifique Eau, Terre et Environnement, Canada, evaluated the evaporation rate at Loveday Disposal Basin by measuring the stable isotope fractionation of water during evaporation. This fractionation was measured using a constant-feed pan experiment and the data published as part of a CSIRO LW technical report (35/07), LW Adelaide.

LEME has advised on the environmental risks associated with sulfidic materials to the management agencies responsible for planning the drought response in the SA Murray-Darling Basin. In particular, a recent report on the generation of noxious odours from saline wetlands (LEME OFR 208) has been widely distributed to management agencies. The OFR was included in a brief on the environmental risks associated with the drying of saline wetlands, presented to the SA Minister for the Murray.

(2) Geomicrobiology and **Geochemistry of Acid Sulfate Soils**

Sue Welch, Sara Beavis, Dirk Kirste, Luke Wallace, Sarah Tynan

This project focussed on the physical, chemical and biological controls of sulfur and salts in the Loveday Basin.

Detailed analyses of basin sediment acid buffering capacity showed extreme variability in biological activity and oxidation extent over centimetre scales. There was considerable spatial variability within individual peds, but generally increasing from an oxidised edge towards a more reduced middle. This micro scale variability has significant implications when designing representative sampling regimes for these materials.

Salt stores within basin sediments were estimated. Salt distribution and composition of salts varied with location and depth. Maximum concentrations occurred at the wet-dry zone surface where readily soluble salts, largely dominated by gypsum, comprised 50-100 mg/g of sediment. Salts in the pore water comprise only a fraction of the total salt in the sediments, ranging from a few percent in the wet-dry zone up to 30 % of the total in the drier parts of the basin.

X-ray diffraction determined that the mineralogy of the ped's clay fraction, and underlying sediment was composed of montmorillonite/smectite, kaolinite and illite. In contrast, montmorillonite/smectite was absent in the sediments taken from the surface and crack materials. Overall, the ped material and underlying sediment routinely showed a higher clay percentage than found in crack materials and surface sediments.

The differences in clay mineralogy and content will affect salt storage, as montmorillonite/smectite can readily exchange ions from interlayers with the shrink-swell characteristics influencing the salt flux from the peds and underlying sediments to solution. An implication of these findings is that the sediment's physical properties may be exacerbated by the different wetting-drying regimes used in remediation.

Acid Sulfate Soils and Trace Metal Geochemistry

Sue Welch, Dirk Kirste, Sara Beavis, Lloyd Isaacson, Andy Christy



Sampling sediment profiles from the Loveday Basin, prior to flooding.

This long-term study of a coastal ASS site near Kempsey, NSW, has provided a detailed analysis of the spatial variability of surface and pore water geochemistry. During the last few years, the site has changed dramatically as a result of controlled flooding of the area. The surface has evolved from an area with sparse vegetation and extremely acidic conditions (pH < 4) to a site largely covered by dense vegetation and neutral pH. However, below the surface, sediments and pore water are still extremely acidic (pH ~ 3-4), particularly in a jarosite and goethite mottled zone. Trace metal concentrations of cobalt, zinc, copper, cadmium, nickel,



RESEARCH PROGRAMS

Distribution of copper Bottom Floodplain Sediments in the Thomson pilot project area. BH: Broken Hill, T: Tibooburra, W: Wilcannia, B: Bourke, C: Cobar, N: Nyngan, LR: Lightning Ridge.



yttrium, lanthanum and cerium are of the order of 100's ppb to low ppm in pore water extracts. Trace metal concentrations generally correlate with pH, however, the maximum concentrations consistently occurred towards the bottom of the soil profile where the pH begins to increase from about 3.5 to 4. This zone coincides with a mineralogy change from jarosite to goethite rich mottles.

A model describing mineralogical controls on trace element geochemistry in acid sulfate soils was created. The rapid biologicallymediated oxidation of pyrite resulted in the formation of jarosite. Jarosite can incorporate numerous elements as substitutions into its structure, so trace metals leached from the soil matrix can be concentrated in jarosite by a factor of 10 to 100 fold above background levels. This has important implications for managing acidic conditions, as flooding the site to reduce pyrite oxidation can cause jarosite dissolution and trace metal release. This is also an important consideration for understanding metal mobility in the initial stages of oxidation as it appears that jarosite formation in extremely acidic conditions will lessen the initial metal fluxes from the system as they are sequestered in the jarosite structure

Low-Density Geochemical Surveys

Patrice de Caritat, Megan Lech, Amy Kernich

As outlined in previous Annual Reports, LEME and GA have carried out pilot geochemical surveys aimed at developing and field-testing a low-density sampling strategy adapted to Australian landscapes and climatic conditions. Protocols for sample collection, preparation and analysis were developed to ensure the acquisition of quality data.

Pilot projects were undertaken in the Curnamona Region of western NSW and eastern SA, and in the Riverina (southern NSW and northern Vic), Gawler (central SA) and Thomson (northern NSW) regions. Details of these projects have been previously reported by CRC LEME.

Based on the techniques and IP generated by LEME in these pilot projects, a National Geochemistry Survey of Australia received funding under the Australian Government's new Onshore Energy Security Program (OESP) in August 2006.

Inland Acid Sulfate Soils (ASS)

Rob Fitzpatrick, Warren Hicks, Paul Shand, Mark Raven, Graham Heinson, Richard Merry

The Inland ASS Project has a framework in place to develop a national understanding of the spatial distribution and process of Inland ASS formation and related hydrology in Australian regolith environments.

Significant progress has been made using synchrotron techniques to determine mineral host trace element relationships on soil samples containing elevated concentrations of arsenic, selenium, zinc, copper and chromium. Research has focussed on X-ray absorption to study ASS samples and will broaden in the future to X-ray diffraction techniques.

A series of ASS forums were conducted in Tasmania to inform national and local collaborators and stakeholders about the issues and potential impacts that ASS can have on the environment, infrastructure and industry in that State. The forums provided examples of how other States have dealt with ASS, including presentations on policy, research and remediation. Feedback received about these forums has been very positive. During the year, seven new case studies were completed in Tasmania, ranging from near coastal environments to inland saline playa lakes. Several new mechanistic models were developed in the SA Lower Lakes, WA Wheatbelt, Vic Corangamite District, and NSW Dicks Creek using the toposequence approach, which integrates pedological, mineralogical, hydrological, biogeochemical, geological, climatic and land-use information. Improved risk assessment and land management systems for ASS have been completed.

Two LEME/UA PhD students, Andrew Baker and Mark Thomas, completed their theses during the year, which covered such issues as Inland ASS in a lead-zinc mineralised zone, degraded wetlands and polluted streams.

Outlook for 2007-08

The main focus in 07-08 will be the delivery of project outputs to end-users. The WA Wheatbelt Drainage projects will continue beyond the lifetime of LEME. The responsibility for final delivery will rest with the relevant LEME Core Participants, the projects providing an important avenue to continue regolith science studies established through LEME.

Treatment technologies will also be studied, including pilot-scale treatment/evaporation basins, in-stream treatments and mixing with alkaline surface water. Geochemical modelling will be improved by the development of a user-friendly interface. Emphasis will be placed on research delivery through journal and report publications and a science forum in Perth, including the launch of a web-based information delivery system for the project. Delivery to end-users in the Wheatbelt will be linked into EEI forums at locations throughout the region.

The Low Density Geochemical Survey Project will release a LEME OFR summarising the two pilot study regions and a synthesis report.

Work will continue on the production of a thematic volume detailing the distribution, properties, significance and management of inland ASS in Australia and internationally. This publication will be launched at the 2008 International Salinity Forum, Adelaide, March 2008.

Incorporation of inland ASS into the National ASS map of Australia will be a focus for the coming year, with a number of forums planned that will link national and local ASS groups in Northern Territory and South Australia. Program Leader: Dr Ken Lawrie (GA)



Program 4: Salinity Mapping And Hazard Assessment

Highlights

- Successful delivery of airborne geophysics-based products, underpinning groundwater and salinity management in several projects along the River Murray Corridor in SA and Vic.
- Development of a new generation of groundwater flow system (GFS) products in collaboration with DPI Vic, MDBC and CMAs in NSW and Vic.
- Delivery of new 3D models of aquifer systems in the Ord and Burdekin Catchments for the Irrigation sector.
- Development of the first national salt accession map.
- LEME-developed NanoTEM tool yields high-quality results.
- Andrew Fitzpatrick receives an award for his paper delivered at the 20th Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP) in Denver, USA.
- Release of LEME OFR 193 Potassium-Argon Ages of Late Mesozoic and Cainozoic Igneous Rocks of Eastern Australia
- Australian Journal of Earth Sciences (AJES) accepts 17 papers based on Program 4 research outputs, as part of a two-volume issue on South Australian Salinity, for release in 2007-08.

Overview

Program 4 generates knowledge and techniques to facilitate the mapping, assessment and prediction of salinity stores and discharges, in both regolith materials and groundwater. This is achieved through an understanding of generic processes such as salt stores and mobility, aquifer parameters, and groundwater flow models. The Program utilises a range of AEM platforms and systems, including DigHEM, Resolve, TEMPEST, and SkyTEM to provide reliable and relevant geological and Hydrogeological information. In addition a new NanoTEM tool has been developed that can be towed behind a vehicle to create a shallower, but rapid means of data acquisition. The Program has also applied new generation of GFS products to groundwater and salinity management issues. These map, and model-based products provide, new insights into understanding groundwater and salt movements, from small sub-catchment to regional scales.

New towed frame NanoTEM tool developed by Mike Hatch, UA, provides images to a depth of some 10 m at a rate of 5 km/hr.



Collaborative Projects with Murray-Darling Basin Commission

Ken Lawrie, John Wilford, Colin Pain

In the past year, Uplands Dryland Salinity Program outcomes have been finalised, through the creation of detailed GFS maps for multiple landscape processes and asset protection, including salinity management. Three basic products have now been developed with sensitivity analysis carried out to ensure they have the resources and are equipped to address the specific problems faced at different scales. The first map provided a rapid assessment, desktop studybased GFS map for Gardiner's Creek (Vic); the second map involved a more detailed approach that incorporated fieldwork in the Bet Bet Catchment; and the third map, based around a rules-based, multi-scale approach, allowed the creation of new data sets over catchments and regions such as the Upper Loddon and Central West NSW catchments. While these products have much potential, work is planned with the CRC for Future Farm Industries (FFI), other State Agencies, and CMAs to further assess their practicality in addressing specific management issues.

(1) Desktop Study – Gardiner Catchment, Victoria

A new GFS map has been compiled for the Gardiner Catchment located in the southwestern part of the Goulburn River Drainage System in Central Victoria. The Gardiner Catchment contributes about 3569 tonnes of salt a year to the Goulburn River. A moderate resolution option for defining the GFS was the main consideration when designing the map, compiled from aerial photography interpretation combined with soils, regolith, landform, geological, DEM, radiometric and drilling data. Now completed, it is expected to provide a suitable framework within which more detailed investigations, such as those developed by LEME in the Bet Bet Catchment, can be developed.

A significant improvement in flow system resolution was achieved by subdividing four GFS units on an earlier version of the map into 17 new GFS units. This subdivision has provided a more accurate depiction of scald distribution than previously. The new seepage zone data provides a much greater understanding of the hydrological and salinity characteristics within the catchment. The new GFS map will be used to build more reliable hydrological catchment models to support more effective and targeted salinity management options.

(2) Catchment Extrapolation Product-Loddon Catchment, Victoria

The Loddon Catchment, which is about 1.5 million hectares in size, is a northwarddraining subdivision of the Murray River System within the North Central Catchment Management Authority Region (NCCMAR) located in central Vic. The Loddon GFS Map is a rapid catchment characterisation model, which provides improved information on groundwater and salinity movements to assist in effective salinity management.

Extract from the new GFS map for the Loddon catchment showing the GPS units in colour and bedrock structural features as black lines.



The mapping approach delineated and integrated geology, bedrock structures, landforms and regolith to identify and describe individual GFS units. Existing 1:100 000-scale geological maps were then used to define main bedrock and depositional units, with enhanced airborne magnetics identifying multi-layered aquifers associated with basalt flows under cover. Magnetics and DEM derivative images highlighted structural lineaments and valley constrictions on the map. While other landforms were determined using terrain modelling techniques based on the 25m DEM units, the degree of surface weathering over bedrock dominated landscape was determined using a rules-based approach based on the airborne gamma-ray spectrometry imagery. These components, which had similar hydrological and salinity characteristics, were then combined into GFS units.

This type of analysis has led to a greater understanding of the inter-relationships between regolith, bedrock structures, landforms, groundwater and salinity. A sensitivity analysis will be conducted to assess the value of the new GFS data within the hydrological modelling environment.

Part of the Loddon catchment. Top – classification of the digital elevation model. Bottom – GFS units as defined through the analysis of terrain attributes, geology and regolith.



River Murray Corridor (RMC)

Ken Lawrie, Colin Pain, KP Tan, Jon Clarke, Heike Apps, Dave Gibson, Richard Lane, Vanessa Wong

The River Murray Corridor (RMC) Salinity Mapping Project, managed by the Bureau of Rural Sciences (BRS), has generated vital data to address salinity, land management and groundwater resource issues along a 450 km reach of the Murray River from the South Australian border eastwards to Gunbower in Victoria.

River Murray Corridor study areas.



The AEM data will be further interpreted using a 4D landscape analysis approach to complement more traditional hydrogeological analytical techniques. This approach provides key constraints on interpretation of both near-surface AEM responses and floodplain hydrostratigraphy. On a broader regional scale, this approach has been used to predict major changes in AEM responses and hydrostratigraphy related to the avulsion of the Murray-Wakool-Edwards River systems.

South Australian Murray Floodplains

Tim Munday, Andrew Fitzpatrick

Funded jointly with the South Australian Centre for Natural Resources Management (CNRM), the project is creating a better understanding of floodplain processes and managing floodplain riparian vegetation through the use of airborne geophysics. Results from the Chowilla Floodplain and Living Murray project's Bookpurnong Pilot Site have confirmed the flushing zone extent



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adjacent to the Murray River, and the vegetation dependency on these fresh water lenses. In particular, this project has improved the confidence to use this data to define floodplain process, such as the attenuation and release mechanisms of salt stores, and the spatial variability of these processes.

A collaborative study with Ian Overton (CSIRO LW) demonstrated that Helicopter EM (HEM) products incorporated into the "WINDS" model, result in an improved vegetation health prediction across the Chowilla Floodplain, rising from 60 % to 72 %. The project has also demonstrated that the textural characteristics of the floodplain sediments are influenced by lateral recharge effectiveness, which has significance in determining the value of selected flooding (environmental flows) along some of the isolated anabranches in the floodplain.

In collaboration with CSIRO LW and DWLBC, the CNRM Project has also linked the its geophysical studies to detailed investigations of wetland biodiversity and vegetation health. Volmer Berens (DWLBC) was seconded into the project to assist in technology transfer, and ensure a more direct interaction with the Centre's Living Murray research on the Bookpurnong Floodplain and elsewhere. Volmer has also helped LEME in the evaluation of a new AEM system recently introduced into Australia, the Danish SkyTEM. In particular, he has begun working with the Centre, GeoForce and SkyTEM in determining SkyTEM data processing issues, given the very high ground conductivities encountered in Australian landscapes.

Stockyard Plains salt disposal basin HEM case study has demonstrated how spatial data derived from airborne geophysics can assist the understanding of disposal basin performance elsewhere in the Murray Basin.

Sunraysia and Gol Gol Lake AEM Surveys, Victoria and NSW

Tim Munday, Andrew Fitzpatrick, KP Tan, Kevin Cahill, Amanda Cornelius

In late 2005, the Sunraysia Salt Interception Integration and Optimisation Steering Committee, endorsed by the MDB Ministerial Council and supported by the Mallee CMA, Goulburn-Murray Water, the Department of Water and Energy (NSW), and the Lower Murray Darling CMA, initiated an AEM data acquisition project over the Murray River Sunraysia Region. Data has provided an insight into groundwater salinity variation across the floodplains and adjacent highland areas, resulting in an improved knowledge of the flushing extent adjacent to the main channels. This information will be used to refine groundwater models, ecological management, and salt interception strategies for the area. In the latter case, the data will underpin the refurbishment planning and extension of the Mildura-Merbein Salt Interception Scheme, and assist in the design of a new salt interception scheme in the Red Cliffs area. It is also expected to play a role in the development of long-term management strategies for Salt Interception Schemes throughout NSW, such as the Kings Billabong Area.

Eyre Peninsula

Andrew Fitzpatrick, Tim Munday

The aquifer systems of the lower Eyre Peninsula are an important water supply source for the region. Demand from these aquifers is approaching current extraction limits, and there is a need to undertake further modelling of existing groundwater systems in order to determine their resource limitations. Following encouraging results from EM surveys in the area, which suggested that Quaternary and Tertiary aquifer system elements could be resolved by electrical methods, LEME worked with SA Department of Water to put forward a modelling study framework to determine whether AEM would produce similar results. The proposed AEM survey would focus on generating data that could help map the top of the Tertiary aquifer, define water quality in the Quaternary aquifer, provide an approximation of the lower Tertiarybasement boundary, determine quality variability in the Tertiary aquifer and assess the potential for saltwater incursion into the quaternary aquifer. AEM data acquisition occurring over the Coffin Bay area commenced in the second half of 2006.

Stockyard Plains, SA

Andrew Fitzpatrick, Tim Munday

Airborne geophysics, particularly AEM, has significant, though unrealised potential to increase the understanding of disposal basin hydrodynamics. This project has examined the use of HEM to provide an understanding of the scale and magnitude of processes operating in the Stockyard disposal basins, located southwest of Waikerie. The project is also expected to provide practical information for formulation of management options for the disposal basins located adjacent to the Stockyard Plains.

The project was initiated by the SA DWLBC to interpret HEM data acquired over the Stockyard Plains. Through the application of constrained inversion techniques, the project has identified the extent of a saline plume migrating away from the basin in a south easterly direction. This observation appears to be at odds with the accepted model for plume migration to the west. Examination of the regional geology, linked to an understanding of the neotectonism of the western Murray Basin, suggests existing hydrogeological models for disposal basin performance are in need of revision. An understanding of regional geology, particularly the presence or absence of the Blanchetown Clay, which acts as an aquitard, has been inferred from the data. When linked with local topographic data, this information will provide an indication of the potential for extending disposal options in the vicinity of the existing basin. This case study has demonstrated how spatial data derived from airborne geophysics can assist the understanding of disposal basin performance elsewhere in the Murray Basin.
Beaufort Palaeochannel WA, and Angas Bremer WA/SA

Tim Munday Andrew Fitzpatrick, Kevin Cahill

Both projects are investigating the potential of AEM data to better define regolith hydrogeology at selected study sites. The Beaufort Palaeochannel project is a pilot project to assess the role of SkyTEM data in defining the location, extent and thickness of a palaeochannel in the Haddleton Nature Reserve in southern WA. During the year, test lines were successfully processed to reveal the palaeochannel in its anticipated location.

AEM data previously obtained for the Angas Bremer Plains Region of SA as part of the South Australia – Salinity Mapping and Management Support Project (SA-SMMSP) was re-processed, with constraints applied, to better define aquifer salinity and depth to the saturated zone. The project's emphasis was to generate data for direct use in conceptual and analytical models that determine regional water and salt mass balance. It has already produced models for shallow aquifer salinity and soil salinity. At a time of drought, project outputs have added value in better constraining the available groundwater resource for the Bremer Plains Irrigators.

Airborne EM

Tim Munday, Andrew Fitzpatrick, Richard Lane

The AMIRA P407B Airborne EM project concluded in September 2006. The project achieved its objectives of developing a methodology for AEM system calibration and improving the conductivity maps and sections derived from HEM through the automated fitting of 2D and 3D models.

The Centre has made significant use of HEM data, particularly its environmental utilise applications that accurate conductivity information. Results from the calibration and geometrical variation studies of HEM data have provided valuable insights. Detailed procedures and software (Phiß) that delivers calibration and recalibration methodologies have gone on to be used by other Centre projects. Overall, the project has developed and delivered key software and provided useful recommendations on AEM system calibration and conductivity processing.



Ord Irrigation Area-Improving Hydrogeological Models of Aquifer Systems

Ken Lawrie, Jon Clarke, Paul Wilkes, Mike Hatch

The project applied geophysical acquisition and modelling techniques to map and model complex layered sand/gravel aquifer systems in the Ord region where near-surface salinity is an issue.

It completed its three phase strategy during the year, which included: the evaluating new geophysical and remote sensing technologies for mapping, developing new insights and understanding of regolith and aquifer systems, and using these findings to develop innovative salinity management strategies.

The final six months of the project focussed on interpretation and integration of acquired data and the incorporation of this data into the environmental management tools for the Catchment.

Lower Burdekin – New Insights into Aquifer Systems in the Burdekin Irrigation Area

Ken Lawrie, Andrew Fitzpatrick and Jon Clarke

This project has concluded its study of the hydrogeology of the Burdekin Delta – an area subject to salt water intrusion due to a prolonged period of irrigation.

Geophysical data acquisition surveys such as active gamma and neutron logging and Electro-Kinetic Seismic (EKS) surveys provided detailed information on lithology, porosity and permeability. The data have revealed the complex stratigraphy of the Delta.

The project is a small component of several large multi-disciplinary projects within the CSIRO Water for a Healthy Country Flagship. Results have been included in the publication Irrigation Insights Number 7 – Geophysics for the Irrigation Industry.

Rural Towns – Liquid Assets WA

Paul Wilkes, Brett Harris

Through resource identification and management strategies, this project is developing new local water resources for a selection of Western Australian rural towns impacted by salinity. LEME is a research partner in this three-year (2004-2007), multi-agency project led by the WA Department of Agriculture and Food in collaboration with CSIRO, through the Water for a Healthy Country Flagship, the WA Chemistry Centre, the University of Western Australia, and the WA Water Corporation, as well as 16 Western Australian rural shire councils.

The project has worked with these 16 shires which are most affected by salinity, to devise and deliver water management plans aimed at water abstraction and re-use.

LEME's role has been to provide regolith geoscience expertise to help develop workable saline water management plans.

In late 2006, 20 boreholes and one production bore near the town of York were geophysically logged. Originally drilled in 2002, these bores intercepted palaeochannel located at about 75 m below the surface. The program measured electrical conductivity (EF) and gamma log data to reveal that the intercepted palaeochannel is located west of the Avon River. Gamma log data has provided information about the regolith and bedrock, while electrical conductivity logs have shown the salinity variation in regolith. Geophysical investigations will be completed in the final guarter of 2007.



Landscapes Analysis

Dave Gibson, Colin Pain, Jon Clarke

During the reporting period, data was collated on more than 1100 potassium-argon age determinations on Late Mesozoic and Cainozoic igneous rocks in Eastern Australia, for publication as LEME OFR 193. This dataset will allow easy reference to locations and ages of basalt flows, knowledge of which is critical in determining rates of landscape development since eruption, as well as providing a database for the study of Cainozoic igneous rock. The data has been tabulated in a form for ready use in GIS applications, along with digital geology coverages and DEMs.



Richard Cresswell, Dirk Kirste, KP Tan, Richard Greene

The majority of Murray Darling Basin (MDB) rivers export more salt than received by rainfall or surface inflow. This has been ascribed to water balance changes following clearing and agricultural development. Salt transfer is generally treated as a hydrological problem, with electrical conductivity (EC) measurements assumed to reflect salt load.

During the reporting period Hodgson Creek, a third order salt-exporting catchment located in the northern MDB, was used to evaluate the efficacy of this assumption.



Program 4 generates knowledge and techniques that facilitate the mapping, assessment and prediction of salinity stores and discharges, in both regolith materials and groundwater. This is achieved through an understanding of generic processes such as salt stores and mobility, aquifer parameters, and groundwater flow models.

Hodgson Creek exports 9000 t salt per year. This is comparable to the higher exporting catchments of the southern MDB. In contrast to rivers in the southern MDB, EC in Hodgson Creek groundwaters is dominated by non-chloride salts, mostly sodium bicarbonates and relatively high levels of magnesium from regional basalt weathering. Salt export is dominated by infrequent, large flood events of low salinity which has raised the issue of salt load significance when describing salinity impacts and end of valley targets. Of the 1400 bores sunk in the area, only 21 are used for routine monitoring, 500 have geochemical data and 200 are pumped for irrigation.

Geochemical and isotope analysis has helped define the GFS and appropriate attributes required for modelling catchment groundwater and salt movement, as well as reactive salt evolution. Groundwater chemistry will be compared with stream base-flow to examine its significance to wider salinity studies and end-of-valley salinity determinations. The groundwater component will be quantified and equilibrium mass balance reactions will be used to estimate water evolution through regolith. As part of this project, work commenced on the compilation of a salt accession map of Australia





Left: Richard Cresswell determining alkalinity in groundwater in the Goondoola Basin, Queensland Murray-Darling Basin. This internally draining region is at high risk from salinity and acidsulphate soils, with serious consequences for the Moonie River.

Above: Rising saline groundwater resulted in the (locally known) "Dead Sea" near Yeppoon, Fitzroy Basin, Qld. Remnant Tertiary volcanic plugs remain in this heavily eroded landscape.



Aquifer Parameterisation

Anton Kepic

This project has applied high resolution experimental seismic reflection methods such as EKS to gather aquifer formation information that will assist aquifer modelling.

During the year, Karl Butler from University of New Brunswick (Canada) and his PhD student Christian Dupuis undertook an EKS study site in the Burdekin River Delta, Qld following the successful results achieved by LEME/CUT PhD student Mohammad Rosid. Data from this study is still being analysed and reviewed. Once completed, it is anticipated that the results will be published during 2008. Some difficulties were experienced reconciling the numerous EKS responses, due to the area's complex stratigraphy.

Outlook for 2007-08

Program 4 will shift its focus from research to Legacy Product finalisation to ensure outcomes are captured and communicated to stakeholders and clients.

Products from the River Murray Corridor Project will include a suite of surface maps that show landforms, vegetation and surface materials, set for release in late 2007. The Project's geomorphology-surface map materials have been compiled at 1:25 000scale with draft 1:100 000-scale products planned for production in 2007-08. The surface material maps will serve as a valuable range of stand-alone products for broader application, which will aid the interpretation of AEM data.

A special monograph reviewing research into the sedimentology, stratigraphy and regolith geology of Australia's Cenozoic cratonic basins will be produced in conjunction with the International Association of Sedimentologists (IAS). The publication will feature a selection of papers by LEME authors, edited by Jon Clarke and Colin Pain. Once released, the 300-400 page monograph is expected to become a benchmark for understanding Australian Cenozoic cratonic basins. Its release is planned to coincide with the 2008 International Salinity Forum (ISF08).

A special volume of case studies discussing the use of DEMs in environmental mapping and management will be released during 2007-08. This volume will present case studies that illustrate how DEMs can be used for environmental mapping and management and explain how science geomorphology-regolith and mapping can be applied environmental A LEME thematic volume issues. summarising environmental geophysics case studies will also be released in the coming vear.

'Knowledge Series' products will be developed with the MDBC. They include: a report documenting the new GFS valueadding methodologies for the MDB, summarising in-river nanoTEM geophysics and comparing and contrasting AEM and inriver technologies, a summary of the use of AEM geophysics for salinity management in floodplains, a two-volume issue of the Australian Journal of Earth Sciences on salinity in South Australia, and a thematic volume on salt accession to Australia – including national and regional maps.

A key focus will be on the ISF08 to be held in Adelaide between 30 March and 3 April. The Centre is co-organising the event and has a leading role in running of field trips and organising workshop activities. A selection of LEME Legacy Products will be launched at this event.

Project-based knowledge transfer activities will continue throughout the year. Program 4 staff will contribute to a number of national and international conferences including the International Geoscience Convention in Norway, and assist in the organisation of sessions at Australian Earth Sciences Convention 2008 in Perth.

Efforts will be made to ensure there is a successful transition of the research Program to Core Participants beyond the life of the Centre. Already, the success of the airborne geophysics projects in south eastern Australia has led to incorporation of airborne geophysics as an integral component of CSIRO's Water for a Healthy Country Flagship. Similarly, AEM research will continue along the Murray River in the BRS-managed RMC project with discussions under way with Core Participants to undertake similar studies elsewhere.

For the dryland/uplands salinity research projects, workshops are planned during 2007-08 to fully assess next generation GFS products designed for multiple landscape processes and asset protection, including salinity management.



LEME continues to engage in a high level of collaboration internally and externally, while maintaining effective collaborative linkages between its eight Core Participants, industry end-users, the scientific research community, government authorities and community stakeholders.

Internal Research Linkages

The many multi-party and multi-disciplinary LEME projects ensure regolith knowledge is directed towards the needs of the diverse set of stakeholders in both MINEX and NRM industries. Of the 43 projects funded by the Centre, 16 had participation from more than one Core Participant. Most 'one-party' projects concentrated on technology developments (for example, geochronology Dating methods) or specialist services.

CSIRO and Queensland Department of Natural Resources and Water share the load (and each other's clothes!), sampling groundwater in the Goondoola Basin. L-R Richard Cresswell (CSIRO LW), Ralph Devoil (QDNRW), John Dighton (CSIRO LW), Andrew Biggs (QDNRW)

Student Program Linkages

Honours and PhD student studies are integrated into research projects with LEME staff members providing supervision. However, for ease of financial and IP management, they are not formally brought into individual projects in the core research Programs. LEME students make significant contributions to the overall research effort. They benefit from networking with LEME government industry and staff, organisations: WA Departments of Environment and Conservation, Agriculture and Food, and Water, DWLBC South Australia, ANSTO, Tanami Gold, Heathgate Resources, Newmont Australia, Barrick Gold, Anglo American and Zong Engineering.

Linkages with industry and other end users

Twenty six of the LEME 2006-07 projects are classified as industry/commercial projects. They draw cash contributions from National and State Government NRM agencies, as well as major, mid-tier and junior MINEX companies. In addition to the cash contributions, there is a significant in-kind contribution to several of these projects.



Sampling ASS in a salt lake near Tunbridge, Tasmania: part of a national study to map and characterise inland ASS.

Networks are continuously expanded via the two interactive advisory groups – MAC and LUAC – providing MINEX and NRM stakeholders with opportunities to define research focus and appropriate delivery strategies. In this way,

Linkages with users of Centre research are also promoted through staff and student participation in conferences and industry workshops. This publicises LEME research and facilitates networking. Details of these activities are provided in the Communication and Publications section. LEME personnel presented at 20 international and 30 national conferences/seminars during the reporting period. LEME conducted or sponsored 11 seminars and symposia that attracted some 1,300 attendees.

International Linkages

LEME continues to nurture its international linkages where collaborative knowledge can improve the understanding of Australian regolith processes.

For example the work with the Guilin University of Technology, China to evaluation the CHIM electro-chemical technique and other geochemisal methods as outlined in Program 1 Central Gawler Landscapes Project description

The Centre, as part of its involvement in the Program 2 Predictive Geochemistry Project (AMIRA P778), collaborated in a metal mobility field trial at the Codelco-owned, Inca del Oro porphyry copper prospect in Chile and participated in sponsors meetings at the University of Chile and other workshops. Right: Researchers from University of Chile and Codelco with Ravi Anand studying geology of the Inca del Oro prospect (P778).

Far right: Alviro Puig (Codelco), Ravi Anand (LEME), Graham Carr (CSIRO EM) and Brian Townley (Uni Chile) studying regolith in the Atacama Desert.

LEME's pioneering work, especially in salinity research, is increasingly recognised internationally. This has been demonstrated by Program 4 Leader, Ken Lawrie's involvement in the Organising Committee for ISF08 to be held in March-April. This will be a key LEME legacy event where the Centre will deliver many of its salinity focussed project outcomes.

Collaboration with CRCs and other research providers

Collaboration with CSIRO Mathematical and Information Sciences continued to be a critical part of the LEME's Program 2 Objective Logging Project, which has developed unmixing algorithms for the rapid determination of relative regolith material abundance in core and chip field samples.

The Centre's work with the GSWA and MERIWA concluded this year with the release



of the project's final report *Laterite Geochemical Database for the Western Yilgarn Carton,* Western Australia as a GSWA report and as CRC LEME OFR 116. Since its release in June 2007, the report has become a valuable reference for mineral explorers.

During the year, LEME commenced its collaboration with the Qld Department of Natural Resources, Mines and Water to produce a 1:2.5 million-scale regolith map and associated atlas of the State. The Dept, through the Geological Survey of Queensland, has included the project as part of its \$20 million Smart Exploration Initiative. It is anticipated the project will be completed by mid 2008.

LEME continued to gain exposure from its collaboration with the CRC PBMDS by providing articles for its quarterly technical magazine, *Focus on Salt*. This publication has a circulation list of some 5,500 with CRC PBMDS responsible for the overall editing, layout and production. During 2006-07, LEME contributed some 15% of editorial material and production costs.

CRC PBMDS contributes, along with LEME towards research funding for ANU PhD student, Glen Bann, who is working on a these is into dryland salinity and biodiversity loss.

LEME, other Perth based CRCs and CRCA representatives formed the organising committee for the 2007 CRCA Conference, May 07, Perth. This group selected keynote speakers, gained sponsorship and organised the CRC Expo and PR.

LEME CEO, Steve Rogers, continues to represent the Minerals and Energy Sector on the Cooperative Research Centre Association Board.



LEME has conducted consultancies and training courses with a number of companies and government agencies during the year.

Shown below are organisations that contributed financially towards LEME activities during the reporting period.

Anglo American Australian Mineral Fields Pty Ltd Barrick Gold **BHP** Billiton Bureau of Rural Sciences Cameco Australia Pty Ltd Codelco CVRD Dept Environment and Conservation, WA Dept of Water WA Dept Water and Land Biodiversity SA Dept Natural Resources and Mines, Qld GeoForce Goulburn Murray Water Authority Iluka Resources Ltd Inco Technical Services Independence Gold Land and Water Australia MERIWA Mindax Ltd Murray Darling Basin Commission Newmont Australia NSW Catchment Management Agency Quasar Resources Ltd South Australian Centre for Natural **Resources Management** Tanami Gold NL Tech Cominco SA Water SGS Minerals



The Centre, as part of its involvement in the Program 2 Predictive Geochemistry Project (AMIRA P778), collaborated in a metal mobility field trial at the Codelcoowned, Inca del Oro porphyry copper prospect in Chile and participated in sponsors meetings at the University of Chile and other workshops.



Collaboration, Technology Transfer and Utilisation

The following tables list organisations that collaborated with the Centre or were end-users of LEME research outputs during the reporting period. In addition to sponsorship, *most of these organisations contributed in-kind – e.g. travel costs, equipment.*

LEME RESEARCH USERS AND COLLABORATORS SMALL, MEDIUM AND LARGE ENTERPRISES

Research User/Collaborator	Project – Activity	Interaction	Leader, Student / Supervisors	Core Party
Anglo American	Tanami	Research collaboration	Lisa Worrall and team	GA
Anglo American	Nickel Hydrogeochemistry	Research collaboration	David Gray	CSIRO
Anglo American	Interpretation of groundwater chemistry on exploration tenements	Research collaboration	Patrice de Caritat, Bear McPhail	GA, ANU
Anglo American	Interpretation of groundwater geochemistry: Northern Chile and north western India	Research collaboration	Bear McPhail, Patrice de Caritat	ANU, GA
Australian Mineral Fields Ltd	Nickel Hydrogeochemistry	Research collaboration	David Gray, Ryan Noble	CSIRO
Barrick Gold	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Barrick Gold	Tamami	Research collaboration	Lisa Worrall and team	GA
BHP Billiton	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Cameco Australia	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Cobar Management Pty Ltd	Regolith assessment, and training	Technology Transfer	Ken McQueen	ANU
Codelco Copper Company (Chile)	Predictive Geochemistry AMIRA P778	Research Collaboration	Ravi Anand and team	CSIRO
Comalco Aluminium Ltd	Weipa Bauxite	Research project	Tony Eggleton/ Graham Taylor	ANU
CVRD	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Echo Resources Ltd	Nickel Hydrogeochemistry	Research collaboration	David Gray, Ryan Noble	CSIRO
Genalysis Laboratory Services	Evaluating spectral logging issues within a laboratory services environment	Research collaboration	Cajetan Phang	CSIRO
Hamersley Iron	Regolith geochronology	Research collaboration	Brad Pillans	ANU
Heathgate Resources	U phytoexploration, paleolandscape reconstruction	Research collaboration	Steve Hill	UA
Iluka Resources	Eucla Margins: Placer deposit study	Research contract	Louisa Ruperto	GA
Inco Technical Services	Nickel Hydrogeochemistry	Research project	David Gray	CSIRO
Inco Technical Services	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Independence Gold	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Jabiru Metals	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
JOGMEC	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
LionOre Australia	Nickel Hydrogeochemistry	Research project	David Gray, Ryan Noble	CSIRO
Mercator Gold	Regolith Geochronology	Research collaboration	Brad Pillans	ANU
Mincor Ltd	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	
Mindax Ltd	Uranium in WA Wheatbelt waters	Research contract	David Gray, Ryan Noble, Grant Douglas	CSIRO
MMI Technologies	Thomson Orogen Project – baseline geochemical surveys	Research collaboration	John Greenfield	NSW DPI

COLLABORATION, TECHNOLOGY TRANSFER AND UTILISATION

Newmont Australia	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Newmont Australia	Regolith Geochronology in the Tanami Region	Research collaboration	Brad Pillans	ANU
Newmont Asia Pacific	Tamami	Research collaboration	Lisa Worrall and team	GA
Newmont Australia	Biogeochemistry of regolith associated with Au deposits in the Tanami, WA and NT	Student research	Nathan Reid, Steve Hill	UA
Newmont Australia	Termitaria and other landscape indicators of sub-surface regolith	Student research	Anna Petts, Steve Hill	UA
Quasar Resources PL	Uranium in WA Wheatbelt waters	Research project	Grant Douglas	CSIRO
Rio Tinto Exploration	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Rio Tinto Aluminium	Weipa Bauxite project	Research collaboration	Tony Eggleton	ANU
SGS Minerals	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Tanami Gold NL	Tamami	Research collaboration	Lisa Worrall and team	GA
Tanami Gold NL	Biogeochemistry of regolith associated with Au deposits in the Tanami, WA and NT	Student research	Nathan Reid, Steve Hill	UA
Tanami Gold NL	Termitaria and other landscape indicators of sub-surface regolith	Student research	Anna Petts, Steve Hill	UA
Teck Cominco	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
Teck Cominco	Regolith & exploration in Gnaweeda Belt	Student research	Siriporn Soongpankhao, Mehrooz Aspandiar	CUT
Tritton Resources Ltd	Weathered rock recognition, Girilambone	Research collaboration	Ken McQueen	ANU
Woodside Energy	Nature, age and history of rock surfaces associated with petroglyphs at Burrup Peninsula, WA	Research contract	Brad Pillans	ANU
Xstrata Copper Chile	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
BHP Billiton	Nickel Hydrogeochemistry	Research project	David Gray	CSIRO

GOVERNMENT ORGANISATIONS AND UNIVERSITIES

Research User/Collaborator	Project – Activity	Interaction	Leader, Student / Supervisors	Core Party
Agriculture Forestry and Fisheries Australia (Federal Dept) (AFFA)	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
Australian Nuclear Science and Technology Organisation (ANSTO)	Salinity Dynamics (Australia-wide network to measure rainfall chemistry and isotopic composition)	Research collaboration Richard Cresswell		CSIRO
Aust Collaborative Land Evaluation Program	Physiographic regions	Research contract	Colin Pain	GA
ANU	Palaeoenvironmental records in western Victoria	Research collaboration	Kathryn Fitzsimmons	ANU
Avon Catchment Council	EEI-Geochem Phase III	Research contract	Paul Shand	CSIRO
Bureau of Meteorology	Salinity Dynamics (Australia-wide network to measure rainfall chemistry and isotopic composition)	Research collaboration	Richard Cresswell	CSIRO
Bureau of Rural Sciences	Angas Bremer Plains AEM interpretation	Research contract	Andrew Fitzpatrick	CSIRO
Central West Catchment Management Authority	Central West NSW Groundwater Flow Systems	Research contract	John Wilford	GA
Chilean Government	Chilean Bicentennial Program of Science and Technology	Multi-agency collaborative R&D	Steve Rogers, Ravi Anand	CSIRO
CSIRO Mathematical & Information Sciences	Objective Logging	Research collaboration	Tim Munday and team	CSIRO
CSIRO LW	dC13 distribution in Inland Acid Sulfate Soils	Student research	Luke Wallace, Evelyn Krull	ANU
CSIRO LW	Microbiology of Inland Acid Sulfate Soils	Student research	Luke Wallace, Steve Wakelin	ANU
CSIRO LW – Research Fellows	Inland acid sulfate soil thematic volume	Research collaboration	Rob Fitzpatrick	CSIRO
CSIRO Plant Industry	Study of phosphorus runoff from horticultural soils	Student research	Richard Greene	ANU
CSIRO Publishing	Regolith Text Book	Publishing contract	Keith Scott	CSIRO Fellow
CSIRO Water for a Healthy Country Flagship (CWHC)	Acidic Groundwater WA Wheatbelt - Evaluation Phase I	Research project	Paul Shand, Grant Douglas	CSIRO
CWHC	WA Rural Towns – salinity control	Research contract	Paul Wilkes	CUT
Engineering Evaluation Initiative WA (EEI)	EEI Acid Drainage WA	Research project	Paul Shand	CSIRO

GOVERNMENT ORGANISATIONS AND UNIVERSITIES (cont'd)

Research LEME Project – Activity Interaction Jser/Collaborator		Interaction	Leader, Student / Supervisors	Core Party	
Environment and Heritage (Federal Dept)	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO	
GA	Bureau of Rural Sciences Victorian Salinity Mapping project	Research contract	Ken Lawrie	GA	
Geological Society Australia Specialist Group in Environ- mental Geoscience, Engineering and Hydrogeology (EEHSG)	Environmental and geological hazards and risks to Australasia – Symposium within Aust Earth Sciences Convention 2006. Proceedings Volume and scientific papers	Research collaboration	Ken Lawrie	GA	
Geological Survey of Norway	Element sources and cycles at the Earth's surface	Research collaboration	Patrice de Caritat	GA	
Geological Survey Queensland	Queensland Regolith Mapping Project	Research collaboration	Mike Craig, Ian Robertson, M Thomas	GA, CSIRO	
Geological Survey NT	Tanami project	Research collaboration	Lisa Worrall and team		
Geological Survey WA	Tamani project	Research collaboration	Lisa Worrall and team	GA	
Geological Survey WA	Yilgarn Laterite Atlas	Research collaboration	Ian Robertson	CSIRO	
Geological Survey WA	Regolith geochronology	Research collaboration	Brad Pillans	ANU	
Golburn-Murray Water	Salinity management and industry development from the Beaufort Palaeochananel	Research contract	Tim Munday	CSIRO	
Golburn-Murray Water	Sunraysia AEM surveys	Research contract	Tim Munday	CSIRO	
Guilin University of Technology, China	CurnaMinex (exploring through cover in the Curnamona)	Research collaboration	Dirke Kirste, John Keeling, Baohong Hou	ANU, PIRSA, UA	
Land and Water Australia	Geophysics for Irrigation	Publication Review contract	Paul Wilkes	CUT	
International Association of Sedimentologists	Special Publication on Australian Cainozoic Cratonic Basins	Research collaboration	Jonathan Clarke	GA	
International Union of Geological Sciences (IUGS) Commission on Geosciences for Environmental Management (GEM)	United Nations International Year of Planet Earth (2008) – planning and presentations/papers	Research collaboration	Ken Lawrie	GA	
Lower Murray Darling Catchment management Authority	Gol Gol Lake and Swamp airborne electromagnetic survey	Research project	Tim Munday	CSIRO	
MDBC	MDBC Projects	Research contract	Ken Lawrie	GA	
MDBC	Salinity Dynamics (Australia-wide network to measure rainfall chemistry and isotopic composition)	Research contract	Richard Cresswell	CSIRO	
MDBC	Loveday rehabilitation	Research collaboration	Sebastien Lamontage, Warren Hicks	CSIRO	
MDBC	Stockyard Plains, Murray Basin – airborne geophysics for spatial patterns and hydrodynamic processes	Research contract	Tim Munday	CSIRO	
National Heritage Trust and National Land and Water Resources Audit 2	Atlas of Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO	
National Action Plan for Salinity and Water Quality (NAP SWQ)	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO	
Northern Agricultural Catchment Council	NACC Project – Resource assessment and coastal management, WA	Research project	Lindsay Collins	CUT	
NSW Dept Natural Resources	Central West NSW Groundwater Flow Systems	Research contract	John Wilford	GA	
NSW Dept of Infrastructure, Planning and Natural Resources (NSW DIPNR)	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO	
Queens University, Canada	Interpretation of groundwater geochemistry: Northern Chile and north-western India	Research collaboration	Bear McPhail, Patrice de Caritat	ANU, GA	
Qld Dept Natural Resources and Water (QDNRW)	Salinity Dynamics	Research collaboration	Richard Cresswell	CSIRO	
QDNRW	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO	
QDNRW	Acid Sulfate Soils workshops, Tasmania	Technology transfer	Rob Fitzpatrick	CSIRO	
SA Dept Water Land and Biodiversity Conservation (SADWLBC)	Hydrophysics Program. National Water Initiative	Research collaboration	Graham Heinson, Sukhyoun Kim	UA	

COLLABORATION, TECHNOLOGY TRANSFER AND UTILISATION

SADWLBC	River Nano/TEM	Research collaboration	Michael Hatch, Volga Berens, Tim Munday, Graham Heinson	UA, CSIRO
SADWLBC	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
SADWLBC	Loveday rehabilitation	Research collaboration	Sebastien Lamontagne, Warren Hicks	CSIRO
SADWLBC	SA Murray Floodplains – hydrogeological studies using airborne and ground geophysics	Research contract	Tim Munday CSIRO	
SADWLBC	Eyre Peninsular – airborne geophysical surveys	Research contract	Tim Munday	CSIRO
SADWLBC	Stockyard Plains, Murray Basin – airborne geophysics for spatial patterns and hydrodynamic processes	Research contract	Tim Munday	CSIRO
SA Dept Environment and Heritage	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
SA Water Corporation	Eyre Peninsular – airborne geophysical survey	Research contract	Tim Munday	CSIRO
SA Water Corporation	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
SA Water Corporation	SA Murray Floodplains – hydrogeological studies, airborne and ground geophysics	Research contract	Tim Munday	CSIRO
SA Water Corporation	Stockyard Plains, Murray Basin – airborne geophysics for spatial patterns and hydrodynamic processes	Research contract	Tim Munday	CSIRO
Southern Cross University	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
Tasmanian Dept Primary Industries and Water	Acid Sulfate Soils workshops, Tasmania	Technology transfer	Rob Fitzpatrick	CSIRO
University of California, Berkeley	Biogeochemical research at Lake Tyrrell	Research collaboration	Sue Welch	ANU
University of Oxford and Sheffield University, UK	Complexities in the preservation and interpret- ation of late Quaternary dune records	Student – Research collab- oration on conference paper	Kathryn Fitzsimmons	ANU
University of Melbourne	Palaeoenvironmental and archaeological records at Mulan, north western Australia	Research collaboration	Kathryn Fitzsimmons	ANU
University of Sydney	Dust characteristics	Research collaboration	Richard Greene	ANU
University of WA	WA Rural Towns – salinity control	Research contract	Paul Wilkes	CUT
University of WA	Metal migration: tracing timing and modelling	Research collaboration	Robert Hough	CSIRO
Vic Dept Primary Industries	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
WA Chemistry Centre	WA Rural Towns – salinity control	Research contract	Paul Wilkes	CUT
WA Water Corporation	WA Rural Towns – salinity control	Research contract	Paul Wilkes	CUT
WA Dept Agriculture and Food WA (WADAF)	Acidic Groundwater WA Wheatbelt - Evaluation Phase I	Research contract	Paul Shand, Grant Douglas	CSIRO
WADAF	Engineering Evaluation Initiative II, WA Wheatbelt – Geochemistry Risk Assessment	Research contract	Paul Shand, Grant Douglas	CSIRO
WADAF	WA Rural Towns - salinity control	Research contract	Paul Wilkes	CUT
WADAF	Avon Catchment Council – feasibility study of options for treatment of acid groundwater	Research contract	Paul Shand	CSIRO
WADAF	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
WA Dept Environment and Conservation (WADEC)	Avon Catchment Council – feasibility study of options for treatment of acid groundwater	Research contract	Paul Shand	CSIRO
WADEC	Resource assessment and coastal management, Northern Agricultural Region, WA	Research contract	Lindsay Collins	CUT
WADEC	Engineering Evaluation Initiative II, WA Wheatbelt – Geochemistry Risk Assessment	Research collaboration	Paul Shand, Grant Douglas	CSIRO
WADEC	Acid Drainage WA	Research contract	Paul Shand	CSIRO
WADEC	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
WADEC	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
WADEC	EEI-Geochem Phase II	Research contract	Paul Shand	CSIRO
WADEC	Palaeochannel in Helena River Catchment	Student research	Sean Adams, Mehrooz Aspandiar	CUT
WA Dept Water	Acidic Groundwater WA Wheatbelt – Evaluation Phase I	Research contract	Paul Shand, Grant Douglas	CSIRO
WA Dept Water	Avon Catchment Council – feasibility study of options for treatment of acid groundwater	Research contract	Paul Shand	CSIRO
WA Dept Water	Palaeochannel in Helena River Catchment	Student research	Sean Adams, Mehrooz Aspandiar	CUT



COOPERATIVE RESEARCH CENTRES

Research User/Collaborator	LEME Project – Activity	Interaction	Leader, Student / Supervisors	Core Party
pmd CRC	Metal migration: tracing, timing and modelling	g Research collaboration	Robert Hough	CSIRO
CRC PBMDS	Focus on Salt	Joint publication	Greg Lawrence and other authors	CSIRO-GA-UA
CRC PBMDS	Dryland salinity and biodiversity loss	Student research	Glen Bann	UA
CRC Greenhouse	The effects of salinity and sodicity on soil carbon stocks and fluxes	Student Research	Vanessa Wong	ANU
SPECIAL CATEGORY				
Research User/Collaborator	LEME Project – Activity	Interaction	Leader, Student / Supervisors	Core Party
2nd International Salinity Forum: Salinity, Water and Society – Global issues, local action. 31 March – 3 April 2008, Adelaide, SA	LEME represented on Steering and Technical Organising Committees which comprise members from Dubai, China, Pakistan, USA and Australia	Research Collaboration LEME Sponsorship	Ken Lawrie	GA
INDUSTRY ASSOCIATIONS				

INDUSTRY ASSOCIATIONS

Research User/Collaborator	LEME Project – Activity	Interaction	Leader, Student / Supervisors	Core Party
American Society of Soil Science	Inland Acid Sulfate Soils	Research collaboration	Rob Fitzpatrick	CSIRO
Avon Catchment Council	Engineering Evaluation Initiative II, WA Wheatbelt – Geochemistry Risk Assessment	Research contract	Paul Shand, Grant Douglas	CSIRO
Avon Catchment Council	Avon Catchment Council – feasibility study of options for treatment of acid groundwater	Research contract	Paul Shand	CSIRO
Australian Synchrotron Research Program	Metal migration, Tracing, timing and modelling	Research support	Robert Hough	CSIRO
Aus Mineral Industries Research Association (International) (AMIRA)	Predictive Geochemistry AMIRA P778	Research collaboration	Ravi Anand and team	CSIRO
AMIRA	Chilean Bicentennial Program of Science and Technology	Multi-agency collaborative R&D	Steve Rogers, Ravi Anand	CSIRO
Geotrack Pty Ltd	Constraining landscape evolution with apatite fission track dating	Research collaboration	Ken McQueen	ANU
Minerals and Energy Research Institute WA (MERIWA)	Yilgarn Laterite Atlas	Research financial support	Ian Robertson	CSIRO
WA Channel Management Group	Engineering Evaluation Initiative II, WA Wheatbelt – Geochemistry Risk Assessment	Research contract	Paul Shand, Grant Douglas	CSIRO
Yarra Yarra Catchment Council	Engineering Evaluation Initiative II, WA Wheatbelt – Geochemistry Risk Assessment	Research contract	Paul Shand, Grant Douglas	CSIRO
Yarra Yarra Catchment Council	Yarra Yarra – catchment governance and planning concepts	Research contract	Paul Wilkes	CUT

COLLABORATION, TECHNOLOGY TRANSFER AND UTILISATION

RESEARCH GRANTS RECEIVED OUTSIDE OF LEME FUNDING

Name	Core Party	Activity / Name of grant	Period of Grant	Amount	Relationship to CRC Research
Colin Pain	GA	Australian Collaborative Land Evaluation program	2005-07	\$35,000	Physiographic Regions Project
Richard Greene	ANU	Sydney Catchment Authority	Jan – Dec 2007	\$10,000	Study of catchment health
Anna Petts	UA	Eric Rudd Memorial Travel Scholarship Award	2006-07	\$5,000	Overseas travel to compete field and laboratories work
Brad Pillans	ANU	The nature, age and weathering history of rock surfaces associated with petroglyphs at Burrup Peninsula	2006-07 (12 months)	\$47,520	Commercial project funded by Woodside Energy related to LEME Geochronology Project
Boahong Hou	PIRSA	Australia-China Fund for Scientific and Technological Exchange	2006-09 (3 yrs)	\$45,000	CHIM geochemical techniques
Rob Fitzpatrick	CSIRO	Travel grant for airfare and accommodation to attend present keynote and public address	Apr to May 2007	\$2,500	ASS and forensic regolith
Richard Cresswell, Richard Greene	CSIRO, ANU	MDBC funding	2005-10	\$5,000 pa	Provision of rainfall ion accession data for MDBC
Richard Cresswell in the Fitzroy Basir	CSIRO	QDNRW	2006-07	\$76,000	Fieldwork and analysis funding
Richard Cresswell	CSIRO	Isotrace, NZ data exchange	2006-08	\$10,000	Provision of rainfall data
Richard Greene	ANU	Australian Institute of Nuclear Science and Engineering	Jan – Dec 2007	\$13,000	Analysis of dust samples containing aeolian salts
Richard Greene	ANU	Barrick Australia Ltd (honours project)	Jul 2007- Jun 2008	\$16,500	Minesite Rehabilitation
Michael Hatch, Graham Heinson	UA	Australian Society of Exploration Geophysicists Research Foundation	2007	\$5,000	Industry body with vested interest
Sarah Tynan	ANU	HDR Travel Grant	Sep to Nov 2007	\$5,000	Travel to overseas laboratories to use specific equipment

VISITORS TO THE CENTRE

Visitor	Visitor Organisation	LEME Host	Project / Activity	Date
Ms Wendy Corbett	Platsearch NL	John Greenfield, NSW DPR	Thomson Orogen	July 2006
Prof Graham Harris	Former Chief of CSIRO Land and Water, Chair Independent Scientific Review Panel	Steve Rogers, LEME CEO, Perth	LEME Fifth Year Review	July 2006
Prof Gerry Govett	CRC LEME Visitor, Independent Scientific Reviewer	Steve Rogers, LEME CEO, Perth	LEME Fifth Year Review	July 2006
Dr Nigel Radford	Newmont Australia, Independent Scientific Reviewer	Steve Rogers, LEME CEO, Perth	LEME Fifth Year Review	July 2006
Messrs Regis Neroni, Gwendal Fily, Florian Le pape, Baudoin Luce, Alexandre Jego	Ecole et Observatoire des Sciences de la Terre, Strasbourg, France	Graham Heinson, UA, Adelaide	Hydrogeophysics Internship	8 July-15 September 2006
Dr David Nash	University of Brighton, UK	Steve Hill, UA, Adelaide	Research Visit	22-26 July 2006
Dr Colin Dunn	Geological Survey of Canada	Steve Hill, UA, Adelaide	Research Visit	22-26 July 2006
Mr Mal Bunning	Earth Resources Australia Pty Ltd	John Greenfield, NSW DPR, Maitland	Thomson Orogen	August 2006
Delegation	Council of Geoscience, South Africa	Lisa Worrall, GA, Canberra	Visit of GA premises	1-2 August 2006
Prof Basil Gomez	Indiana State University	Lisa Worrall, GA, Canberra	GA Seminar attendee	10 August 2006
Prof Dirk Kirste	Simon Frazer University, Canada	Lisa Worrall, GA Canberra	Tanami Project	11 August 2006
Dr Dirk Wallschlaeger	Trent University, Canada	Ken McQueen and Bear McPhail, ANU, Canberra	Scientific exchanges	September 2006
Mr Trevor Beardsmore	Barrick Gold	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr David Nixon	Barrick Gold	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Jeremy Wilkes	Cameco	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr David Burrows	Inco	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr John Jackson	Inco	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Paul Parker	Independence Group	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Jamie Days	Independence Group	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Simon Bolster	Newmont	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Paul Agnew	Rio Tinto Exploration	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Phil Baker	Rio Tinto Exploration	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Harry Firns	SGS Minerals	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Ken Litjens	SGS Minerals	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Peter Crowhurst	Teck Cominco	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007

VISITORS TO THE CENTRE (cont'd)

Visitor	Visitor Organisation	LEME Host	Project / Activity	Date
Mr Michael Taylor	Teck Cominco	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Dr Adriana Horbe	Universidade Federal do Amazonas	Ravi Anand, CSIRO, Perth	Sabbatical – Comparison of lateritic profiles Amazonian region and Yilgarn Craton	1 September 2006 to 30 April 2007
Dr Joe Cucuzza	AMIRA International	Ravi Anand, CSIRO, Perth	AMIRA P778	October 2006 and May 2007
Mr Florian Le Pape	Ecole et Observatoire des Sciences de la Terre, Strasbourg, France	Graham Heinson, UA, Adelaide	Hydrogeophysics Internship	8 July-15 September 2006
Mr Baudoin Luce	Ecole et Observatoire des Sciences de la Terre, Strasbourg, France	Graham Heinson, UA, Adelaide	Hydrogeophysics Internship	8 July-15 September 2006
Prof Taofa Zhou	Hefei University of Science and Technology China	Baohong Hou, PIRSA, Adelaide	Eucla Margins	14-21 January 2007
Ms Julie Corriveau	Institut National de la Recherche Scientifique	Sebastien Lamontagne, CSIRO, Adelaide	Loveday Disposal Basin	January- March 2007
Ms Sara Jakica	University of Melbourne	Lisa Worrall, GA, Canberra	Eucla Margins	22 January 2007
Dr Brian Murphy	NSW Dept of Natural Resources	Richard Green, ANU, Canberra	NSE Soil Science Society Branch Meeting	29-30 March 3007
Dr David Nash	University of Brighton, UK	Steve Hill, UA, Adelaide	Research Visit	10 April 2007
Dr Mary Bourke	Planetary Science Institute, Tuscon Arizona	Jon Clarke, GA, Colin Pain, GA, Canberra.	General discussion on regolith science and geomorphology	19 June 2007
Mr Warrick Rafferty	NuPower Resources, Darwin	Jon Clarke, GA, Ken Lawrie, GA, Canberra	Sediment hosted U deposits and Cainozoic Cratonic Basins discussions	22 June 2007
Prof Lyn Beazley	WA Chief Scientist	Steve Rogers, LEME CEO, Perth	ARRC site visit	16 May 2007
Mr Alexandre Jugo	Ecole et Observatoire des Sciences de la Terre, Strasbourg, France	Graham Heinson, UA, Adelaide	Hydrogeophysics Internship	11 June-30 Sept 2007

VISITS BY CENTRE STAFF – SABBATICALS

LEME staff or Student Name and Core Party	Host organisation and Location	Host staff	Project/activity	Date (from /to)
Mike Craig & Mark Thomas GA	Qld Dept of Natural Resources and Mines	Dave Mason	Qld Regolith Map	24 July 2006
Lisa Worrall, GA, and Steve Hill, UA	Geological Survey of Western Australia, Perth	David Howard	Tanami Project	18-20 July 2006
Lisa Worrall, GA, and Steve Hill, UA	Newmont Australia, Perth	Nigel Radford	Tanami Project	20-21 July 2006
Baohong Hou, PIRSA	US Geological Survey, Denver, Colorado, USA	Bob Horton	Churchill Fellowship	3-10 August 2006
Baohong Hou, PIRSA	Colorado School of Mines, Colorado, USA	Andreas Dietrich	Churchill Fellowship	11 August 2006
Baohong Hou, PIRSA	Geological Survey of Canada	Simon Hanmer	Churchill Fellowship	12-18 August 2006
Baohong Hou, PIRSA	Institute of Geology of Ore Deposits, Petrology, Mineralogy and Geochemistry Russian Academy of Sciences, Moscow, Russia	Natalia Patyk-Kara	Churchill Fellowship	19-25 August 2006
Baohong Hou, PIRSA	College of Geoexploration Science and Technology, Jilin University, Changchun, China	Cai Liu & Ligup Han	Churchill Fellowship	26-30 August 2006
Baohong Hou, PIRSA	Beijing Research Institute of Uranium Geology, Beijing, China	Ziying Li	Churchill Fellowship	31 August- 3 September 2006
Colin Pain, GA	CSIRO Black Mountain – National Committee for Soils and Terrain		Physiographic Regions	14-15 September 2006
Colin Pain, GA	Vic Dept of Sustainability and Environment		Physiographic Regions	14-15 September 2006
Baohong Hou, PIRSA	Institute of Southwest Geological Survey, Non-ferrous Metal Resources. Geological Survey, Kumming University of Science and Technology, Kumming China	Rensheng Han	Churchill Fellowship	23-30 September 2006
Baohong Hou, PIRSA	College of Earth Sciences, Jilin University, Changchun, China	Fengyue Sun, Xiaofei Yu & Bile Li	Churchill Fellowship Adjunct Professorship	4-19 October 2006
Baohong Hou, PIRSA	Jilin Geological Survey China	Jianmin Lu	Churchill Fellowship	3 October 2006
Lisa Worrall, GA, and Luisa Ruperto, GA	PIRSA, Adelaide		Eucla Margins	22 November 2006



Lisa Worrall, GA, Luisa Ruperto,	Iluka Resources, Adelaide	Ian Warland	Eucla Margins	28 November 2006
GA, John Keeling, PIRSA,				
Baohong Hou, PIRSA				
Colin Pain, GA	CSIRO Land & Water	Neil McKenzie	Physiographic regions	14 December 2006
			project	
John Joseph, UA	Tokyo University of Marine Science	Prof Akio Yasuda	Development of an	December 2006
			airborne gravimeter	
Lisa Worrall, GA	Tanami Projects Sponsors, Perth		Tanami Project Sponsors	9 May 2007
Colin Pain, GA	National Committee of Soil and		Physiographic Regions project	22-23 May 2007
	Terrain, Mt Gambier			
Michael Hatch, PhD, UA	CSIRO Exploration and Mining,	Tim Munday	EM Methodology comparison	May and June 2007
	Perth			
Colin Pain, GA	IAG Working Group on Applied		Physiographic Regions project	23-30 June 2007
	Geomorphic Mapping, Kota			
	Kinabalu Malawia			

Some of LEME's projects lie in the R&D niche of precompetitive geoscientific information. Such information is generated by other geoscientific agencies to make MINEX more effective and efficient. The objective is to release information expeditiously and freely, in order to stimulate commercial mineral exploration.



Commercialisation and Utilisation

Commercialisation and Utilisation Strategies and Benefits

CRC LEME is a 'knowledge-based' CRC which delivers its research outputs as publicly available IP with targeted dissemination to the MINEX industry and NRM sector. It has set protocols to maximise adoption and utilisation of its research outputs.

The original Commonwealth Agreement did not specify commercialisation milestones, but emphasised the utilisation of outputs which are reported under the Centre's Performance Measures.

Some of LEME's projects lie in the R&D niche of pre-competitive geoscientific information. Such information is generated by other geoscientific agencies to make MINEX more effective and efficient. The objective is to release information expeditiously and freely, in order to stimulate commercial mineral exploration. This is the key driver for the Centre's knowledge transfer to the MINEX industry. Some LEME industry projects generate knowledge which remains confidential to industry sponsors until the expiry of an agreed confidentiality period, as per the project agreement.

An example of LEME generated IP utilisation is the National Geochemical Survey of Australia. Directly based on the techniques and IP generated by LEME in the 'Low Density Geochemical Survey' pilot projects, a NGSA project received funding under the Australian Government's new OESP in August 2006. The project, coordinated by GA, will result in Australia's first continentalscale, internally consistent geochemical data layer. The data will be useful for an array of applications, such as identifying geological domains likely to host specific uranium and thorium deposits, and correlating geochemical data with airborne radiometric data.

Fee-for-service opportunities have continue to be expanded in the fields of natural resource and environmental management, where our clients are government agencies, Landcare Groups, CMAs or organisations contracted to them. Research opportunities have arisen due to LEME's competitive position in the application of geophysical technologies, to assess saline groundwater discharges and improve the understanding of saline groundwater flow dynamics and salinity mitigation.

Potential Commercial Projects

As part of its internal technical review process LEME maintains a list of potential projects warranting Centre or Project IP protection. These are described below.

LEME Regolith Spectral Logger

This project is developing and enhancing spectroscopic logging technologies for the purpose of characterising regolith materials in an objective manner through the application of CSIRO – LEME developed HyChips automated spectroscopic logging technology. It aims to create logging technology that rapidly characterises regolith samples from drill chips and core.

The project's medium-term aim is to build a regolith version of *The Spectral Assistant*, a TSG Software Package used by the minerals industry for spectroscopic analysis. Progress during 2006-07 has defined a potential pathway to use a mixture-model algorithm that can be incorporated into the software.

LEME is also significantly closer to delivering an automated device that determines the

mineral abundances in regolith material. This fundamental work has been complemented by activities with AusSpec International aimed at developing a Regolith Geological Environment Specific Spectral Library (Regolith GESSL) and a Spectral Expert File (SEF) that characterises regolith material spectral responses as a market-ready AusSpec product for the MINEX industry.

Queensland Regolith Map and Atlas Methodology

In July 2006, LEME commenced its collaboration with the Queensland Department of Natural Resources, Mines and Water to produce a 1:2.5 million-scale regolith map and associated Atlas of the State. The detailed mapping program will begin in late 2007.

Geophysical Developments at Curtin University of Technology

CUT has continued to develop innovative geophysical techniques with LEME PhD student input. The Intellectual Property (IP) resulting from any of these projects is yet to be negotiated.

Audio-magnetotellurics (AMT)

No progress was made during the year due to a lack of postgraduate students and time for the principal researcher to address the technical problems encountered in 2005.

Electrokinetic seismic (EKS)

This technique was further investigated by Anton Kepic (CUT) during the year, and Karl Butler from University of New Brunswick, Canada, and his PhD student Christian Dupuis spent several months working on EKS projects including one study site located





in the Burdekin Delta, Qld. Some project funding has come from non-LEME sources following the promising results achieved by LEME/CUT PhD student Mohammad Rosid. The Burdekin EKS study borehole data are still being analysed and reviewed, with the results expected to be published in a journal in 2008. The data are taking time to analyse due to difficulties in reconciling the numerous responses with the area's complex stratigraphy.

Data collected from an area north of Perth have demonstrated this technique can be used to produce clear images of the vadose zone and map the water table in areas unsuitable for GPR and other geophysical methods. A paper in the journal *Geophysics* has been accepted for publication in 2007, and this will acknowledge the past work and support given by LEME.

Signal Processing Algorithms

During the year, LEME/CUT PhD student Margarita Norvill resumed her thesis writing and plans to submit her thesis and publish some research results in 2008. Further work needs to be done to improve the ability of the algorithms to reject noise in most data sets.

Knowledge and Technology Transfer

Since the full commencement of CRC activities in 2002-03, 22 contract and consultancy-type projects have been successfully completed.

Program 3 and 4 contracts have been with State Government NRM, agriculture and water agencies, the MDBC and the BRS at Federal Government level. Projects of this nature are important because they establish the relevance of LEME's research with NRM and CMAs. They also provide a springboard from which more strategic and localised research can be developed. The successful strategy of initially engaging NRM agencies in the MDB and in WA through work contracts, has continued to be an effective way to transfer LEME research outcomes and technology to end-users.

Programs 1 and 2 have entered into contractual research collaboration with various MINEX companies and State Government Geological Surveys. For example with: GSWA, MERIWA CSIRO EM for the Yilgarn Laterite Atlas project, Mindax/Quasar for the WA Wheatbelt Uranium project, and Anglo American, Newmont and Tanami Gold for the Tanami project.

Intellectual Property Management

The aims of LEME commercialisation and Intellectual Property Management Strategy are to:

- Protect and disseminate knowledge.
- Promote developments within Australia and overseas.
- Transfer knowledge on a fee-for-service basis.
- Identify marketing opportunities of technological developments with industry partners.

Where Centre projects generate knowledge with potential economic or service value, it is considered 'Centre Intellectual Property' All Centre Intellectual Property (IP) is owned by the Core Participants equally as tenants in



common in proportion to equity. Each Participant then has a non-exclusive royaltyfree licence to use that Centre IP.

Projects receiving external resources or additional resources from a Core Participant may generate 'Project Intellectual Property.' Specific Project IP provisions are set out in the relevant project agreements. This can provide for the IP to reside only with those Core Participant(s) who have contributed resources to the project.

In regard to student projects not formally part of a Commercial Project, the student owns the IP unless there is a contractual arrangement between the student and the university, in which case the university owns the IP. However if the CRC invests resources into the student project, then LEME negotiates with the university on a sharing arrangement for the student IP.

Any Centre IP with potential for commercialisation, as well as background IP necessary for the commercialisation of Centre IP, is assessed by the LEME Executive and Board. Where applicable, the Board will resolve the distribution of any revenue derived from commercialisation of Centre IP.

During 2006-07, the Centre put in place procedures to manage the ongoing protection of LEME IP, including any assignment for commercialisation or further development and distribution of any commercial returns, once the Centre ceases operations on 30 June 2008.

While no IP has been created or is expected to be created during LEME's tenure, research results are disseminated to appropriate parties to ensure an efficient and effective transfer of technology and research utilisation. Any IP arrangements made would be in accordance with the IP clause in the Commonwealth Agreement.

LEME will use its best endeavours to commercialise or otherwise make available any IP to maximise the benefits accruing to Australia, including Australian industry, the Australian environment and the Australian economy generally. The use and exploitation of such IP will be consistent with CRC Programme Objectives. During the reporting period LEME researchers had papers accepted in the two most prestigious international scientific journals *Nature* and *Science*.



Communications Officer, Mr Greg Lawrence

Communication Policy

Timely dissemination of LEME research developments continues via: journal articles, technical reports, regolith maps, proceedings or abstract volumes, newsletters, media statements, LEME Annual Reports, and presentations at workshops and conferences. Uptake by end-users is facilitated by demonstration projects and outcomes, and promotion on research delivery, rather than intent.

As the Centre moves towards the cessation of research activities on 30 June 2008, staff will concentrate on delivery of final research outputs. LEME Legacy Products will include: a series of Explorers' Guides, special volume OFRs, a digital atlas of regolith maps, an inland ASS thematic volume, and a Regolith Textbook.

The Centre has entered into a collaborative agreement with AMIRA to make available technical reports and mineral prospect data via the AMIRA *Data Metallogenica* online searchable geoscience exploration database.

LEME Website (http://crcleme.org.au)

The LEME website is the main medium for the communication of Centre activities. The majority of LEME publications are digitally available to download as .PDF files free of charge.

The website will undergo significant modifications to become an interactive key communication medium for the delivery of Centre research outputs to end-users once its operations have ceased. CSIRO EM will maintain the LEME web site through to 2013.

Publications

LEME OFRs (over 220 currently available) date back to LEME 1 (1996). Thirteen new OFRs were published in 2006-07. Regolith 2006 – Consolidation and Dispersion of Ideas, the Proceedings from the LEME Symposium held at Hahndorf Resort, SA was published in November 2006 and some 90 individual extended abstracts are available to download from the LEME web site. The two thematic volumes, *Regolith Landscape Evolution Across Australia and Regolith Expression of Australian Ore Systems* originally released in October 2005, continue to be the Centre's most popular publications.

Hard copies of all LEME publications are provided to the WA State Library, the National Library and LEME Core Participant Libraries.

There has been a significant increase in Publication Output generated by LEME researchers and students during the reporting period, as shown on the following pages.





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Conference Activity

The Centre was well represented at the Australian Earth Science Convention in July 2006 with 41 oral and poster presentations; sponsorship of the Conference *Environmental and Geological Hazards and Risks Symposium*; a booth dedicated to LEME outputs; and two LEME regolith geoscience field trips. Program 4 Leader, Ken Lawrie, coordinated LEME's involvement at this event.

With 25 oral and poster presentations, the Centre's research was highly acclaimed by an international audience at the 23rd International Geochemical Exploration Symposium and 2nd International Applied Geochemistry Symposium held in Oviedo, Spain , 14-19th June 2007.

More than 100 industry representatives attended the annual LEME Mineral Exploration Seminar, held 11 August 2006 Perth, to hear LEME staff and students discuss their latest research and it's relevance to exploration issues. These seminars have received very positive feedback from industry.

In October 2006, the Centre held a public lecture on gold nugget formation presented by LEME Researcher, Rob Hough (CSIRO EM) at the Australia Resource Research Centre.

The 2006 Regolith Symposium was held at the Hahndorf Resort, SA in early November 2006. For four days, LEME researchers and students gave more than 90 presentations on regolith research covering the full spectrum of the Centre's research activities.





CONFERENCE PRESENTATIONS

Date	Event	Location	LEME representative	Activity
2-6 Jul 06	Australian Earth Sciences Convention	Melbourne, Vic	Ken Lawrie <i>et al</i> Abstracts in The Australian Earth Sciences Convention 06 Handbook. www.earth06.org.au (listed in Publications)	Session Convenor 40 Oral and Poster presentations. LEME Booth
5-7 Jul 06	2nd Australian Aerosol Workshop, Qld University of Technology	Brisbane, Qld	Richard Greene, Richard Cresswell	Oral presentations
9-15 Jul 07	18th World Congress of Soil Science	Pennsylvania, USA	Rob Fitzpatrick	Oral presentations (4)
25 Jul 06	Geological Survey Queensland Lecture Series	Brisbane, Qld	Mike Craig	Oral Presentations
4 Aug 06	Mineralogical Society of NSW – Betty Mayne Lecture	University of Western Sydney, NSW	Ken McQueen	Invited Lecturer
5-9 Aug 06	US Geological Survey (2 presentations)	Denver, Colorado, USA	Baohong Hou	Invited speaker
10 Aug 07	Colorado School of Mines (2 presentations)	Denver, Colorado, USA	Baohong Hou	Invited speaker
14-18 Aug 06	Geological Survey of Canada (4 presentations)	Ottawa, Ontario, Canada	Baohong Hou	Invited speaker
15 Aug 06	UWA Centre for Land Rehabilitation - Seminar	Perth, WA	Steve Rogers	Invited Speaker
21-25 Aug 06	12th Int Assoc Genesis of Ore Deposits Symposium – Russian Academy of Science	Moscow, Russia	Baohong Hou	Co-Session Chairman and Invited speaker
26-30 Aug 06	College of Geoexploration, Science and technology, Jilin University (5 presentations)	Changchun, China	Baohong Hou	Invited speaker
1 Sep 06	Beijing Research Institute of Uranium Geology (2 presentations)	Beijing, China	Baohong Hou	Invited speaker
27 Aug – 1 Sep 06	16th Annual VM Goldschmidt Conference	Melbourne, Vic	Bear McPhail, Paul Shand Ravi Anand, Sarah Beavis, Charles Butt, Richard Cresswell, Patrice de Caritat, Chris Gunton, Chris Jones Dirk Kirste, Mat Lenahan, David Little, Frank Reith, Ken McQueen, Sarah Tynan, Alan Usher, Luke Wallace, Sue Welch	Session Chairs/ Convenors 16 Oral Presentations, plus Poster presentations
4 Sep 06	Guilin University of Technology	Guilin, China	Baohong Hou, John Keeling	Invited lectures
Sep 06	The Australian National University College of Science – PhD Conference	Canberra, ACT	Luke Wallace	Oral presentation
10-14 Sep 06	13th Agronomy Conference 06	Perth, WA	Glen Bann	Presentation of plenary paper and poster
18-20 Sep 06	10th Murray Darling Basin Commission Groundwater Workshop	Canberra, ACT	Volga Berens, Jon Clarke, Richard Cresswell, Andrew Fitzpatrick, Larysa Halas, Mike Hatch, Graham Heinson, Andrew Herczeg, Jeremy James, Tim Munday, Colin Pain, John Wilford	Oral and Poster Presentations
25-29 Sep 06	Kunming University of Sciences & Technology (5 presentations)	Kunming, China	Baohong Hou	Invited speaker

CONFERENCE PRESENTATIONS (cont'd)

Date	Event	Location	LEME representative	Activity
26-28 Sep 06	Broken Hill Exploration Initiative Conference: Discovery without borders	Broken Hill, NSW	Karen Barovich, John Greenfield, Steve Hill Karen Hulme, Alan Mauger, Keith Scott, John Watkins,	Oral and Poster presentations
3-4 Oct 06	Jilin Geological Survey (3 presentations)	Changchun, China	Baohong Hou	Invited Speaker
6 Oct 06	Bureau of Rural Sciences Seminar	Canberra, ACT	Steve Rogers	Invited Speaker
15-18 Oct 06	Aust National Committee on Irrigation and Drainage (ANCID) Conference	Darwin, NT	Jon Clarke	Invited Speaker
22-25 Oct 06	Australian Forest Growers Biennial International Conference	Launceston, Tas	Glen Bann	Oral presentation
26-28 Nov 06	13th Australian Remote Sensing and Photogrammetry Conference	Canberra, ACT	Alan Mauger, Matilda Thomas	Oral presentations
27-29 Nov 06	International Symposium on Applied Geochemistry	Santiago, Chile	Ravi Anand and Steve Rogers	Invited Speakers
1 Dec 06	South Australian Explorers Conference	Adelaide, SA	John Keeling	Invited speaker
4-7 Dec 06	30th Hydrology & Water Resources Symposium	Launceston, Tas	Sue Welch, David Rassam	Oral presentations
13-15 Dec 06	9th Australasian Environmental Isotope Conference and 2nd Australasian Hydrogeological Research Conference	Adelaide, SA	Richard Cresswell, Paul Shand	Oral presentation
3-7 Dec 07	National Soils Conference ASSSI*-ASPAC-ACMS	Adelaide, SA	Sara Beavis, Rob Fitzpatrick, Paul Shand Sue Welch, Vanessa Wong	Oral presentations
4-7 Dec 06	30th Hydrology and Water Resources Symposium	Launceston, Tas	Sara Beavis, Sue Welch, David Rassam	Oral presentations
4-7 Dec 06	Geological Society of New Zealand Annual Conference	Palmerston, North NZ	Brad Pillans	Keynote Speaker
13-15 Dec 06	2nd Australasian Hydrogeology research Conference & 9th Australasian Environmental Isotope Conference	Adelaide, SA	Richard Cresswell	Oral presentations
3 Jan 07	Mineral Deposits Study Group, Geological Society of London	Brighton University, England	Charles Butt	Keynote Speaker
4-7 Jan 07	Sustainability, 07, 3rd International Conference on Environmental, Cultural, Economic and Social Sustainability	Chennai, India	Glen Bann	Virtual Presentation
23 Feb 07	VICMIN07. Mineral Exploration Undercover. 4th Conference on developments in Victorian Geology and Mineralisation	Melbourne, Vic	Steve Rogers, Keith Scott	Invited Speakers
20-21 Mar 07	Annual Geoscience Exploration Seminar	Alice Springs, NT	Lisa Worrall	Invited Speaker
22-28 Mar 07	Young Scholar Workshop – Sustainable Water Management at Local, Regional and Global Scales	Canberra, ACT	Fern Beavis, Sue Welch	Invited speaker, Oral presentation
26-29 Mar 07	AMIRA 7th Biennial Exploration Managers Conference: Making collaborative R&D an integral part of the exploration business	Barossa Valley, SA	Steve Rogers	Invited Speaker
1-5 Apr 07	Symposium on the Application of Geophysics to Engineering and Environmental Problems (SAGEEP)	Denver, Colorado, USA	Andrew Fitzpatrick, Oral presentat Kokpiang Tan	
11-13 Apr 07	XVII Conference of The Southern African Society for Quaternary Research. Understanding environmental change: the contribution of Quaternary hindsight to future sustainability	Natal, South Africa	Rob Fitzpatrick	Keynote Speaker and Invited Speaker
16-29 Apr 07	European Geophysical Union General Assembly	Vienna, Austria	Ken Lawrie, Colin Pain	Oral and Poster presentations
2 May 07	South Australian Resources and Energy Investment Conference	Adelaide, SA	John Keeling, Steve Hill and others	Oral presentations
15-16 May 07	Australia's Uranium Conference 07	Darwin NT	Lisa Worrall	Workshop Presenter
16-18 May 07	CRC Association Conference: Driving Innovation through Cooperative Research	Perth, WA	Steve Rogers, Gary Kong and Greg Lawrence	Organising Committee and PR
22-24 May 07	National Committee on Soils and Terrain	Mt Gambier, Vic	Colin Pain	CRC LEME Representative
7-9 Jun 07	AMEC National Mining Congress	Perth, WA	Ravi Anand, Andrew Fitzpatrick, David Gray, Ian Robertson	Oral presentations

COMMUNICATION AND PUBLICATIONS

13-19 Jun 07	23rd International Applied Geochemistry Symposium	Oviedo, Spain	Ravi Anand, Fern Beavis, Charles Butt, Patrice de Caritat, Adrian Fabris, David Gray, Robert Hough, Dirk Kirste, Melvyn Lintern, Ken McQueen, Ryan Noble, Anna Petts, Nathan Reid, Ian Robertson, Steve Rogers, Lisa Worrall	Oral and Poster presentations – listed in the Publications section (25)
22 Jun 07	Mineral Exploration Through Cover 07	Adelaide, SA	Joel Brugger, Baohong Hou, Steve Hill, Robert Dart	Presenters
25-29 Jun 07	International Association of Geomorphology Regional Meeting	Kota Kinabalu, Malaysia	Colin Pain	Oral presentation
26-28 Jun 07	Frontiers in Mineral Sciences 07	Cambridge, UK	Keith Scott/Rob Hough	Poster presentation

*Australian Society of Soil Sciences Inc

*Australasian Soil and Plant Analysis Council

*Australian Clay Mineral Society

CONFERENCES – SEMINARS – WORKSHOPS CONDUCTED OR CO-HOSTED BY LEME PERSONNEL

Date	Event	Location	LEME Personnel	Activity	No of attendees
9-15 Jul 06	18th World Congress Of Soil Science. Individual Symposiums:-	Philadelphia, USA	Rob Fitzpatrick – Chairman, IUSS Soil Mineralogy Commission	Joint Organiser, Invited speaker	
	"Poorly crystalline minerals in Soils" "Soil Mineralogy and Geophysics for Environmental Management and Mineral Exploration"		U,		250 150
	"Acid Sulfate Soils"				150
11 Aug 06	CRC LEME Minerals Exploration Seminar	Perth, WA	Ravi Anand 14 LEME Presentations – Listed in Publications	Convenor	95
23 Aug 07	First National Atlas of Acid Sulfate Soils Working Group meeting	Adelaide, SA	Rob Fitzpatrick	Organiser and invited speaker	120
Oct 07	Surficial Geology III course and field trip "Acid sulfate soils origin, distribution, development and management"	The University of Adelaide and Hermanns Catchment, Adelaide Hills	Rob Fitzpatrick	Organiser and presenter	59 PhD and other students
5-9 Nov 06	Regolith 06: Consolidation and Dispersion of ideas – CRC LEME Annual Symposium	Hahndorf Resort, Adelaide Hills, SA	Steve Rogers 90 Oral Presentations, plus posters. Listed in Refereed Publications	LEME event	120
Dec 06	Australian Clay Mineral Society and SA Branch Australian Soil Science Society – Symposium and Field Trip	Adelaide and SE South Australia	Rob Fitzpatrick	Convenor	55 at Symposium 24 on Field trip
24 Jan 07	Geoscience Australia, Eucla Basin workshop	Canberra, ACT	Lisa Worrall, John Keeling	CRC LEME / GA	7
Feb 07	Public Forums on Acid Sulfate Soils, Tasmania	Tasmania	Rob Fitzpatrick	Organiser and Invited Speaker	120
27 Feb 07 – 2 Mar 07	Australian Soil Resources Information Systems (ASRIS) Workshop	CSIRO, Canberra, ACT	Colin Pain	Organiser and speaker	20
22 Jun 07	Mineral Exploration Through Cover Conference	Adelaide, SA	Graham Heinson, John Keeling, Andreas Schmidt Mumm	Organising Committee	130
25-29 Jun 07	International Association for Geomorphology, Working Group Meeting on Applied Geomorphic Mapping	Kota Kinabalu, Malaysia	Colin Pain	Chair and Speaker	80



MEDIA

Centre activities and research outputs have continued to reach general and specialised media via LEME Communications Officer, Greg Lawrence, and Core Participant publications.

New Scientist Magazine published a feature article in late June 2007 highlighting LEME research activities in the Tanami Desert relating to the potential for termite mounds

and Spinifex to be used as geochemical sampling media by the MINEX industry.

The announcement in August of Ravi Anand as the 2006 Butt Smith Medal Winner, and LEME phyto-exploration research received considerable media attention.

Magazine and newsletter articles coupled with the Centre's own quarterly publication, the Minerals Brief, continued to effectively communicate LEME research to it

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stakeholders nationally and internationally. Significant coverage of LEME research results was featured in PIRSA's MESA Journal, The Mining Chronicle and The Australian Geologist (TAG).

The Centre contributed feature articles to the CRC PBMDS Focus on Salt Magazine each quarter. The arrangement concluded on 30 June 2007 when CRC PBMDS officially ceased business.

CRC LEME Minerals Brief – Regolith Science in Mineral Exploration

Edited by Greg Lawrence

Minerals Briefs are produced as printed copies, are circulated electronically to over 700 mineral explorers, and are available on LEME web site: http://crcleme.org.au as .PDFs. 4pp

- No. 11, September 2006
- No. 12, December 2006
- No. 13, March 2007
- No. 14, June 2007





Want to find buried treasure? Nature's little diggers will show you the way, says Beth Geiger

THE Kalahari desert in Botswa guards its geological secrets well. A layer of sand, soil and weathers rock tens of metres thick blankets all but a few outcrops of the underlying bedrock. Trying to find precious minerals embedded in the bedrock is a blind and very expensive grope.

That's why, when a geologist in the 1970s discovered a single fleck of a mineral called ilmenite on the surface, he paid attention Ilmenite comes from a type of rock called kimberlite, and kimberlite hosts diamonds That telltale fleck gave up an invaluable secret from the rock below: the richest diamond deposit in the world, now the Jwaneng diamond mine. But the minerals were 40 metres down, so how did a lone grain of ilmenite see the light of day? Termites hauled it. Desert termites dig deep. They need to. In

hot, arid areas, termites build large mounds above ground to help air circulation and temperature control. If a mound is damaged, it must be repaired immediately to keep out predators and protect the colony. However dry the desert, termites always need wet mud for

construction. To get it the insects tunnel 30 metres or more down to the water table, clamp bits of clay or wet rock in their jaws, then climb back home to build the mound, grain by damp grain. In doing this they not only bring up samples of the soil from that depth, but also traces of water that may have flowed through rocks containing preci ores. Termite mounds are packed with clues

to what lies beneath. Now geologists and mining companies are waking up to the true potential of termite sampling. A team of Australian researchers is developing precise techniques that make the mounds, along with desert plants, reliable indicators of the rocks below. As well as scouring termite mounds for traces of gold, they are searching for chemical signatures of gold formation, brought up from the water table and concentrated in the mounds. Termites they believe, are the ticket to new reserves of diamonds, gold and other buri

Normally, to get a sample of B0 sock f&RC LEME ANNUAL REPORT 2006-07 beneath all the accumulated sand, soil and stones, collectively known as regolith,

.

Media Statements, Magazine Articles and Radio Interviews

Subject	CRC LEME contact	Publication	Date
LEME mineral exploration showcased at seminar	Greg Lawrence	Media Statement	Jul 06
Seminar shows Spinifex may hold the secrets of the desert	Greg Lawrence	Media Statement	Jul 06
Clay that turns green in the cold	John Keeling	Mineral Exploration South Australia (MESA)	Aug 06
Source of heavy minerals in the Eucla Basin palaeobeach placer province, South Australia: age data from detrital zircons	Baohong Hou	MESA	Aug 06
Great Victoria Desert: New dates for South Australia's oldest desert dune system	Mel Lintern	MESA	Aug 06
CSIRO study finds bacteria vital in gold formation	Frank Reith	The Mining Chronicle	Aug 06
LEME mineral exploration research set for showcasing at seminar	Ravi Anand	The Mining Chronicle	Aug 06
New technology draws in chemistry for mineral explorers	Roger Fidler	The Mining Chronicle	Aug 06
Humble Spinifex could be the exploratory key: CRC	Steve Hill	MiningNews.net	Aug 06
The mystery of gold nuggets explained as part of Earth Science Week	Greg Lawrence	Media Statement	Sep 06
CSIRO geoscientist awarded research medal	Greg Lawrence	Media Statement	Sep 06
CSIRO geoscientist awarded Butt Smith research medal	Ravi Anand	The Mining Chronicle	Sep 06
Spinifex metal detectors	Steve Rogers	National ABC Rural Radio (live)	Sep 06
Using plants to search for minerals	Steve Rogers	Nightline Program, Radio 6PR Perth (live)	Sep 06
Spinifex gold has explorers salivating	Steve Rogers	WA Country Hour	Sep 06
CSIRO geoscientist awarded	Ravi Anand	Uthayam	Sep 06
Gold nugget research	Rob Hough	National ABC Rural Radio: Resources Beat	Sep 06
CSIRO scientist awarded research medal	Ravi Anand	Queensland Government Mining Journal	Sep 06
Bacteria form gold nuggets	Frank Reith	Queensland Government Mining Journal	Sep 06
Handing over gold nuggets	Rob Hough	ABC Radio, WA Country Hour	Sep 06
Loveday Basin restoration underway	Sebastien Lamontagne	Focus on Salt	Sep 06
'Bird' the latest in salinity mapping technology	Tim Munday	Sunraysia Daily	Sep 06
Mystery of gold nuggets	Rob Hough	WA Science Network	Oct 06
Mystery of gold nuggets explained	Rob Hough	MiningNews.net	Oct 06
Growing for gold	Frank Reith	Materials World	Oct 06
Spinifex helps us eat further into the crust	Steve Hill	Australian Financial Review	Oct 06
Rethinking regolith	Ravi Anand	MiningNews.net	Oct 06
Mining by-products could help WA manage its acid-saline drainage	Greg Lawrence	Media Statement	Nov 06
Mining products could help WA manage its acid-saline drainage	Grant Douglas	Farm Weekly	Nov 06
Acidity up to mud	Grant Douglas	Countryman	Nov 06
York under the microscope	Paul Wilkes	Rural Towns - Liquid Assets Newsletter	Nov 06
Mining products could help WA manage its acid-saline drainage	Grant Douglas	Industry Search Australia	Nov 06
Yilgarn Craton Geochemistry	Matthias Cornelius	GSWA Fieldnotes	Dec 06
Awards for excellence	Ravi Anand	Earth Matters	Dec 06
South Australian Explorers' Conference, St Barbara's Day	John Keeling	MESA	Dec 06
CHIM electro-geochemical trials: Results from Challenger Gold Mine	John Keeling	MESA	Dec 06
Book review: Expressions of Australian Ore Systems	Charles Butt, Ian Robertson, Keith Scott & Matthias Cornelius	The Australian Geologist	Dec 06
Book review: Regolith Landscape Evolution Across Australia	Ravi Anand & Peter de Broekert	The Australian Geologist	Dec 06
Future of Australian regolith R&D and innovation in Australia – end user priorities	George Savell	The Australian Geologist	Dec 06
Multi-scale mapping for better salinity management	Greg Lawrence	Focus on Salt	Dec 06
Natural exploring	Steve Hill	Australian Mining Monthly	Jan 07
2006 in Review	John Keeling and Steve Hill	MESA	Jan 07



Media Statements, Magazine Articles and Radio Interviews (cont'd)

Subject	CRC LEME contact	Publication	Date
Drill rigs make way for plants in minerals search	Steve Hill	ABC Radio SA	Feb 07
Plants point the way to uranium mineralisation	Greg Lawrence	Media Statement	Feb 07
SA plants hold uranium	Steve Hill	Science Alert Australia & New Zealand	Feb 07
Understanding helps handle the water challenge	Steve Rogers	Process Magazine	Feb 07
New way to find uranium	Steve Hill	Red-hot resources	Feb 07
'Bird' back for another survey	Tim Munday	Mildura Midweek	Feb 07
Geological strengths finally exposed	Charles Butt	Gold and Minerals Gazette	Feb 07
Water points the way to nickel wealth	Greg Lawrence	Media Statement	Mar 07
New sampling technique to help Australia assess its energy potential	Greg Lawrence	Media Statement	Mar 07
Plants hold uranium secrets	Michael Neimanis	Australia's Paydirt	Mar 07
CSIRO may have found better nickel exploration method	David Gray	ABC Radio News, WA	Mar 07
Water leads the way to nickel wealth	David Gray	Science Alert Australia & New Zealand	Mar 07
Rock fishing	David Gray	Canberra Times	Mar 07
Water leads the way to nickel wealth	David Gray	Care2 News Network	Mar 07
The Salinity Threat	Ken Lawrie	Issues 78 – Disasters	Mar 07
Natural exploring	Steve Hill	MiningNews.net	Mar 07
River drilling to test salinity	Tim Munday	Sunraysia Daily	Mar 07
What's all the stink about: A guide to sulfur gas emissions in Australian wetlands and disposal basins	Greg Lawrence, Sebastien Lamontagne	Focus on Salt	Mar 07
New sampling technique to help Australia assess its energy potential	Patrice de Caritat	AusIMM Online Newsletter	Apr 07
Thomson CRC project	Steve Rogers	Mine Info	Apr 07
New sampling technique to assess energy potential	Patrice de Caritat	Australia's Paydirt	May 07
Geophysics update for York	Paul Wilkes	Rural Towns – Liquid Assets	May 07
Sorting the wheat from the chaff in the west	Steve Rogers	Australia's Paydirt	May 07
Regional geochemical study paves the way for national survey	Patrice de Caritat	Ausgeo News	Jun 07
Sulfidic sediments in inland systems – the Loveday Basin	Paul Shand, Sue Welch, Luke Wallace, and Sara Beavis	Assay: ASS Newsletter	Jun 07
Steel wastes may offer cure	Grant Douglas	License to Operate	Jun 07
Nuggets hide a mystery worth their weight in gold	Rob Hough	WA Science Network	
Plant analysis to aid uranium exploration	Michael Neimanis	WA Science Network	Jun 07
Aerial technology to give Sunraysia a clearer salinity picture	Greg Lawrence, Tim Munday	Focus on Salt	Jun 07
Follow that termite	Lisa Worrall	New Scientist	Jun 07

EDUCATION AND TRAINING

LEME's Education and Training (E&T) Program provides world-class education and training in regolith geoscience to undergraduates, postgraduates and industry professionals through its three Core Participant universities: ANU, CUT and UA.

> Program Leader: Dr Ian Roach (ANU)



Education and Training

Highlights

- Total postgraduate numbers set to exceed Key Performance Indicators (KPI).
- 100 honours students graduated against a KPI of 60
- Core Participant universities experience significant enrolments in second and third year undergraduate regolith geoscience programs.
- Strong MINEX and NRM industry uptake of LEME graduates continues with more than 50% of LEME 2006-07 graduates gaining employment.
- LEME breakthrough research in termitaria geochemistry and phytoexploration by LEME/UA PhD students Anna Petts and Nathan Reid profiled in *New Scientist* Magazine.
- Outstanding research contributions made by 12 LEME PhD students recognised by the LEME Regolith Symposium Student Awards.

Introduction

LEME's Education and Training (E&T) Program provides world-class education and training in regolith geoscience to undergraduates, postgraduates and industry professionals through its three Core Participant universities: ANU, CUT and UA. LEME is recognized as a world-class educator and provider of geoscience graduates for careers in research and the MINEX and NRM industries. LEME's E&T Program aims to:

- Provide funds, scientific supervision (in collaboration with industry advisers) and institutional support for students by granting competitive scholarships and operating support at BSc Honours and PhD levels. The Program's quantitative benchmark is to produce more than 60 postgraduate (PhD and MSc) and 60 BSc Honours graduates within the life of the Centre.
- Develop and deliver relevant, industryrelated workshops, seminars and training courses on regolith geoscience and related disciplines directed at students, industry, government and institutional professionals.
- Contribute relevant, up-to-date regolith geoscience content to undergraduate university courses in consultation with industry and other research agencies.

These activities are consistent with milestones set out in the Centre's Commonwealth Agreement.

The E&T Program is managed by Ian Roach with support from the E&T Committee comprising: Mehrooz Aspandiar (Deputy Program Leader, CUT), Steve Hill (past E&T Program Leader, UA), Karin Barovich (UA) and Richard Greene (ANU).

Honours and Postgraduate Scholarship Programs

Postgraduate students

The Centre supports postgraduate students who contribute to the four research Programs by offering a range of scholarship options:

- Full stipend of \$18.5k tax-free and up to \$10k operating expenses per annum.
- PhD top-up stipend, typically of \$5k taxfree, plus operating expenses of up to \$10k per annum.
- PhD operating expenses only, up to \$10k per annum.
- PhD supervision and operating expenses derived from research project funds.
- In 2007-08, PhD supervision with operating expenses by competitive bid from reallocated scholarship funds unspent from previous years.

Supervision in the 2006-07 period was provided by in-kind contributed or contract Centre staff members and outside advisers from industry or research institutions. No new LEME postgraduate scholarships were awarded in the 2006-07 financial year. However, the Postgraduate Scholarship Program will be maintained until the Centre closes at the end of June 2008, to support students currently in the system. Postgraduate student supervision by present in-kind contributed research staff will also continue after the Centre's closure.

LEME Core Participant universities have attracted high-profile students who have gained scholarships from other sources including the Commonwealth Government and other university and Australian Research Council awards in 2006 and 2007. These students will carry on the legacy of regolith research after the Centre's closure in June 2008 and will act as benchmarks to the quality and success of the Centre's research Programs. This will include four students at ANU (Fern Beavis, Andrew Higgins, Julia Jasonsmith and Nicole Mikkelson) and three students at the UA (Jessie Davey, David Haberlah and Michael Neimanis).

Postgraduate students have continued to make an important contribution to the Centre's research with some attracting international attention for their work. Research by Anna Petts (UA) and Nathan Reid (UA) into using termites and Spinifex to search for gold in the Tanami Desert was highlighted in the 30 June 2007 edition of the New Scientist Magazine. Other students who have made significant and externally recognised research contributions include 2006 graduand, Frank Reith (ANU) for his ground-breaking research on the bacterial mediation of gold in the regolith; Mike Hatch (UA) for his work on detecting saline water incursions in the base of the Murray River; and both Karen Hulme (UA) and David Little (ANU) for their understanding of regolith-biota interactions.

During the current minerals boom and associated skills shortage, many Centre students are currently employed on a parttime or full-time basis in national or international resource exploration companies or government geoscience agencies, while they complete their studies. This is an outstanding indicator of the high regard that industry has towards LEME students and graduates.

LEME is on track to meet or exceed its KPI target of graduating 60 postgraduates (PhD and MSc). At the end of the 2006-07, the Centre had 31 postgraduate graduations with an additional nine completions notified after the reporting period. A further 36 students are progressing towards completing their degrees, with at least 75% of those scheduled to submit before the end of LEME.

Honours students

The Centre offered a limited number of Honours scholarships (\$5k tax-free stipend and up to \$5k operating expenses) during the 2006-07 period at ANU and CUT. Other Honours students have contributed to the Centre's research Programs with funds either drawn from research Programs or were supervised by Centre in-kind contributed or contract staff members.

The Centre is on target to double its KPI of 60 Honours graduates by June 2008. At the end of the reporting period, the Centre had graduated 100 Honours students with a further 18 students in the system. More than 50% of the 2006-07 graduates have found employment in the MINEX or NRM industries. Other graduates have gone on to pursue postgraduate studies, either within LEME Core Participants or other Australian universities. These statistics clearly show the Honours Program is one of LEME E&T Program's great successes.

Short courses, workshops and seminars

LEME contributes towards the conduct of annual seminars, short courses and workshops, via:

- National MTEC Honours Program
- National MTEC Masters Program
- Undergraduate courses at Core Participant institutions
- Industry workshops.

LEME is a major contributor to the MCA MTEC national Honours and Masters minerals short course initiatives. MTEC funds a substantial proportion of Ian Roach's salary, as well as incentive payments to develop and deliver courses. LEME provides a top-up to the MTEC Program in the form of supplementary salary and operating expenses.

MTEC Honours short courses

LEME conducted three national Honourslevel short courses for MTEC during the year:

- Regolith Geology and Geochemistry (RGG),19-23 February 2007, Wilsons Promontory National Park, Victoria
- Introduction to Hydrogeochemistry (HGC), 16-20 April 2007, Australian National University
- Environmental Mineralogy (EMN), 18-22 June 2007, Australian National University.

These courses were offered across seven universities – ANU, CUT, James Cook University, The University of Melbourne, Monash University, UA and The University of Tasmania. More than 57 Honours-level undergraduates, postgraduates and industry professionals enrolled in LEME's MTEC courses during 2006-07. Ian Roach was also involved teaching regolith in a second-year MTEC field course run by Melbourne and Monash universities in Broken Hill, July 2006.

Generic courses for LEME students

A range of generic-skills courses are held on an annual basis for students enrolled at LEME Core Participant universities including four-wheel drive training, first aid and field safety, plus workshops, seminars and mentoring programs on thesis writing, research publication writing and scientific communication skills.

Industry workshops and technology transfer

During the year, LEME conducted 'one-onone' courses, workshops, presentations and technology transfer meetings through Programs 1 to 4 and by the E&T Program with the majority of the workshops aligned to specific research projects.

These workshops were:

- An introduction to regolith geology and implications for mineral exploration in the Cobar region, NSW. (Short course to Cobar Management Pty Ltd) organised by Ken McQueen, 7-8 December 2006, Cobar, NSW
- What is regolith? Introduction to regolith and properties of sodic soils. (Presentation and practical demonstration to the ACT science educators conference CONSEA* ACT) organised by Ian Roach, 2 November 2006, Canberra, ACT
- Copper mining in Australia: Discovery, deposit types, distribution and exploration. (Short course to Glencore International) organised by Ken McQueen, 30 November 2006.
- A technology transfer visit to Jabiru Metals Jaguar Deposit, WA organised by Mehrooz Aspandiar and Ravi Anand


LEME is recognised as a world-class educator and provider of geoscience graduates for careers in research and the MINEX and NRM industries.



- Adelaide Exploration Seminar (Andreas Schmidt-Mumm convener)
- Two-day undergraduate regolith field class with second year students from Melbourne and Monash universities, 8-9 July 2006, Broken Hill, NSW
- Uranium exploration phyto-geochemical technology transfer visit to Heathgate Resources (Steve Hill).

Regolith Symposium

Departing from the previous tradition of holding regional regolith symposia at Adelaide, Canberra and Perth, a national LEME Regolith Symposium was held at the Hahndorf Resort, Adelaide Hills, 5-9 November 2006. All LEME staff and students were invited to attend and present. Some 100 presentations by LEME staff and students were published as a 386-page, fully refereed abstract volume in hard copy, CD-ROM and as PDF abstracts available for download from the LEME web site.



Students Margaret Smith (above), Fern Beavis and Mike Hatch receiving their awards at the 2006 Regolith Symposium.

At the Symposium Dinner, LEME Chair, George Savell, and CEO, Steve Rogers presented awards to twelve PhD students who have contributed in an outstanding manner to the generation of innovative LEME regolith science outcomes over the life of LEME:

- Andrew Baker (UA) Isotopic and geochemical studies of soil-regolith-rock interaction with ground waters, stream waters and base metal mineralisation: implications for mineral exploration and the environment
- Robert Dart (UA) Research the origin and distribution of calcrete in Southern Australia
- Kathryn Fitzsimmons (ANU) Relationships between regional landform patterns and landscape history in the Lake Eyre Basin dunefields
- Michael Hatch (UA) The use of shallow geophysical techniques to help characterise hydrological parameters
- Karen Hulme (UA) Biogeochemistry of river red gums (Eucalyptus camaldulensis) in the Curnamona Province and adjacent parts of SA and NSW
- David Little (ANU) Investigate, quantify and model rhizosphere in regolith formation in temperate landscapes in south-eastern Australia

- Ryan Noble (CUT) 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
- Mark Paine (CUT) Regolith and landscape evolution of the Dundas Tableland, western Victoria, with implications for salinity management and heavy mineral exploration
- Anna Petts (UA) Termitaria and other landscape indicators of sub-surface regolith
- Nathan Reid (UA) Biogeochemistry of regolith associated with Au deposits in the Tanami, WA and NT
- Frank Reith (ANU) Interactions of microbes and gold in regolith in moderate, arid and tropical climates
- Margaret Smith (CUT) Groundwater acidification process with the Lake Muir-Unicup natural diversity recovery catchment, WA.



A panel of industry leaders met in May 2007 to advise on the core and specialist knowledge necessary for Honours geology graduates for the Australian and international minerals industry. At this meeting it was unanimously acknowledged that regolith was one of the specialist disciplines needed for industry-ready geology graduates.

Other Student Awards during the reporting period were:

Student name	Uni	Event, Prize description	Date recd
Glen Bann	ANU	Travel Bursary Australian Society Agronomy Annual Conference	September 2006
Anna Petts	UA	2006 Australian Earth Science Convention Best Student Poster Award	July 2006
Frank Reith	ANU	Research School of Earth Sciences – Robert Hill Memorial Prize for excellence in research and scientific communication	October 2006
Margaret Smith	CUT	Best Student Poster, CRC LEME Regolith Symposium	November 2006
Fern Beavis	ANU	Best Student Talk, CRC LEME Regolith Symposium	November 2006
Fern Beavis	ANU	PhD Student Oral Presentation Award at 23rd International Applied Geochemistry Symposium, Oviedo, Spain	June 2007

Undergraduate students

Undergraduate regolith courses are coordinated and taught by in-kind and contract LEME staff members at ANU, CUT and UA, together with staff from other LEME Core Participants. These courses provide an essential prerequisite for students either wanting to become regolith researchers or 'regolith-savvy' work as industry professionals. During 2007, more than 300 undergraduate students were introduced to the fundamentals and applications of regolith geoscience including regolith mineralogy, rock weathering, landscape evolution, groundwater flow, regolithgroundwater interactions, remote sensing of regolith and regolith geophysical techniques.

At ANU, regolith science is taught to undergraduates at second and third year level in a range of courses that provide students with the fundamentals of regolith and water interactions, landscape evolution and regolith-related environmental problems. Beginning in 2007, ANU had a major curriculum change and divided aspects of regolith geoscience from one stand-alone course in 2006 to three individual courses in 2007:

- Regolith and Hydrology 2006 (Secondyear, 14 students)
- Environmental Chemistry 2007, including regolith-groundwater interactions (Second-year, 41 students)
- Groundwater 2007, including hydrogeology (Third-year, 16 students)
- Environmental and Regolith Geoscience 2007 – the principal regolith course at the ANU (Third-year, 14 students).

At CUT, regolith geoscience components are taught in the second, third and fourth years of undergraduate training (excluding MTEC courses):

- Second Year Remote Sensing 2007, including regolith, landforms, mapping (60 students)
- Regolith and Exploration Geochemistry 2007, the principal regolith course at CUT and includes presentations by practicing regolith mineral exploration professionals as part of its curriculum (Third-year, 33 students)
- Third-year Sedimentology Field Class 2007 (26 students)
- Fourth year (Honours) Remote Sensing 2007 (11 students).

Regolith geoscience at UA is taught to undergraduates in the second and third year:

- Second-year Landscape Processes and Environments 2007, the principal regolith course at UA (68 students)
- Third-year Environmental Geoscience Processes 2007 (31 students).

During the year, a number of in-kind and contract staff from a number of LEME Core Participants taught undergraduate courses at ANU, CUT and UA, including Mehrooz Aspandiar, Charles Butt. David Chittleborough, Patrick De Deckker, Tony Eggleton, John Field, Richard Greene, Steve Hill, Brad Pillans, Ian Roach, Ian Robertson, Bear McPhail and Sue Welch. The bulk of the teaching load at CUT and UA was undertaken by Mehrooz Aspandiar and Steve Hill, respectively, who are to be congratulated for maintaining their teaching excellence despite heavy teaching, research and student supervision loads.

National Undergraduate Regolith Geology School (NURGS)

This annual undergraduate regolith geology field trip, was held 10-14 July 2006 at the Fowlers Gap Arid Zone Research Station in far western NSW. NURGS uses examples of LEME's research in Curnamona Province and Thomson Orogen to provide students with essential grounding in regolith and landscape evolution and regolith-landform mapping, together with some hands-on demonstrations of regolith and biological sampling procedures, regolith geophysical techniques and soil description. The field trip is an essential part of the undergraduate curriculum at ANU and UA and contributes to the direct entry of students into the Honours programs at both institutions. Over 60 students from ANU and UA attended. Staff involved in organising and running the course were Steve Hill (UA), Ian Roach (ANU), John Field (ANU) and Graham Heinson (UA).

The E&T Program Regolith Teaching and Training Materials Project develops teaching materials for undergraduate courses at the Core Participant universities and NURGS.



Outlook for 2007-08

Although LEME's research begins to wind down in 2007-08, the Centre anticipates its E&T activities will continue at the level experienced during the reporting period. This is largely due to the fact that the Centre's E&T Program is recognised for its successful development and delivery of world-class education and training courses at undergraduate, Honours, Masters and industry professional levels. These courses are essential technology transfer vehicles. They pass on LEME research to individuals and organisations, for utilisation by the wider MINEX and NRM industries and academia.

Undergraduate and postgraduate regolith geoscience teaching programs will continue at ANU, CUT and UA during 2007-08 and beyond. These programs will build upon the teaching and training materials developed and delivered in the MTEC and RTTM projects. Strong enrolments in undergraduate regolith geoscience courses are projected to continue at all three Core Participant universities, ensuring there will be a good supply of graduates with regolith knowledge to take into industry or research careers. These universities will continue to offer regolith geoscience as part of their core curricula, ensuring the skills and knowledge developed by the Centre will continue to be transferred to future students, as a part of LEME's legacy.

The Centre anticipates the ownership transferral of the MTEC Honours and Masters Coursework Programs to individual universities in 2007-08, after the current MTEC contract with the Centre expires in December 2007. A panel of industry leaders met in May 2007 to advise on the core and specialist knowledge necessary for Honours geology graduates for the Australian and international minerals industry. At this meeting it was unanimously acknowledged that regolith was one of the specialist disciplines needed for industry-ready geology graduates.

Planned Legacy Products include:

- Interactive electronic self-paced, learning modules, course notes, virtual field trips, journal papers, maps and teaching data collations.
- Fowlers Gap Regolith-landform 1:12,500-scale maps: Sandstone and Sandstone Ridge, South Sandstone and Conners Paddock, NSW
- Regolith Geology and Geochemistry MTEC Honours short course notes and

virtual field guide, Wilsons Promontory, Vic

- Regolith Mapping and Field Techniques MTEC Honours course notes and interactive regolith-landform mapping tutorial, Fowlers Gap, NSW
- Fowlers Gap data DVD imagery and regolith-landform maps of the Fowlers Gap Arid Zone Research Station for teaching
- Environmental Mineralogy MTEC Honours course on regolith mineralogy and X-ray Diffraction Courses notes
- Radiometric imagery interpretation selfpaced learning module
- Teaching regolith geoscientists a Journal of Geological Education paper describing LEME's E&T activities.

As the Centre activities begin to conclude it is pleasing and positive to note that the outlook for regolith geoscience teaching and training in Australia looks assured. LEME's Education and Training activities have raised the profile of regolith science so that it is now an integral part of graduate and postgraduate geoscientist training in a large proportion of Australian universities.



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Graduate destinations

The Centre has been advised of the following.

Recent Honours graduates

Owen Davis (CUT) – Geophysicist, Woodside Energy

Russell Eade (CUT) – Geophysicist, Independence Group

Layla Tucker (UA) - Geologist, AngloCoal

David McAvaney (UA) – Geologist, Heathgate Resources

Rachel Wilson (UA) – Geologist, NuPower U exploration

Jack Lowrey (UA) – Geologist, BHP Billiton graduate program

Jennifer de Livera (ANU) – Hydrogeologist, Parsons Brinckerhoff Australia Pty Ltd, now PhD UA

Lloyd Issacsson (ANU) – PhD Southern Cross University

Simeon Hui (ANU) – PhD ANU

Andrew Higgins (ANU) - PhD ANU

Jacob Smith (CUT) – Geophysicist, Resolute Mining

Gabrielle Yeates (ANU) – Hydrogeologist, Snowy Mountains Engineering Corporation.

Recent Postgraduates

John Fawcett – Department of Primary Industries, Victoria

Anousha Hashemi – Geophysicist, BHP Billiton, WA

Martin Smith – Researcher, Geoscience Australia, ACT

Recent postgraduate thesis submissions

These students submitted during, but may have graduated after, the reporting period:

Andrew Baker (UA)

Bahman Bayat (CUT)

Kathryn Fitzsimmons (ANU)

Chris Gunton (ANU)

Philip Heath (UA) – Geophysicist, Canadian Micro Gravity, Timbuktoo, Mali

Kamal Khider (ANU)

Mohammed Rosid (CUT)

Mark Thomas (UA)

Alastair Usher (ANU)

Vanessa Wong (ANU) – Researcher, Geoscience Australia, ACT LEME/UA PhD geophysics graduand Philip Heath finds adventure in Timbuktu where he was collecting and interpreting gravity data from an airborne platform.

EDUCATION AND TRAINING

POSTGRADUATE STUDENTS

Student	Project	Prog	Supervisor(s)	Funding	Year	Uni
Doctor of Philoso	phy (PhD) – Graduated					
John Fawcett	Processes and implications of scald formation on the eastern Dundas Tablelands: a case study	3	Rob Norton (UM), Rob Fitzpatrick (CSIRO LW) Peter Dalhaus (Dalhaus Environmental Geology Pty. Ltd.)& Bill Gardner (WestVic Agservices)	Nil LEME	2006	Uni Melb
Anousha Hashemi	Innovative geophysical and geochemical exploration for high-grade manganese ore under cover in the East Pilbara of WA	2	Jayson Meyers (CUT)	LEME	2006	CUT
Ryan Noble	Dispersal mechanisms of As and Sb in regolith and surface deposits in the vicinity of buried Au ore bodies, NW Victoria: implications for Au prospectivity and environmental management	2	Ron Watkins (CUT)	APA + LEME top-up	2006	CUT
Martin Smith	Landscape evolution of western NSW: a framework for comparison of regolith dating methods	1	Brad Pillans (ANU)	ANU + LEME top-up	2006	ANU
Victor Waclawik	The regolith geology and landscape evolution of Umbum Creek, West Lake Eyre, SA	1	Simon Lang (UA), Steve Hill (UA), Pat James	LEME/ UA	2006	UA
Doctor of Philosop	ohy (PhD) – commenced, graduand and continuing					
Student	Project	Prog	Supervisor(s)	Funding	Year	Uni
Simon Abbot	Application of geophysical technologies for 3D visualization of palaeochannels and use of this information for management of dryland salinity in Western Australia.	4	Jayson Meyers (CUT), Anton Kepic (CUT), Keith Smettem	CUPS+ LEME Top-up	2004-	CUT
Andrew Baker	Isotopic and geochemical studies of soil-regolith-rock interactions with ground waters, stream waters and base metal mineralisation: implications for mineral exploration and the environment	1	Rob Fitzpatrick (CSIRO LW) John Foden (UA)	, APA + LEME Top-up	2002-	UA
Glen Bann	Dryland salinity, biodiversity and geodiversity: biotic and abiotic indicators	4	John Field (ANU), Colin Pain (GA)	LEME	2003-	ANU
Bahman Bayat	Indirect exploration of ore deposits in weathered terrains with airborne gravity gradiometry	2	Anton Kepic (CUT), Jayson Meyers (CUT)	LEME Op. only	2005-2007	CUT
Fern Beavis	Diagenetic and anthropogenetic transformations of metals and other elements in regolith	2	David Ellis (ANU), Sue Welch (ANU)	ANU + LEME opex	2006-	ANU
Kirsty Beckett	Multispectral analysis of high spatial resolution, 256-channel radiometrics for soil and regolith mapping	3&4	Jayson Meyers (CUT), Anton Kepic (CUT), Bichard Coorga (WADAE)	CUPS + LEME Top-up	2002-	CUT

Kirsty Beckett	Multispectral analysis of high spatial resolution, 256-channel radiometrics for soil and regolith mapping	3&4	Jayson Meyers (CUT), Anton Kepic (CUT), Richard George (WADAF)	CUPS + LEME Top-up	2002-	CUT
Aaron Brown	Regolith geochemistry and biogeochemistry of the White Dam Cu-Au deposit, Curnamona Province, SA	1	Steve Hill (UA)	LEME	2002-	UA
Paul Carlile	Development of semi-distributed catchment hydrology model for simulation of land-use change, streamflow and groundwater recharge within the Little River Catchment, NSW	4	Tony Jakeman (ANU), Brian Lees (ANU)	LEME	2004-	ANU
Troy Cook	Geochemical investigation into the acid generating potential of wetland sediments of the Gnaugara and Jandakot Mounds : Implications for long-term water quality	3	Ron Watkins (CUT)	APA + LEME Top-up	2004	CUT
Mike Craig	Regional regolith and landscape evolution in the eastern Goldfields, Yilgarn Craton, Western Australia	1&2	Ken McQueen (ANU), Graham Taylor (UC), Colin Pain (GA)	GA	1998-	UC
Robert Dart	The origin and distribution of calcrete in Southern Australia	1	Karin Barovich (UA), David Chittleborough (UA), Steve Hill (UA)	LEME/ UA	2004-	UA
Jessie Davey	Mesozoic regolith in SW Eromanga Basin	1	Steve Hill (UA), Neville Alley (UA)	APA	2006	UA
Tania Dhu	Electrical and EM studies of regolith and sub-regolith structure	1	Graham Heinson (UA), Stewart Greenhalgh (UA)	LEME/ UA	2003-	UA
John Drewry	Modelling nutrient generation in Australian catchments: land use, regolith and management factors affecting surface and groundwater quality	3	Tony Jakeman (ANU), Barry Croke (ANU)	APA + LEME Top-up	2004-	ANU
Michael Durkey	Effect of drains on soil properties in SE SA	3	David Chittleborough (UA), Steve Hill (UA)	UA/ DWLBC	2003-	UA

POSTGRADUATE STUDENTS (cont'd)

Student	Project	Prog	Supervisor(s)	Funding	Year	Uni
Doctor of Philoso	ohy (PhD) – commenced, graduand and continuing (cont'd)				
Kathryn Fitzsimmons	Relationships between regional landform patterns and landscape history in the Lake Eyre Basin dunefields	1	John Magee (ANU), Ed Rhodes (ANU)	APA + LEME Top-up	2003-	ANU
Baihua Fu	Fingerprinting suspended sediment in spatial and temporal scales in Australian coastal catchments	3	Tony Jakeman (ANU), John Field (ANU), Lachlan Newham	ANU	2005	ANU
Lachlan Gibbins	Measuring hydraulic conductivity with streaming potentials	4	Graham Heinson (UA)	LEME/ UA	2004-	UA
Chris Gunton	Element dispersion and mobility in the regolith	2	Bear McPhail (ANU), Andy Christy (ANU)	APA + LEME Top-up	2002-	ANU
David Haberlah	Aeolian dust accessions to regolith, Flinders Ranges, SA		Martin Williams (UA), Steve Hill (UA)	IRPS	2006-	UA
Michael Hatch	The use of shallow geophysical techniques to help 4 Graham characterise hydrological parameters		Graham Heinson (UA)	nil leme	2005-	UA
Philip Heath	3-D automated inversion of potential field tensor data	2	Stewart Greenhalgh (UA), Nick Direen (UA)	LEME/ UA	2003-	UA
Andrew Higgins	Loveday Basin or similar	3	Sue Welch (ANU)	ANU	2007-	ANU
Karen Hulme	Biogeochemistry of river red gums (<i>Eucalyptus camaldulensis</i>) in the Curnamona Province and adjacent parts of SA and NSW	1	Steve Hill (UA), Steve Rogers (LEME)	LEME/ UA	2003-	UA
Donald Hunter	Application of nuclear magnetic resonance in groundwater studies	4	Anton Kepic (CUT)	APA + LEME Top-up	2002-	CUT
Julia Jasonsmith	Salinity tracers in the Hunter catchment, NSW		Bear McPhail (ANU), Ian White (ANU), Ben Macdonald (ANU)	ANU	2007	ANU
Kamal Khider	Regional chemical dispersion processes in the regolith of Cobar Nymagee area, Central West, NSW		Ken McQueen (ANU), Bear McPhail (ANU)	LEME	2002-	ANU
Sukhyoun Kim	Electrokinetic groundwater exploration	4	Graham Heinson (UA)	Nil LEME	2006	UA
Sam Lee	Hydrogeology of the Cape Range karst and coastal plain aquifers, Exmouth, NW Australia	3	Qadeer Rathur (CUT), Lindsay Collins (CUT)	APA + LEME Top-up	2002-	CUT
Matthew Lenahan	Origin, nature and mobility of salt in the regolith		Bear McPhail (ANU), Dirk Kirste (ANU)	LEME	2003-	ANU
Mel Lintern	The role of biological and non-biological factors in the formation of Au anomalies in calcrete	2	Lindsay Collins (CUT), Mehrooz Aspandiar (CUT), Ravi Anand (CSIRO EM)	nil leme	2001-	CUT
David Little	Investigation, quantification and modelling of regolith interactions in rhizospheres in temperate landscapes in SE Australia	1	John Field (ANU), Sue Welch (ANU), Steve Rogers (LEME)	LEME	2003-	ANU
Aija Mee	Origin, formation and environmental significance of sapropels in shallow Holocene coastal lakes of south-eastern Australia	1	David McKirdy (UA), Martin Williams (UA), Evelyn Krull	APA + LEME Top-up	2003-	UA
Nicole Mikkelson	Freshwater-saline water interactions in aquifers	4	David Ellis (ANU), Sara Beavis (ANU)	ANU + LEME opex	2006-	ANU
Michael Neimanis	Uranium biogeochemistry in plants	1	Steve Hill (UA), Stephen Hore (PIRSA)	APA	2006-	UA
Margarita Norvill	The use of distributed sensor arrays in electrical imaging	2	Anton Kepic (CUT), Jayson Meyers (CUT)	APA + LEME Top-up	2002-	CUT
Anna Petts	Termitaria and other landscape indicators of sub-surface regolith, Tanami	2	Steve Hill (UA), Lisa Worrall (GA)	leme/ ua	2004-	UA
Nathan Reid	Biogeochemistry of regolith associated with Au deposits in the Tanami, WA and NT	1	Steve Hill (UA), David Lewis (UA)	Nil LEME	2005-	UA
Mark Reilly	Evolution and internal architecture of ephemeral streams and delta/splay complexes, Umbum Creek, Lake Eyre, Central Australia	1	Simon Lang (UA), Steve Hill (UA)	LEME/ UA	2003-	UA
Mohammad Rosid	Groundwater investigations using the seismo-electric method	13	Anton Kepic (CUT)	Nil LEME	2001-	CUT
Greg Shirtliff	Weathering of waste rock dumps at Ranger Uranium Mine	1	Tony Eggleton (ANU)	LEME		ANU
Suzanne Simmons	U-Th-Pb systematics of opaline silica: implications for the dating of surface processes	1	Alexander Nemchin (CUT)	LEME	2002-	CUT
Michael Smith	The geochemical evolution of alkaline salt-affected soils on the western slopes of northern New South Wales	4	Bear McPhail (ANU)	ANU + LEME Top-up	2003-	ANU

EDUCATION AND TRAINING

POSTGRADUATE STUDENTS (cont'd)

Lloyd Isaacson

Kevin Kinnison

Jack Lowrey

David McEvaney

The distribution of acidity, salts and metals in a highly

Plant biogeochemistry of gold mineralisation buried by

an aeolian dunefield, Tunkillia South Australia

New Bendigo - South Waratta landscape evolution

modified acid sulfate soil backswamp, Mays Swamp,

Partitioning of acid in acid sulfate soils

Kemsey, NSW

Student	Project	Prog	Supervisor(s)	Funding	Year	Uni
Doctor of Philoso	ophy (PhD) – commenced, graduand and continuing (cont'	d)				
Margaret Smith	Groundwater acidification process with the Lake Muir- Unicup natural diversity recovery catchment, Western Australia	3	Ron Watkins (CUT), David Gray (CSIRO EM)	APA+ LEME Top-up	2005-	CUT
Peter Somerville	Dryland salinity in the Widden Creek Valley in the Upper Hunter Valley NSW	3 & 4	Ian White (ANU), Sara Beavis (ANU), Sue Welch (ANU), Ben Macdonald (ANU), Richard Bush (SCU)	LEME Op. Ex. only	2005-	ANU
Siriporn Soongpankhao	Geochemical dispersion mechanisms into regolith with application to selection of sample media, Gnaweeda, WA	2	Mehrooz Aspandiar (CUT), Ravi Anand (CSIRO EM)	LEME Op. Ex. only	2005-	CUT
Camilla Sorensen	Mapping of the regolith using Passive Seismics in combination with other geophysical methods	4	Ken Lawrie (GA)	Nil LEME	2005-	Monash
Greg Street	Interpretation of geophysics for catchment management	4	Jayson Meyers (CUT)	Nil LEME	2000-	CUT
Mark Thomas	New landscape analysis approaches for soil-regolith patterns and their salinity types in South Australia	4	Rob Fitzpatrick (CSIRO LW), Graham Heinson (UA)	LEME/ PIRSA	2002-2007	UA
Michael Turner	3 Dimensional pore scale characterisation of the permeability and porosity of regolith materials	4	Bear McPhail (ANU), Mark Knackstedt (ANU)	APA + LEME Top-up	2002-	ANU
Sarah Tynan	Geochemistry of heavy metals in coastal and inland sediments	3	David Ellis (ANU), Bradley Opdyke (ANU)	LEME	2005-	ANU
Alastair Usher	Gold mobility and geochemistry in hypersaline solutions		Bear McPhail (ANU), David Gray (CSIRO EM)	APA + LEME Top-up	2003-	ANU
Luke Wallace	Geochemistry and hydrogeology of inland acid sulphate environments	3	Bear McPhail (ANU), Sue Welch (ANU)	LEME	2004-	ANU
Paul Wilkes	Geophysics in the search for diamonds	2	Jayson Meyers (CUT), Simon Wilde (CUT)	Nil LEME	2000-	CUT
Vanessa Wong	The effects of salinity and sodicity on soil carbon stocks and fluxes	4	Richard Greene (ANU), Graham Farquhar (CRC GA)	ANU + CRC Greenhouse + LEME Top-up	2004-	ANU
Martin Worthy	Major water quality degrading events in the Cotter River Catchment: characteristics and management	3	Robert Wasson (CDU), Mike Hutchinson (ACTEW), John Magee (ANU)	ACTEW+ LEME Operating	2004-	ANU
Pierre-Allain Wulser	Mobility of uranium and rare earth in the Mt Painter-Lake Frome-Curnamona Craton Regions, SA : Geochemical and temporal controls	2	Joel Brugger (UA), John Foden (UA)	IPRS + LEME Top-up	2003-	UA
Master of Science	e (MSc) commenced and continuing					
Katie Dowell	Low temperature silicification in the regolith using black opal as a primary example	1	John Mavrogenes (ANU)	APA + LEME top-up	2003-	ANU
Mark Fritz	XRF method for analysing acid sulfate soils	3,4	Rob Fitzpatrick (CSIRO LW)	LEME/ UA	2003-	UA
HONOURS STU	JDENTS					
Student	Project	Prog	Supervisor(s)	Funding	Year	University
Honours Degree	- completed					
Owen Davis	Detection of uranium bearing stratigraphy beneath cover	1	Jayson Meyers (CUT)	LEME	2006	CUT
Russell Eade	Geophysical signatures of gold bearing epithermal high sulphidation systems	1	Paul Wilkes (CUT)	LEME	2006	CUT
Andrew Higgins	Physicochemical properties of regolith in the Loveday Basin SA	3	Susan Welch (ANU), Sara Beavis (ANU)	LEME	2006	ANU
Simeon Hui	Sources and sinks of uranium in the regolith	2	Bear McPhail (ANU),	LEME	2006	ANU

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Patrice de Caritat (GA)

Nil LEME

Nil LEME

Nil LEME

Nil LEME

2006

2006

2006 Jul

2006

ANU

ANU

UA

UA

Susan Welch (ANU),

Sara Beavis (ANU)

Dirk Kirste (ANU),

Sue Welch (ANU), Sara Beavis (ANU)

Steve Hill (UA)

Steve Hill (UA),

Alan Collins (UA)



HONOURS STUDENTS (cont'd)

Student	Project	Prog	Supervisor(s)	Funding	Year	University
Honours Degree -	completed (cont'd)					
Jason Raapana	Biogeochemical indicators of mineralisation	2	John Field (ANU), Richard Greene (ANU)	LEME	2006-2007	ANU
Jacob Smith	Hardrock seismic to image near-vertical structures	1	Anton Kepic (CUT)	LEME	2006	CUT
Layla Tucker	New Bendigo plant biogeochemistry	1	Steve Hill (UA)	Nil LEME	2006	UA
Rachael Wilson	Palaeodrainage reconstruction at "The Pimples", northern	1	Steve Hill (UA)	Nil LEME	2006 Jul	UA
	Flinders Ranges: implications for uranium mineralisation and exploration					
Gabrielle Yeates	Salinity dynamics in a sand bed stream: the Wollombi Brook, upper Hunter catchment, NSW	3	Susan Welch (ANU), Ben Macdonald (ANU)	LEME	2006-2007	ANU
Honours Degree -	commenced or continuing					
Sean Adams	Stratigraphy and hydrogeology of Goods Road Palaeochannel, Helena Catchment, Southern WA	3	Mehrooz Aspandiar (CUT)	Nil LEME	2007	CUT
David Baker	Something about CurnaMinex geophysics	1	John Joseph (ANU)	LEME Op. Ex. P1	2007	UA
Cynthja Bolton	Dating of the Willandra History of Aridity in Western NSW	1	Ed Rhodes (ANU), Rainer Grun (ANU)	LEME	2006-	ANU
Clinto Dubienecki	Regolith-landform mapping and subsurface structure, Paralana Tenement, Beverley Uranium Mine, SA	1	Steve Hill (UA), David Giles (UA)	Nil LEME	2007	UA
Deanne Gallasch	Regolith carbonate chemistry and origins, Four Mile Ck prospect, Beverley Uranium Mine, SA	1	Steve Hill (UA), Karin Barovich (UA)	Nil LEME	2007	UA
Andrew Hector	regolith-landform mapping and palaeodrainage, Paralana Tenement, Beverley Uranium Mine, SA	1	Steve Hill (UA), David Giles (UA)	Nil LEME	2007	UA
James Hughes	Regolith geochronology and landscape evolution of the Wombat area, New South Wales	3	Ian Roach (ANU), Brad Pillans (ANU)	LEME	2007	ANU
Mikaela Jennings	Soil-Biota interactions, Beverley Uranium Mine, SA	1	Steve Hill (UA), Karin Barovich (UA)	Nil LEME	2007	UA
Joanna McMahon	Shrub-grass-biota biogeochemistry, Beverley Uranium Mine, SA	1	Steve Hill (UA), Karin Barovich (UA)	Nil LEME	2007	UA

SHORTCOURSES / AND INDUSTRY WORKSHOPS

Shortcourse title	Presenter(s)	Format	Venue	Date	No of participants
National Undergraduate Regolith Geology School (NURGS)	Steve Hill (UA), Ian Roach (ANU), Graham Heinson (UA)	5-day intensive field course	Fowlers Gap NSW	10-14 July 2006	46 UA 14 ANU
RGG	Steve Hill (UA), Mehrooz Aspandiar (CUT), Ian Roach (ANU)	5-day intensive field course National Park, Victoria	Wilsons Promontory	20-24 February 2007	30
HGC	Patrice de Caritat (GA), Susan Welch (ANU), Bear McPhail (ANU)	5-day intensive field course	Department of Earth and Marine Sciences, ANU	16-20 April 200	7 17
EMN	Mehrooz Aspandiar (CUT), Ulrike Troitzsch (ANU), Tony Eggleton (LEME Fellow, ANU)	5-day intensive field course	Department of Earth and Marine Sciences, ANU	18-22 June 2007	' 10
Cobar	Ken McQueen	2-day intensive industry course	Cobar Management Pty Ltd., Cobar NSW	7-8 December 2006	10

Business Manager, Mr Gary Kong FCPA



Specified Personnel

The values held by LEME staff, and guiding our activities, are:

- Excellence and scientific integrity.
- Long-term commitment.
- Professionalism.
- Fairness.

These are underpinned by basic commitments to safety, staff development and national benefit.

Staff complement

LEME has world-class expertise in regolith geoscience, and supporting disciplines such as mineralogy, geochemistry, hydrogeochemistry, sedimentology, geophysics and geochronology. In this sixth year of operation, LEME had a total complement of 136 staff, 125 of whom were professional geoscientists. This equates to 61.7 FTE scientists, made up of 41.2 in-kind contributed and 20.5 cash funded scientists.

Additionally, other staff members provide technical, administrative, cartographic, illustrative, laboratory and field support. Staffing resources, in terms of FTEs, are shown in the accompanying tables.

Specified Personnel

Specified personnel are the science leaders and managers, as required by the Commonwealth Agreement. They form the core of the Executive, and comprise the following:

Dr Ravi Anand, Program Leader, CSIRO, 100%

Dr Charles Butt, Key Researcher, CSIRO, 75%

Dr Steven Hill, Program Leader, UA, 60%*

Dr Ken Lawrie, Program Leader, GA, 100%

Dr D.C. (Bear) McPhail, Key Researcher, ANU, 100%

Dr Colin Pain, Key Researcher, GA, 100%

Dr Ian Roach, Program Leader, ANU, 40%*

Dr Steve Rogers, Chief Executive Officer, CSIRO, 100%*

Dr Paul Shand, Program Leader, CSIRO, 70%*

Ms Lisa Worrall, Program Leader, GA, 100%

*Paid from the CRC Grant

LEME has world-class expertise in regolith geoscience, and supporting disciplines such as mineralogy, geochemistry, hydrogeochemistry, sedimentology, geophysics, geochronology, microbiology, molecular biology and botany.

Name	Main	Main Total % of Activity Time		% Sp e		% Spent on CRC				
	Activity		Regolith Geoscience	Mineral Exploration	Environmental Applications	Salinity Mapping	Total on Research	Education	Commer- cialisation	Admin- istration
The Australian N	ational Univ	ersity (ANU)								
Arculus R	R	20				20	20			
Beavis S	R	25			10	15	25			
Christy A	R	25	10	15	10	15	25			
Croke B	R	20				20	20			
DeDeckker P	R	20				20	20			
Dunlap I	R	25	15	10			25			
Eggins S	R	20	10	10			20			
Ellis D	R	25	15	10			25			
Field I	R	50	10	10			0	50		
Greene R	R	30				30	30	50		
Grun R	R	15	15			50	15			
Harrold B	R	20	15			20	20			
Iakeman T	R	20				20	20			
Маяее І	R	25				25	25			
McMorrow I	R	25				25	25			
McPhail D	P	100	20	65	5	23	90	10		
Norman M	P	100	20	10	5		10	10		
Opdyke B	P	20		10		20	20			
Dillane B	P	50	50			20	50			
Phodos E	D	25	25				25			
Troitech II	D	25	23			25	25			
White I	D	20				20	20			
Williams I	D	10	10			20	10			
vviiliailis i	K	625	170	120	15	260	565	60	0	0
Geoscience Aust	ralia (GA)									
Apps H	P	100				100	100			
Craig M	P	100	100			100	100			
Cibeon D	P	80	100			80	80			
Gibson D	D	100				100	100			
Dain C	R D	100	20			100	100			
Wilford I	D	100	20			100	100			
Warral I	R D	100	100			100	100			
WOITAI L	K	680	220	0	0	460	680	0	0	0
Curtin University	y of Technol	ogy (CUT)		,	-			-	-	-
Aspandiar M	р	50	50				50			
	D	50	60				60			
Collins DI E	K D	20	20				30			
Collins PLF	K D	20	20				20			
Kopic A	K D	20	20 E0				20			
Nepic A	K	50	50				50			
Dathur A	R	50	50				50			
Martho I	K	15	10				15			
Wathing P	K	15	15				15			
watkins K	R	40	40				40			
wilde 5	K	10	395	0	0	0	10	0	0	0
The University o	f Adelaide (I	JA)		0	0	0	555	0	0	0
Parovich V	D	70					0	70		
Brugger I	R	/0	10				0	/0		
Diroop N	R	10	0				0			
LITERT N	IS .	0	õ				0			

Research Staff In-kind Contribution

Foden J

Heinson G

Williams M

Schmidt-Mumm A

R

R

R

R



Research Staff In-kind Contribution (cont'd)

RetringHineRegolith GeoscienceMin GeosciencePrimary Industries & Resources, South Australia (PIRSA)Cooper BRPabris AR100100Gouthas GR3030Hou BR100100Keeling JR10055Mauger AR80	heral protection Application Application a a a a a a a a a a a a a a a a a a a	ntal Salinity Mapping Tot Mapping 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	al on earch Education 90	n Commer- cialisation	Admin istratio
Primary Industries & Resources, South Australia (PIRSA)Cooper BR9090Fabris AR100100Gouthas GR3030Hou BR100100Keeling JR100553Mauger AR807Sheard MR100100Stamoulis VR3030Zang Wen LongR9090Town BRR2525	35 10 75 30 40 10		90 00 30 00 00 75 5 00 30 30 90 445 5	0	0
Cooper B R 90 90 Fabris A R 100 100 Gouthas G R 30 30 Hou B R 100 100 Keeling J R 100 55 5 Mauger A R 80 7 Sheard M R 100 100 Stamoulis V R 30 30 Zang Wen Long R 90 90 R 90 90 Trimary Industries (NSW DPI) Brown B R 25 25	35 10 75 30 40 10		90 00 30 00 00 75 5 00 30 30 90 245 5	0	0
Fabris A R 100 100 Gouthas G R 30 30 Hou B R 100 100 Keeling J R 100 55 5 Mauger A R 80 7 5 Sheard M R 100 100 100 Stamoulis V R 30 30 30 Zang Wen Long R 90 90 750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	35 10 75 30 40 10		00 30 00 00 75 5 00 30 30 90 245 5	0	0
Gouthas G R 30 30 Hou B R 100 100 Keeling J R 100 55 5 Mauger A R 80 7 Sheard M R 100 100 Stamoulis V R 30 30 Zang Wen Long R 90 90 750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	35 10 75 30 40 10		30 00 00 75 5 00 30 30 90 245 5	0	0
Hou B R 100 100 Keeling J R 100 55 5 Mauger A R 80 7 Sheard M R 100 100 Stamoulis V R 30 30 Stoian L R 30 30 Zang Wen Long R 90 90 T50 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	35 10 75		00 00 75 5 00 30 30 90 445 5	0	0
Keeling J R 100 55 55 Mauger A R 80 67 Sheard M R 100 100 Stamoulis V R 30 55 Stoian L R 30 30 Zang Wen Long R 90 90 750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	35 10 75	0 7	00 75 5 00 30 30 90 '45 5	0	0
Mauger A R 80 7 Sheard M R 100 100 100 Stamoulis V R 30 30 30 Stoian L R 30 30 30 Zang Wen Long R 90 90 750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	75 30 40 10	0 7	75 5 00 30 30 30 90 90 245 5	0	0
Sheard M R 100 100 Stamoulis V R 30 30 Stoian L R 30 30 Zang Wen Long R 90 90 750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	40 10	0 7	00 30 30 90 45 5 25 5	0	0
Stamoulis VR3030Stoian LR3030Zang Wen LongR90907505951New South Wales Department of Primary Industries (NSW DPI)Brown BR2525	30 40 10	0 7	30 30 90 '45 5	0	0
Stoian LR3030Zang Wen LongR90907505951New South Wales Department of Primary Industries (NSW DPI)Brown BR2525	40 10	0 7	30 90 25	0	0
Zang Wen LongR90907505951New South Wales Department of Primary Industries (NSW DPI)Brown BR2525	40 10	0 7	90 45 5 25	0	0
750 595 1 New South Wales Department of Primary Industries (NSW DPI) Brown B R 25 25	40 10	0 7	25 25	0	0
New South Wales Department of Primary Industries (NSW DPI)Brown BR2525			25		
Brown B R 25 25			25		1
			23		
Burton G R 20 20			20		
Campbell L R 20 20			20		
Dicke S R 30 30		-	30		
Cilmore P R 25 25			25		
Clen R R 20 20			20		
Creenfield I R 30 30			30		
Healy M R 30 30			30		
Mille K R 20 20			20		
Miligrave P P 20 20			20		
Reid W P 95 95		-	95		
Trigge S P 20 20		· · · · · · · · · · · · · · · · · · ·	20		
Vickety N P 25 25			25		
Watking L R 10 10			10		
390 390	0 0	0 3	10	0	0
Commonwealth Scientific and Industrial Research Organisation		0 5	0	0	0
	7(05)		70		
Butt C R /0	70		70		
Gray D K 100 8	85 15	1	00		
KODELISON I K IUU I	.00		40		
FILZPAUTICK K K 40	40		40		
Anana K K 100 l		1			
Comenus M K 55	22	100	00		
FILZPAULICK A K 100	00	100	.00		
Hough K K 100 I	25		.00		
Munuay I K 100	75	65	75		
Return F K /5	()	15	15		
Dation A K 15		15	15		
Davies r K 20		20	15		
Digition r K 15	10 15	15	15		
Cildfedder M P 10	10 15	10	10		
Herczeg P 10	10	10	10		
Hicke W P 20	10		20		
Lamontagne S R 20	20		20		
Passam S P 20	20	20	20		
Shand D D 50	FO	20	50		
Stenson M R 10	50	10	10		
	30 170	255 1	15 0	0	0
TOTAL RESEARCH STAFF:	170	255 1	0000	0	0



Research Staff CRC LEME Funded

Name Employer Main		Main	Total %	% Spent on Research Program						% Spent on CRC	
		Activity	of lime	Regolith Geoscience	Mineral Exploration	Environmental Applications	Salinity Mapping	Total on Research	Education	Commer- cialisation	Admin- istration
CRC Grant Funde	d										
Lenahan M	ANU	R	80			70		70	10		
McQueen K	ANU	R	75	55	20			75			
Pillans B	ANU	R	50	50				50			
Roach I	ANU	R	100	30				30	70		
Welch S	ANU	R	100	10	10	50	10	80	20		
de Caritat P	GA	R	70	20	20	20		60	10		
Aspandiar M	CUT	R	50		15			15	35		
Wilkes P	CUT	R	100				100	100			
Hill S	UA	R	50	25	10			35	15		
Joseph J	UA	R	100	100				100			
Cornelius A	CSIRO	R	100		85		15	100			
Eastham J	CSIRO	R	33		33			33			
Lintern M	CSIRO	R	100		100			100			
Noble R	CSIRO	R	100		100			100			
Phang C	CSIRO	R	100		100			100			
Barton A	CSIRO	R	25				25	25			
Cox J	CSIRO	R	20				20	20			
Cresswell R	CSIRO	R	80				80	80			
Dighton J	CSIRO	R	5				5	5			
Gildfedder M	CSIRO	R	10				10	10			
Hicks W	CSIRO	R	15			15		15			
Lamantague S	CSIRO	R	5			5		5			
Rassam S	CSIRO	R	20				20	20			
Shand P	CSIRO	R	20			20		20			
			1408	290	493	180	285	1248	160	0	0
Industry or Exter	nally Fund	led									
Clarke J	GA]	R	100				100	100		
Wong V	GA	R	100				100	100			
Halas L	GA	R	100				100	100			
Woolrich T	GA	R	10				10	10			
James J	GA	R	100				100	100			
Lane R	GA	R	5				5	5			
Luckman J	GA	R	100				100	100			
Ruperto L	GA	R	25	25				25			
Tan K P	GA	R	100	-			100	100			
TOTAL RESEARC	CH STAFF: ID		640	25	0	0	615	640	0	0	0
EXTERNAL FUN	IDS		2048	315	493	180	900	1888	160	0	0

KEY: 100 = 1 person year

Summary of Research Staff Resources

	Total Equiv.		Person Year	rs Spent on Resera	ich Program		Person Years Spent on		
	Person Years	Regolith Geoscience	Mineral Exploration	SUBPROGRAM Environmental Applications	Salinity Mapping	Total on Research	Education	Commer- cialisation	Admin- istration
TOTAL IN-KIND Contributed	41.23	18.28	8.9	2.05	9.95	39.18	2.05	0.0	0
CRC GRANT FUNDED	14.08	2.9	4.93	1.8	2.85	12.48	1.6	0.0	0
INDUSTRY FUNDED	6.4	0.25	0.0	0.0	6.15	6.4	0.0	0.0	0
TOTAL FUNDED By CRC LEME	20.48	3.15	4.93	1.8	9	18.88	1.6	0.0	0
GRAND TOTAL	61.71	21.43	13.83	3.85	18.95	58.06	3.65	0.0	0
Proportion of total professional staff resources in each activity	100	35	22	6	31	94	6	0	0

Administration and Technical Staff

Name	Position	Main Activity	Total % of Time
In-kind Contributio	ns		
CRC Grant Funded			
Australian National U	Jniversity		
Coldrick M	Education Support Officer	А	50
			50
Geoscience Australia	L		
Moon S	Program Support Officer	А	50
			50
University of Adelaid	le		
Hulme K	Program Support Officer	А	50
			50
CSIRO			
Game S	PA to CEO/Centre Support Officer	А	100
Hink H	Program Support Officer	А	50
Kong G	Business Manager	А	100
Lawrence G	Communications Officer	А	100
Rogers S	Chief Executive Officer	А	100
Mills J	Financial Accountant	А	60
Tyrell S	Admin Support Officer	А	40
			550
			700
Industry or Externa	lly Funded		
Geoscience Australia	l i i i i i i i i i i i i i i i i i i i		
Luttrell T	Program Support Officer	А	80
			80
TOTAL ADMINISTRAT	ION AND TECHNICAL STAFF:		780

KEY:100 = 1 person year

Staff OH&S Matters

As an unincorporated joint venture, LEME is not a direct employer of staff and relies on the personnel services of Core Participants. However, in the course of carrying out research activities, staff and students frequently operate in remote and difficult environments. Consequently LEME aims to instil an awareness of safety in the field, especially for students who must learn to work safely in remote areas. The Board has a duty of care in all safety matters, but since

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LEME is an unincorporated joint venture, the primary duty of care in respect of all occupational health and safety matters rests with the Core Participants, who are the designated employers. LEME follows the occupational health and safety policies and procedures of its Core Participants. The employing agency has an obligation to develop and implement safe working procedures, and to provide necessary training and instruction.

A Manual entitled CRC LEME Policy and Procedures on Field Safety was prepared in 2001 by GA and the Board Safety Committee members, in consultation with the Health Occupational and Safety representatives from the other Core Participants. This Manual drew together bestpractice materials from companies in the exploration industry, providing essential reference materials for all LEME staff and students. An abridged Manual The Glove Box Guide to Health and Safety in the Field was produced, enabling critical safety information to be easily taken into the field.

These Manuals do not supplant the requirements stipulated by the Core Participants for their staff, but prescribe minimum procedures where they may not be stipulated by the host agency. They were endorsed by the Board, drawn to the attention of all staff by way of the LEME intranet, and have been implemented.

There is a standing directive that all accidents and incidents that are reportable under Core Participant requirements are also reported to the LEME Head Office. During the reporting period, one notable OH&S vehicle incident occurred and no lost time injuries or incidents were recorded. LEME has continued to sustain a high level of external collaboration and funding. The increased involvement in overseas research projects recognises the international relevance of the Centre's research outputs.



Performance Measures

Performance Measures/Indicators (PIs), along with milestones and outputs, provide a numerical measure of performance against our stated objectives. Our PIs are those itemised in Schedule 6 of the Commonwealth Agreement, for which quantitative measures were developed and presented in the 2001-02 Annual Report. By including those numerical scores from previous years, we now have time-series charts to develop benchmarks and compare annual performances.

Objectives of the Centre

Broad indicators of progress towards Centre objectives are:

■ The Centre will provide the mineral industry with world-class capabilities

leading to breakthroughs in exploration in Australia's extensive areas of cover.

- The Centre will produce essential multidisciplinary knowledge of Australia's regolith areas, package this knowledge in readily useable forms, and ensure that it is transferred into practice in the minerals industry and environmental management.
- The Centre will provide high quality, geoscience-based education for those entering the minerals industry, landcare and environmental realms and provide continuing education for those professionals.
- The Centre will inform and guide decision-makers in Australian and State policy arenas about the relevance and

contribution of regolith research to Australia.

- The Centre will increase the number of companies, agencies and institutions using LEME outputs and participating in LEME projects.
- The Centre will attract overseas researchers to work in LEME and encourage visits by LEME staff to counterpart institutions overseas.
- The Centre will encourage requests for LEME collaboration from companies, agencies and institutions overseas.

Centre Objective Outcomes

- 1 Collaboration with external researchers
- 2 Gaining external sponsorship
- 3 Gaining international recognition

Output/ Outcome No:	PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
1	Number of external research collaborators	47	86	75	80	80	21
2	Number of commercial contracts and the annual value of sponsorship	13 \$756,540	13 \$616,000	14 \$1,183,000	16 \$1,662,000	32 \$1,363,000	26 \$879,000
3	Number of overseas researchers visiting LEME sites	4	10	10	6	8	12
3	Number of overseas visits by LEME staff	19	7	8	9	2	11
3	Number and value of overseas research projects	1 \$27,489	0	0	1 \$12,000	1 \$8,300	3 \$963,000

Centre Objectives Performance Indicators



LEME has continued to sustain a high level of external collaboration and funding. The increase in involvement in overseas research projects recognises the international relevance of the Centre's research outputs.

Quality and Relevance of the Research Programs

To ensure the quality and relevance of its Research Programs, LEME will:

- Develop a best-practice benchmark for the number of articles accepted for publication in leading national and international scientific journals, and in refereed conference proceedings.
- Accept invitations to contribute chapters in books, and present keynote addresses, papers and workshops at national and international conferences.
- Record the number of eminent scholars choosing to undertake sabbatical visits to LEME centres.

- Recognise the significance of LEME research as measured by the bestowal of honours and awards upon Centre staff.
- Record the number of companies and agencies using LEME-developed protocols for exploration in regolithdominated terrains.
- Promote LEME innovations in airborne salinity mapping for management and remediation of dryland salinity and in other land-care issues.
- Obtain acknowledgement of the roles played by LEME concepts, methods and technologies in mineral discoveries by exploration and mining companies.
- Obtain acknowledgement of the roles played by LEME concepts, methods and technologies in environmental issues by Australian, state and local government bodies and by environmental and engineering companies.

Quality and Relevance of Research Program Outputs

- 1 Generation of high-quality regolith geoscience
- 2 Release of LEME publications and products

Quality and Relevance of Research Program Outcomes

- 3 Publishing of Centre Research in peerreviewed journals
- 4 Publishing of Centre Research
- 5 CRC LEME staff presentations and keynote addresses
- 6 External recognition of the quality and relevance of LEME research outputs

Output/	PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Outcome No:							
3	Number of published journal articles per year	54	23	18	30	30	37
4/5	Number of conference papers presented per year	50	134	186	146	146	181
1/4	Number of books or chapters in books	20	40	41	174	174	5
4	Other forms of publications includes maps, short course notes, field guides, electronic newsletters	28	21	19	13	13	1
2	Number of LEME Technical Reports released, includes OFRs	36	6	10	26	18	13
2	Number of confidential reports, maps	18	9	8	8	12	21
6	Number of keynote addresses given	4	2	6	7	5	3
6	Number of sabbatical leaves taken by overseas personnel at LEME sites	3	2	2	3	2	11
6	Number of awards to LEME researchers and educators	3	8	8	9	7	20
6	Number of professional appointments awarded to LEME researchers and educators	7	5	9	15	10	11

Quality and Relevance of the Research Program

Most outputs increased during the 2006-07 as Centre activities focussed on delivering outcomes such as research products, courses and workshops. An increased presence in the general media and industry publications was sustained through targeted activities of the LEME Communication Officer.

Strategy for Utilisation and Knowledge Transfer of Research Outputs

To realise the benefits flowing from LEME research, the Centre will:

- Record and benchmark the number of technology transfer courses, workshops, public displays and media releases.
- Increase the distribution of open file reports, course notes, manuals, maps, special publications, text books and other materials.
- Ensure that concepts, methods and technologies developed within the Centre are adopted by industry, university and government agencies.
- Record the number of articles published in industry journals.
- Prepare and distribute LEME publications and information documents to companies and organisations in the mineral and environmental industries.

- Actively pursue the development of collaborative research projects with industry and organisations.
- Secure adequate funding from companies, agencies and institutions for Centre projects.

As part of the Strategic Plan, LEME aims to produce scientific outputs (refereed papers and book chapters, monographs, conference publications, technical reports, short course notes, maps) that total an average of three outputs per full-time-equivalent staff per year. It also aims to increase external revenues from contract research over the life of the Centre.

Utilisation and Knowledge Outputs

- 1 Short course workshops
- 2 Products sold/released

Utilisation and Knowledge Outcomes

- 3 Media/industry magazine coverage
- 4 External LEME Collaborators

Most outputs increased during the 2006-07 as Centre activities focussed on delivering outcomes such as research products, courses and workshops. An increased presence in the general media and industry publications was sustained through targeted activities of the LEME Communication Officer. The noticeable drop in number of items sold reflects the change in LEME Head Office policy to disband the purchase of publications and instead send out complimentary copies upon request. The policy came into effect at the beginning of the 2007 calendar year.

Education and Training

To enhance the regolith knowledge of current and future geoscientists in Australia, LEME Education and Training Program will:

Maximise the number of postgraduate research scholars undertaking their degrees within the Centre or through universities associated with the Centre, within the constraints of the budget.

Output/ Outcome No:	PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
1	Number of short courses and workshops	7	11	6	4	9	1
3	Number of media reports and releases	8	9	21	17	39	46
2	Number of items sold (open file reports, manuals, course notes)	120	75	101	119	464	157
3	Number of articles in prospecting magazines	3	1	9	11	22	25
2	Number of reports to sponsors and companies	15	9	13	8	12	21
4	Number of collaborative projects with industry users and user organisations	49	48	56	60	55	26
4	Annual external research income	\$782K	\$616K	\$1,183K	\$1,662K	\$1,331K	\$2,242K
1/2	Number of scientific outputs per FTE staff	2.4	3.4	4.2	4.4	5.25	5.51
4	Increase in external revenues from contract research	NA	-21%	+92%	+41%	-20%	-55%

Strategy for Utilisation and Knowledge Transfer of Research

- Produce a continuing stream of Bachelor Degree Honours graduates from the Core Participant universities and other universities associated with the Centre.
- Ensure postgraduate research and Honours students have access to generic training courses during their studies in the Centre.
- Allocate an advisor for all postgraduate research and Honours students outside their enrolled university and preferably in a non-university Core Participant or other external partner.
- Develop a formal Masters by Coursework Degree in Regolith Studies.
- Provide and market professional short courses and workshops to research users and increase awareness of the Centre's research in the community at large.

As part of its Strategic Plan, LEME aims to produce at least 60 new PhD graduates and

Education and Training



60 Honours graduates throughout the lifetime of the Centre. For the purpose of meeting PIs, we define a LEME student where:

- LEME has given financial support either by way of scholarship or contribution to stipend and operating cost, or:
- A LEME in-kind or cash-funded staff member has been a primary supervisor on a regolith project that aligns with a LEME Program objective.

Education and Training Outputs

1 Number of CRC LEME PhD and Honours Graduates

Education and Training Outcomes

2 External interest in supervising LEME students

Output/ Outcome No:	PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
1	Number of postgraduate students working on LEME research projects	38	51	50	59	62	58
1	Number of MSc and PhD completions, each year/cumulative	1	7/8	7/15	5/20	1/21	10/31
1	Number of BSc Honours graduates completing LEME projects	16	11	21	17	12	12
1	Number of BSc Honours students commenced/ continuing LEME projects	37	20	10	13	12	26
2	Number of external supervisors of research students	20	12	16	21	14	9
1	Number of student class hours of instruction in Masters by Coursework degrees related to the regolith	80	80	80	80	80	0*
1	Number of Honours graduates produced over the lifetime of LEME (incl graduands)	16	27	58	77	89	100

* Course held over until 2007-08

Collaborative Arrangements

To ensure that the research and educational Programs have access to adequate resources and expertise to meet their objectives, the Centre will:

- Maintain an appropriate mix of staff, in terms of disciplines and function, within the core participants, and across the nodes.
- Develop multi-disciplinary project-based research teams involving staff from several core participants and supporting participants.
- Establish a culture of collaboration between core participants, such that collaboration will continue beyond the life of the Centre.
- Ensure that the mineral industry, environmental agencies and other user groups participate in the functioning of the Centre, including the Board and Advisory Councils, in project generation, support and collaboration, education, technology transfer and application of research findings.
- Develop collaborative projects where overseas researchers participate in Centre research to the benefit of its staff and students.
- Attract leading scientists from overseas for sabbatical study.
- Develop collaboration with appropriate bodies such as other CRCs.

- Increase the extent of PhD and Honours student involvement in research activities.
- Develop and extend an Associate network of Supporting Participants.
- Support the interchange of personnel among different sites within the Centre.

Collaborative Arrangements Outputs

1 LEME Collaborations

Collaborative Arrangements Outcomes

2 External involvement in collaborations

Collaborative Arrangements

PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Number of Centre-funded projects involving staff from more than one core party	28 (of 30)	27 (of 29)	38 (of 59)	33 (of 45)	32 (of 60)	16 (of 43)
Number of external stakeholders involved in the direction of LEME through the Governing Board and Advisory Councils	14	27	26	22	24	24
Number of projects involving international collaborators	6	0	5	1	5	3

Resources and Budget

PI	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007
Total resources (cash and in-kind excluding CRC Grant)	\$17.6M	\$16.7M	\$19.8M	\$17.4M	\$21.65M	\$17.95M
FTE research staff (excluding students)	73.3	63.1	70.0	63.3	69.38	61.71
FTE technical and other support staff	11.1	6.35	7.05	6.9	6.30	7.80

Safety

As part of the Centre strategic plan and safety policy, LEME aims to have a Lost Time Injury Frequency Rate (an industry standard measure) of zero throughout the life of the CRC. There were no reportable LTIFs involving LEME staff working in any of the Core Participants in 2006-07.



Financial Information

As at 30 June 2007, all Core Participants met or exceeded their in-kind contribution target defined in the Commonwealth Agreement and the Deed of Release and Variation. The total cash income received for collaborative activities from industry and other users in Year 6 is \$2.24M.

The leverage of actual contributed resources to CRC Program funding from the Commonwealth is 6.7:1, for the reporting year.

Actual contributed resources:

Total Cash from Industry and other users, and from Core Participants: \$3.11M,

Total In-Kind resources from participants \$14.84M, giving a total of \$17.95M.

CRC Programme funds: \$2.7M. All figures for the reporting year of 2006/2007 only.

Financial Reports for 2006/2007

The following statements and accounting policy notes represent the known financial status as at 30 June, 2007.

Core Participant equity positions are summarised as follows:

Core Participant Actual Cumulative Equity as at June 2007 (Years 1-6)



Core Participant Equity as per Commonwealth Agreement as at 30 June 2007 (Years 1-6)



Total Income (excluding CRC Grant and cash contributions from Core Participants)

	Year 1 \$′000	Year 2 \$'000	Year 3 \$′000	Year 4 \$'000	Year 5 \$'000	Year 6 \$'000	Cumulative \$'000
Budget	765	1,080	1,658	1,869	1,675	2,100	9,147
Actual	892	811	1,509	1,435	1,522	2,380	8,408
Variance	+127	-269	-149	-434	-153	+280	-739

Significant Accounting Policies

The attached financial statements are prepared specifically for the CRC Secretariat and are presented in a format which enables reporting consistent with the Centre Budget as contained in the Commonwealth Agreement and any subsequent revisions as approved by the CRC Secretariat.

Income

Income is fully credited on receipt. In general, all income is received by CSIRO, the Centre Agent, and distributed to Core Participants to reimburse expenditure incurred in line with the Centre's Budget.

Expenditure

All Core Participants operate with some form of accrual accounting system. Expenditure is recorded on an accrual basis.

Intellectual property

Any intellectual property, as defined in Clause 9 of the Commonwealth Agreement

The in-kind contributions of infrastructure

overhead costs have been costed as multiples of the base salaries of in-kind and CRC

funded staff, in accordance with Schedule 4 of the Commonwealth Agreement and the

dated 13 August 2001, which is generated under the projects currently undertaken, is only recognised when capable of being separately identified as being of commercial value.

Capital expenditure/other expenditure commitments

There were no capital expenditure commitments approved and/or entered into as at 30 June 2006, and for which goods had not been receipted at 30 June 2007.

OTHER NOTES

Costing of contributions

Costing of salaries and on-costs contributed by the Core Participants is as reported to the Centre by each Core Participants. In no case does the reported amount of salary on-costs exceed the agreed valuation of on-costs shown in Schedule 4 of the Commonwealth Agreement and the Deed of Release and Variation, viz:

Core Participant	Salary on-costs as a multiple of base salary
The Australian National University	0.2889
Curtin University of Technology	0.2806
The University of Adelaide	0.2942
CSIRO (CSS Superannuation)	0.3185
CSIRO (PSS Superannuation)	0.2205
Geoscience Australia	0.2050
Primary Industries & Resources, SA	0.2590
NSW Dept. of Primary Industries	0.3300
Minerals Council of Australia	N/A

Deed of Release and Variation, viz:		,
Core Participant	Infrastructure overhead	ls as a multiple of base salary
	For in-kind staff	For CRC funded staff
The Australian National University	2.3656	2.3656
Curtin University of Technology	1.2800	1.2800
The University of Adelaide	1.5400	1.5400
CSIRO	1.3400	1.3400
Geoscience Australia	2.1500	2.1500
Primary Industries & Resources, SA	1.2550	1.2550
NSW Dept. of Primary Industries	0.1700	0.1700
Minerals Council of Australia	N/A	N/A

TABLE 1: IN-KIND CONTRIBUTIONS (PER PARTICIPANT) (Dollars in '000s)

			ACT	UAL				CUMU	LATIVE	PROJI	ECTED	GI	RAND TOTAL	
	YEAR 1 2001 / 02	YEAR 2 2002 / 03	YEAR 3 2003 / 04	YEAR 4 2004 / 05	YEAR 5 2005 / 06	YEAR 6 2006 / 07	YEAR 6 2006 / 07	TOTAL	. TO DATE	YEAR 7 2007 / 08	YEAR 7 2007 / 08	PROJECTED TOTAL	AGREEMENT	DIFFERENCE
	Actual	Actual	Actual	Actual	Actual	Actual	Agreement	Actual	Agreement	Projected	Agreement	/ Years	/ Years	/ Years
		UNIVERCITY												
	A7A	ART ART	765	708	877	788	83/	// 133	3 0/0	850	850	1 007	4 808	18/
CAPITAL	- 4/4	-	-	-		-	-	- 4,155	J,949 -			4,992	4,000	-
OTHER	1,126	1,169	2,336	2,352	2,547	2,305	1,723	11,835	11,019	1,687	1,687	13,522	12,706	816
TOTAL	1,600	1,600	3,101	3,150	3,424	3,093	2,557	15,968	14,968	2,545	2,545	18,514	17,513	1,000
	214	01						205	2/2			205	2/12	52
CAPITAL	- 514	-	-	-	-	-	-	- 292	245 -	-	-	- 265	545 -	- 22
OTHER	852	329	-	-	-	-	-	1,181	1,114	-	-	1,181	1,114	68
TOTAL	1,166	410	-	-	-	-	-	1,576	1,456	-	-	1,576	1,456	120
		020	014	046	005	777	741	5.044	4.600	7(4	764	5 000	5.4(2)	246
CAPITAL	9/4	839	814	846	805	/66	/41	5,044	4,698	/64	/64	5,808	5,462	346 -
OTHER	1,973	1,928	2,457	2,600	2,573	2,413	2,012	13,944	13,519	1,942	1,942	15,886	15,461	425
TOTAL	2,947	2,767	3,271	3,446	3,378	3,179	2,753	18,988	18,217	2,706	2,706	21,694	20,923	771
	SITY OF TECH	INOLOGY	(22	40.6	500	107	407	2.650	2.540		542	2.474	2.052	
CAPITAI	329	423	433	486	500	487	497	2,659	2,540	512	512	3,1/1	3,052	- 119
OTHER	469	646	629	765	784	686	670	3,979	3,791	689	689	4,668	4,480	188
TOTAL	798	1,069	1,062	1,251	1,284	1,173	1,167	6,638	6,331	1,201	1,201	7,839	7,532	307
THE UNIVERSITY	OF ADELAID	E												
SALARIES	314	403	400	363	315	326	522	2,121	2,364	537	537	2,658	2,901	(243)
OTHER	373	626	753	728	950	933	691	4,364	3,954	711	711	5,075	4,665	410
TOTAL	687	1,029	1,153	1,091	1,265	1,260	1,213	6,485	6,318	1,248	1,248	7,733	7,566	167
PRIMARY INDUS	TRIES & RES	OURCES,SOL	JTH AUSTRA	LIA										
SALARIES	506	523	551	594	586	682	601	3,442	3,100	619	619	4,061	3,719	342
OTHER	1,984	521	584	627	619	715	634	5,050	4,729	652	652	5,702	5,381	321
TOTAL	2,490	1,044	1,135	1,221	1,205	1,396	1,235	8,492	7,829	1,272	1,272	9,763	9,101	663
BUREAU OF RUR	AL SCIENCES													
SALARIES	193	16	-	-	-	-	-	209	208	-	-	209	208	1
OTHER	139	12	-	-	-	-	-	151	150	-	-	151	150	- 1
TOTAL	332	28	-	-	-	-	-	360	358	-	-	360	358	2
NEW SOUTH WAI	LES DEPARTA	MENT OF PR	IMARY INDU	STRIES										
SALARIES	224	235	223	318	374	390	373	1,764	1,720	382	382	2,147	2,102	44
OTHER	29	30	63	76	83	85	- 83	366	359	84	84	450	443	- 7
TOTAL	253	265	286	394	457	475	456	2,130	2,079	466	466	2,596	2,545	51
MINERALS COUN	CIL OF AUST	RALIA												
SALARIES	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OTHER	-	-	35	35	- 35	35	- 35	140	140	35	35	175	175	-
TOTAL	-	-	35	35	35	35	35	140	140	35	35	175	175	-
CSIRO														
SALARIES	1,333	1,398	1,169	1,285	1,289	1,352	1,202	7,826	7,118	1,262	1,262	9,088	8,380	708
OTHER	2.559	2,457	2.511	2.772	2.747	2.871	- 1 <i>.</i> 904	15.917	- 14,594	- 1 <i>.</i> 987	1.987	17,904	- 16,581	1.323
TOTAL	3,892	3,855	3,680	4,057	4,036	4,223	3,106	23,743	21,712	3,249	3,249	26,992	24,961	2,031
SUPPORTING CONT	TRIBUTIONS													
SALARIES	-	-	-	-	-	-	-	-	-	· ·	-	-	-	-
OTHER	-	-	-	-	-	-	-		-		-	-	-	-
TOTAL	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL IN-KIND CO	NTRIBUTIONS													
SALARIES	4,661	4,349	4,355	4,690	4,747	4,792	4,770	27,593	26,039	4,937	4,937	32,530	30,976	1,554
OTHER	- 9.504	7.718	9.368	9.955	10.338	- 10.043	7.752	56.927	53.369	7.786	7.786	64.713	61.155	3.558
	.,	.,. 10	5,550	- ,	,	,	.,	- 3,7 27	, - 5 5 5	.,	. ,	.,,, 15	,.55	-,000
GRAND TOTAL (IN-KIND)	14,165	12,067	13,723	14,645	15,085	14,835	12,522	84,520	79,408	12,723	12,723	97,243	92,131	5,112

FINANCIAL INFORMATION

TABLE 2: CASH CONTRIBUTIONS (Dollars in '000s)

			ACT	UAL				CUMU	LATIVE	PROJI	ECTED	GI	RAND TOTAL	
	YEAR 1	YEAR 2	YEAR 3	YEAR 4	YEAR 5	YEAR 6	YEAR 6	TOTAL	. TO DATE	YEAR 7	YEAR 7	PROJECTED	AGREEMENT	DIFFERENCE
	2001 / 02 Actual	2002 / 03 Actual	2003 / 04 Actual	2004 / 05 Actual	2005 / 06 Actual	2006 / 07 Actual	2006 / 07 Agreement	Actual	Agreement	2007/08 Proiected	2007 / 08 Agreement	TOTAL 7 Years	7 Years	7 Years
	NTC								,	,	,			
	100	150	200	200	200	100	100	050	050	100	100	1.050	1 050	
	100	100	200	200	200	100	100	950	950	100	100	1,050	1,050	-
	100	100	100	100	100	100	100	600	600	100	100	700	700	-
	100	50	-	-	-	-	-	150	150	- 100	-	150	150	_
CSIRO	150	100	150	200	200	100	100	900	900	100	100	1 000	1 000	-
GEOSCIENCE AUST	100	150	100	100	113	100	100	663	650	100	100	763	750	13
PIRSA	-	-	-	100	100	100	100	300	300	100	100	400	400	-
BRS	810	-	-	-	-	-	-	810	810		-	810	810	-
NSW DPI	250	250	250	100	100	50	50	1.000	1,000	- I	-	1.000	1.000	-
MCA	100	100	105	80	80	80	40	545	500	40	-	585	500	85
TOTAL	1,810	1,000	1,005	980	993	730	690	6,518	6,460	640	600	7,158	7,060	98
Supporting Participants	-	300	-	141	10	-	-	451	451	-	-	451	451	-
OTHER CASH														
Non Participants	-	-	-	-	-	-	-	-	1,900	-	-	-	1,900	(1,900)
External Grants	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Contract Research	696	599	1,286	1,075	1,331	2,242	1,325	7,228	4,325	703	1,100	7,931	5,425	2,506
Commercialisation	n -	-	-	-	-	-	640	-	2,305	- 1	640	-	2,945	(2,945)
Education	86	17	24	33	32	-	120	192	513	20	120	212	633	(421)
Interest Income	110	195	199	187	159	138	15	988	104	15	15	1,003	119	884
TOTAL	892	811	1,509	1,294	1,522	2,380	2,100	8,408	9,147	738	1,875	9,146	11,022	(1,876)
CRC FUNDING	2,754	3,300	3,300	3,300	3,300	2,700	2,700	18,654	18,654	1,546	1,546	20,200	20,200	-
TOTAL CRC CASH CONTRIBUTION (T	5,456 2)	5,411	5,814	5,715	5,825	5,810	5,490	34,031	34,712	2,924	4,021	36,955	38,733	(1,778)
Cash carried over from previous yea Note (a)	777 Ir	2,504	3,566	3,492	3,087	2,349	2,349	-	-	2,003	2,604	-	-	-
Less Unspent Balance	2,504	3,566	3,492	3,087	2,349	2,003	2,604	-	1,451	-	1,152	-	-	-
TOTAL CASH EXPENDITURE	3,729	4,349	5,888	6,120	6,563	6,156	5,235	32,805	33,261	4,927	5,473	37,732	38,734	(1,002)
ALLOCATION OF C	ASH EXPEND	ITURE BETWE	EN HEADS OF	EXPENDITUR	E									
	1 016	1 000	2 5 4 1	2 704	2 700	2 6 4 2	1 254	14 570	14 606	1 010	1 167	16 200	15 050	521
	1,910	1,070	2,341	2,/94 100	2,/00	2,042	1,204	14,5/9 14	14,090	1,010	1,102	10,309	13,030 /E1	221
OTHER	1 812	245	3 3/17	3 126	3 750	2 512	3 0.91	4) 1 17 77/	ا د 4 18 11 <i>1</i>	3 117	/ 311	20 801	104 77/175	(1 524)
VIIILIN	1,015	2,200	5,547	0,100	5,155	دادرد	J,701	17,774	10,114	5,117	١١ _{८٦} ٣	20,091	22,423	(+22,1)

Note a Balance brought forward at 1.7.01 relates to residual funds from CRC LEME 1 brought into CRC LEME 2

TABLE 3: SUMMARY OF RESOURCES APPLIED TO ACTIVITIES OF CENTRE (Dollars in '000s)

			ACT	UAL				CUM	JLATIVE	PROJ	ECTED	G		
	YEAR 1 2001 / 02	YEAR 2 2002 / 03	YEAR 3 2003 / 04	YEAR 4 2004 / 05	YEAR 5 2005 / 06	YEAR 6 2006 / 07	YEAR 6 2006 / 07	TOTAL	TO DATE	YEAR 7 2007 / 08	YEAR 7 2007 / 08	PROJECTED TOTAL	AGREEMENT	DIFFERENCE
	Actual	Actual	Actual	Actual	Actual	Actual	Agreement	Actual	Agreement	Projected	Agreement	7 Years	7 Years	7 Years
GRAND TOTAL (IN-KIND) From Ta	14,165 able 1	12,067	13,723	14,645	15,085	14,835	12,522	84,520	79,408	12,723	12,723	97,243	92,131	5,112
GRAND TOTAL (CASH EXPENDITU from Table 2	3,729 IRE)	4,349	5,888	6,120	6,563	6,156	5,235	32,805	33,261	4,927	5,473	37,732	38,734	(1,002)
APPLIED TO ACTIVITIES OF CEM	17,894 NTRE	16,416	19,611	20,765	21,648	20,991	17,757	117,325	112,669	17,650	18,196	134,975	130,865	4,110
ALLOCATION OF TO	OTAL RESOUR	CES APPLIED	TO ACTIVITIE	S OF THE CRC I	BETWEEN HE	ADS OF EXPE	NDITURE							
TOTAL SALARIES (CASH AND IN-KIN	6,577 ND)	6,247	6,896	7,484	7,535	7,434	6,024	42,173	40,735	6,747	6,099	48,919	46,834	2,086
TOTAL CAPITAL (CASH AND IN-KIN	- VD)	245	-	190	16	-	-	451	451	-	-	451	451	-
TOTAL OTHER (CASH AND IN-KIN	11,317 ND)	9,924	12,715	13,091	14,097	13,557	11,733	74,701	71,483	10,903	12,097	85,604	83,580	2,025
TOTAL	17,894	16,416	19,611	20,765	21,648	20,991	17,757	117,325	112,669	17,650	18,196	134,975	130,865	4,110

TABLE 4: ALLOCATION OF	RESOURCES BETWEEN	CATEGORIES OF ACTIVITIES

PROGRAM	RESOURCE USAGE				
	\$ CASH (000's)	\$ IN-KIND (000's)	CONTRIBUTED (IN-KIND) RESEARCH STAFF (FTEs)	CRC FUNDED RESEARCH STAFF (FTEs)	
RESEARCH	4,643	12,767	39.18	18.88	
EDUCATION	415	1,229	2.05	1.60	
EXTERNAL COMMUNICATIONS	-	-	-	-	
COMMERCIALISATION/TECHNOLOGY TRANS	FER -	-	-	-	
ADMINISTRATION	1,099	840	-	-	
TOTAL	6,156	14,835	41.23	20.48	

LEME/UA Honours student Clinton Dubieniecki during regolith - landform mapping, overlooking the Four Mile West uranium mineralisation, north eastern Flinders Ranges, SA.



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Independent auditor's report to the Cooperative Research Centre for Landscape Environments and Mineral Exploration

Report on the financial information

We have audited the accompanying financial information, being the statement of in-kind contribution from partners, the statement of cash income and expenditures, the summary of resources applied to activities and the allocation of resources between categories of activities of the centre for the Cooperative Research Centre for Landscape Environments and Mineral Exploration (the CRC LEME) for the year ended 30 June 2007. It has been prepared for distribution to the Cooperative Research Centres Program, Department of Education, Science and Training (the Commonwealth) for the purpose of fulfilling the requirements of the Commonwealth Agreement dated 13 August 2001 ("the Agreement"), and the Deed of Release and Variation dated 27 June 2005.

The responsibility of the board of management for the financial information.

The board of management of CRC LEME is responsible for the preparation and fair presentation of the financial information in accordance with the Agreement. The responsibility of the board of management also includes establishing and maintaining internal control relevant to the preparation and fair presentation of the financial information that is free from material misstatement, whether due to fraud or error; selecting and applying appropriate accounting policies; and making accounting estimates that are reasonable in the circumstances.

Auditor's responsibility

Our responsibility is to express an opinion on the financial information based on our audit. No opinion is expressed as to whether the accounting policies used are appropriate to meet the needs of the Commonwealth. We conducted our audit in accordance with Australian Auditing Standards. These Auditing Standards require that we comply with relevant ethical requirements relating to audit engagements and plan and perform the audit to obtain reasonable assurance whether the financial report is free from material misstatement.

An audit involves performing procedures to obtain audit evidence about the amounts in the financial information. The procedures selected depend on the auditor's judgement, including the assessment of the risks of material misstatement of the financial information, whether due to fraud or error. In making those risk assessments, the auditor considers internal control relevant to CRC LEME's preparation and fair presentation of the financial

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information in order to design audit procedures that are appropriate in the circumstances. An audit also includes evaluating the reasonableness of accounting estimates made by the board of management as well as evaluating the overall presentation of the financial information. These procedures have been performed to assess whether in all material respects the financial information is presented fairly in accordance with the Agreement (specifically those provisions referred to in Section 6 of the CRC Program Guidelines for Annual Reports 2007), which does not require the application of all Accounting Standards and other mandatory financial reporting requirements in Australia.

The financial information has been prepared for distribution to the Cooperative Research Centres Program, Department of Education, Science and Training (the Commonwealth) for the purpose of fulfilling the financial reporting obligations of the Agreement. We disclaim any assumption of responsibility for any reliance on this audit report or on the financial information to which it relates to any person other than the Commonwealth, or for any purpose other than that for which they were prepared.

For further explanation of an audit, visit our website http://www.pwc.com/au/financialstatementaudit.

Our audit did not involve an analysis of the prudence of business decisions made by the board of management.

We believe that the audit evidence we have obtained is sufficient and appropriate to provide a basis for our audit opinion.

This audit opinion expressed in this report has been formed on the above basis.

Independence

In conducting our audit, we have complied with the independence requirements of the Australian professional accounting bodies.

Auditor's opinion

In our opinion:

- a) the attached financial information for the Cooperative Research Centre for Landscape Environments and Mineral Exploration (the CRC LEME) presents fairly, in accordance with Australian Accounting Standards and the provisions of the Commonwealth Agreement dated 13 August 2001, the Deed of Release and Variation dated 27 June 2005, the sources of funding and the application of that funding for the year ended 30 June 2007;
- b) The financial statements present fairly that contributions, both cash and in-kind, have been made and recorded in accordance with the terms of the Budget as specified in <u>Schedule 4</u> in accordance with the terms of the Commonwealth Agreement.
- c) In accounting for Commonwealth Funding and Contributions, the CRC has exercised proper accounting standards and controls.

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- d) The financial statements present fairly that contributions, both cash and in-kind, have been expended in accordance with the Budget as specified in Schedule 4 in accordance with the terms of the Commonwealth Agreement.
- e) The CRC has met its obligations in relation to the treatment of Capital items;
- f) The Cash contributions and Commonwealth Funding have been paid into and expended from the CRC's Account and in accordance with the Commonwealth Agreement and all interest on the balance of the account has been credited to the account.

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Peter B Partner

Perth 4 September 2007





Glossary*

Acid Sulfate Soils: soils characterised by low pH (<3.5), deriving their acidity from the presence of oxidised sulfur

Aeolian: pertaining to wind; said of rocks, soil and deposits whose constituents were transported by the wind, or of sedimentary structures, erosion and deposition accomplished by the wind

Aerobic: requiring or utilising free oxygen in air for metabolic purposes

Alluvial: said of a placer formed by the action of running water; also, said of the valuable mineral (gold or diamond) associated with an alluvial placer

Anaerobic: capable of living without free oxygen

Aquifer: a permeable layer carrying accessible water

Aquitard: a low permeable sedimentary layer that acts as an interface through which recharge and soluble salts from enters an aquifer

Base metals: a term for copper, nickel, lead and zinc, often considered as a group because of their long history of use

Basement: a complex unit, generally of igneous and metamorphic rocks, uncomfortably overlain by sedimentary strata

Breccia: a composite rock consisting of angular fragments of stone, cemented together by some matrix, such as calcium carbonate

Calcrete: used broadly to refer to regolith carbonate accumulations, forming more or less-well cemented aggregates composed largely of calcium carbonate

Colluvial: pertaining to colluvium – heterogeneous material of any particle size, generally composed of soil and/or rock fragments, accumulated on the lower parts of slopes, transported there by gravity, soil creep, sheet flow, rainwash or mudflow

CHIM: electro-chemical method of prospecting using direct electric current that attracts metal iron onto the cathode.

Cover: see Regolith

Craton: a relatively immobile section of the Earth's crust, generally of large size

Duricrust: regolith material that has been hardened by a cement occurring at or near the surface

Facies: general appearance, composition or nature of one part of a rock body as contrasted with another. A lateral subdivision of a stratigraphic unit

Felsic: of or pertaining to such light-coloured minerals as the feldspars, the feldspathoids, quartz, and muscovite, or to rocks containing a high proportion of these or similar minerals

Ferruginous: pertaining to, or containing iron

Goethite: common, yellow-brown iron oxide mineral

Hematite: black/blue-black or red mineral, hexagonal close-packed structure

Hyperscopic: having many narrow spectral bands, used in remote sensing

In situ: in its original place

Kaolinite: white clay mineral

Karst: terrain with distinctive characteristics of relief and drainage arising primarily from a higher degree of rock solubility in natural waters than is found elsewhere

Lacustrine: pertaining to, produced by, or formed in a lake

Lag: surface accumulation of divers materials, eg regolith, rock.

Mafic: rock or mineral of high magnesium and iron content

Magnetite: mineral of the spinel family, strongly ferromagnetic

Mahegmite: magnetic mineral formed by the oxidation of magnetite **Morphology:** shape, form, external structure or arrangement

Morphology. shape, form, external structure of allangement

Nanoparticulate: made up of particles with dimensions of a few nanometres (10⁹ m)

Palaeo: a prefix used to relate subjects to earlier periods of time, eg. palaeoclimatology, palaeodrainage Pathfinder elements of little intrinsic interest that aid in the discovery of valued minerals

Pedology: the study of soil morphology, genesis and classification

Permeability: the capacity of a rock for transmitting fluid

Phyto-exploration: the technique of looking for metal anomalies in plant tissues as an indicator of buried mineralisation.

Placer: a mineral deposit formed by the accumulation of weathering resistant materials, usually in alluvium or on a shoreline

Playa: vegetation-free, flat area at the lowest part of an undrained desert basin, underlain by stratified clay, silt or sand, and commonly by soluble salts, dry most of the time

Porosity: the amount of pore space present, expressed as a percentage of the total volume of the material

Porphyry: igneous rock containing conspicuous phenocrysts (large crystals, generally of feldspar) in a fine-grained groundmass

Radiometric: of, pertaining to, or involving the measurement of radioactivity or ionising radiation

Regolith: the entire unconsolidated or secondarily re-cemented cover that overlies more coherent bedrock, that has been formed by weathering, erosion, transport and/or deposition of older material

Rhizomorphs: A root-like structure in plants

Saprolite: weathered rock in which the fabric of the parent rock is retained

Surficial: at the surface, especially the surface of the earth

Tdhem: time domain helicopter electromagnetic

Transect: a line or a belt of land along which a survey is made; a survey of this kind

Traverse: a line surveyed across a plot of ground

Ultramafic: of an igneous rock: composed chiefly of mafic minerals

Vadose Zone: the region of aeration above the water table

* The principal source for this glossary is *The Regolith Glossary – surficial geology, soils and landscapes,* edited by Richard A. Eggleton, published in 2001 by CRC LEME.



Acronyms

3D: Three-Dimensional

4D: Four-Dimensional (spatial + time)4WD: Four-Wheel Drive

ACLEP: Australian Collaborative Land Evaluation Program

AEM: Airborne ElectroMagnetics

AFFA: Australian Government Department of Agriculture, Fisheries and Forestry

AGC: Australian Geological Convention

AGES: Annual Geoscience Exploration Seminar

AGIA: Australian Geoscience Information Association

AIG: Australian Institute of Geoscientists

AusIMM: Australasian Institute of Mining and Metallurgy

AINSE: Australian Institute of Nuclear Science and Engineering

AJES: Australian Journal of Earth Sciences

AM: Aeromagnetic

AMEC: Association of Mining and Exploration Companies

AMIRA: Australian Mineral Industries Research Association (International)

AMT: Audio-magnetotellurics

ANC: Acid Neutralisation Capacity

ANU: The Australian National University

ANU RSES: ANU Research School of Earth Sciences

ANSTO: Australian Nuclear Science and Technology Organisation

ANZGG: Australia New Zealand Geomorphology Group

APA: Australian Postgraduate Award

APAI: Australian Postgraduate Award (Industry)

ARC: Australian Research Council

ARRC: Australian Resources Research Centre **ASCILITE:** Australasian Society for Computers in Learning in Tertiary Education

ASRIS: Australian Soil Resource Information System

ASEG: Australian Society of Exploration Geophysicists

ASS: Acid Sulfate Soils

ASSS: Australian Society of Soil Science Inc

ASTER: Advanced Spaceborne Thermal Emission and Reflection Radiometer

AVS: Acid Volatile Sulfides

ATSE: Academy of Technological Sciences and Engineering

AutoGeoSEM: Automatic Geological Scanning Electron Microscope

BRS: Bureau of Rural Sciences

BSR: Bacterial Sulfate Reduction

CALM: Western Australian Department of Conservation and Land Management

CDI: Conductivity Depth Image

CD: Compact Disc

CSIRO EM: CSIRO Exploration and Mining

CSIRO LW: CSIRO Land and Water

CMA: Catchment Management Authority

COGEO-ENVIRONMENT: International Union of Geological Sciences Commission on Geological Sciences for Environmental Planning

CRC: Cooperative Research Centre

CRM: Chemical Remnant Magnetism

CSIRO: Commonwealth Scientific and Industrial Research Organisation

CUPS: Curtin University Postgraduate Scholarship

CUT: Curtin University of Technology

DNA: Deoxyribonucleic Acid

DEM: Digital Elevation Model

DTB: Depth To Basement

DTM: Digital Terrain Mapping=

EC: Electrical Conductivity

EKS: Electrokinetic Seismic

ELA: Exploration Licence Application

EMflow: Airborne EM interpretation

EM: Electromagnetic

EMP: Electron Microprobe

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FDEM: Frequency Domain Electromagnetics (could be either ground or airborne)

FTE: Full Time Equivalent

GA: Geoscience Australia

GAB: Great Artesian Basin

GEMOC: The ARC National Key Centre for Geochemical Evolution and Metallogeny of Continent at Macquarie University, NSW

GEOpixie: Software for quantitative and nondestructive Particle-Induced X-ray Emission (PIXE) analysis and imaging.

GFS: Groundwater Flow Systems

GIS: Geographic Information System

GPS: Global Positioning System

GPR: Ground Penetrating Radar

GRM: Gamma Radiometrics Methods

GSWA: Geological Survey of Western Australia

HEM: Helicopter Frequency Domain Electromagnetic

HGU: Hydrogeomorphic Units

HRU: Hydrogeomorphic Response Unit

ICPMS: Inductively Coupled Plasma Mass Spectrometry

IGPC: International Geological Correlation Program

IGU: International Geographical Union

INAA: Instrumental Neutron Activation Analysis

IP: Induced Polarisation

IP: Intellectual Property

IPRS: International Postgraduate Research Scholarship

IUGG: International Union of Geodesy and Geophysics

IUGS: International Union of Geological Sciences

IUSS: International Union of Soil Sciences

KPI: Key Performance Indicator

LA: Laser Ablation

LAICPMS: Laser Ablation Inductively Coupled Plasma Mass Spectrometry



LEME: Cooperative Research Centre for Landscape Environments and Mineral Exploration

LUAC: Land Use Advisory Council

MAC: Minerals Advisory Council

MCA: Minerals Council of Australia

MDB: Murray-Darling Basin

MDBC: Murray-Darling Basin Commission

MERIWA: Minerals & Energy Research Institute of WA

MGA: Map Grid of Australia

MINEX: Minerals Exploration

MMI: Mobile Metal Ion

MTEC: Minerals Tertiary Education Council

NanoTEM: A ground based TEM system

NAPSWQ: National Action Plan (for Salinity and Water Quality)

NatCASS: National Committee for Acid Sulfate Soils

NGSA: National Geochemistry Survey of Australia

NGTN: National Geoscience Teaching Network

NHT: National Heritage Trust

NITO: Portable X-ray Fluorescence technology

NLWRA: National Land and Water Resources Audit

NMR: Nuclear Magnetic Resonance

NRM: Natural Resource Management

NSW DNR: New South Wales Department of Natural Resources

NSW DPI: New South Wales Department of Primary Industries

NTGS: Northern Territory Geological Survey

OFR: (CRC LEME) Open File Report

OSL: Optically Stimulated Luminescence dating method

CRC PBMDS: CRC for Plant-based Management of Dryland Salinity

PCR: Polymerase Chain Reaction

PIRSA: Primary Industries and Resources South Australia

pmd*CRC: CRC for Predictive Mineral Discovery

PDF: Portable Document Format

PHREEQC: A computer program for speciation, batch-reaction, one-dimensional transport and inverse geochemical calculations

PIMA: Portable Infrared Minerals Identifier

ppb: Parts per billion

ppm: Parts per million

ppt: Parts per thousand

PURSL: Productive Use and Rehabilitation of Saline Lands

Q DNRM: Queensland Department of Natural Resources and Mines

RCAs: Regional Carbonate Accumulations

REE: Rare Earth Elements

RESOLVE: A kind of helicopter frequency domain AEM system

RIRDC: Rural Industries Research and Development Corporation

RNA: Ribonucleic acid

RTMAP: Regolith Terrain Mapping

SA DEH: South Australia Department for Environment and Heritage

SA DWLBC: South Australia Department of Water, Land and Biodiversity Conservation

SAM: Sub Audio Magnetics

SDP: Soil Gas Geochemistry

SEG: Society of Economic Geologists

SEG: Society of Exploration Geophysicists

SEGH: International Society of Environmental Geochemistry and Health

SEM: Scanning Electron Microscopy/Microscope

SHRIMP: Sensitive High Resolution Ion Microprobe

SIF3: Salinity Investment Framework III model

SIS: Salt Interception Scheme



SMMSP: Salinity Mapping and Management Support Project

SXRF: Synchrotron X-ray Fluorescence

t/a: Tonnes per annum

TSA: The Spectral Assistant (computer software)

TSG: The Spectral Geologist (computer software)

TEM: Time Domain Electromagnetics (NanoTEM)

TEM: Transmission Electron Microscopy/Microscope

TIMS: Thermal Ionisation Mass Spectrometry

UA: The University of Adelaide

UC: University of Canberra

UNSW: University of New South Wales

UV-VS: Ultra-Violet Visible Spectrophotometry

UWA: The University of Western Australia

VHMS: Volcanic hosted massive sulfide (deposit)

VSWIR: Visual to Shortwave Infra red

WA DAF: Western Australia Department of Agriculture and Food

WA DEC: Western Australia Department of Environment and Conservation

WRI: Water-rock interaction

XRD: X-Ray Diffraction

XRF: X-Ray Fluorescence



NOTES



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