CRC LEME

Cooperative Research Centre for
Landscape Environments
and Mineral Exploration

ANNUAL REPORT 2001–2002

CRC

Established and supported under the Australian Government's Cooperative Research Centres Program

Photographs by Steven Hill

Centre Objectives

Page

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 multidisciplinary 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, geoscience-based 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.**

October 2002

ISSN 1447-4395

Cover photography by Steven Hill, Ian W. Roberts, Ravi Anand and Mark Paine

1. Highlights

The South Australian Minister for Minerals and Energy, The Hon. Wayne Matthew MHA, launched CRC LEME in Adelaide on 30 November 2001.

The co-location of CRC LEME headquarters with staff from CSIRO, and staff and students from Curtin University Department of Exploration Geophysics, at the Australian Resources Research Centre in Perth has greatly improved collaboration and sharing of resources in a very effective research centre.

Innovations in data acquisition, field sample analysis and high sensitivity magnetic sensors represent significant advances for Australian and international exploration companies.

To mark its 50th anniversary, the Geological Society of Australia dedicated the February issue of the *Australian Journal of Earth Sciences* as a thematic issue on the regolith geology of the Yilgarn Craton featuring a single paper by CRC LEME researchers Dr Ravi Anand and PhD student Mark Paine.

The *Victoria Undercover* conference, held in Benalla at the end of April, was an excellent opportunity for CRC LEME staff and students to meet with a diverse range of researchers and land users with interests in Victoria. Proceedings were published, ran to almost 300 pages and included 46 papers.

CRC LEME personnel received several prestigious awards during the year including a Churchill Fellowship.

Australian Research Council grant success was marked by two ARC Linkage Grants and an ARC Linkage Infrastructure Grant.

Dr Rob Fitzpatrick and Dr Richard Greene were invited to deliver keynote addresses at international conferences.

CRC LEME's Education and Training program is on track to exceed the Centre's target of graduating at least 60 honours students and 60 PhD students during the life of CRC LEME. Co-supervisors drawn from CRC LEME partners, industry or government agencies, assist with most student projects.

In 2001–2002 CRC LEME committed $300,000 to scholarship support and operating funds for student projects.

The Centre's short course program continues to provide specialised training for students and professional geoscientists.

The Cooperative Research Centre Program is funded by the Australian Commonwealth Government and has been running since 1990. The program exists to strengthen collaborative links between industry, research organisations, educational institutions and government agencies.

The Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) is an unincorporated joint venture that brings together groups from the Bureau of Rural Sciences, CSIRO, Curtin University of Technology, Geoscience Australia, Minerals Council of Australia, New South Wales Department of Mineral Resources, Primary Industries and Resources South Australia, The Australian National University, The University of Adelaide and the University of Canberra.

CRC LEME's research efforts are directed along nine strategic research themes:

- Regional mineral exploration
- Making geochemistry work in areas of cover
- Regolith processes
- Landscape evolution
- Geophysical mapping and modelling
- Acid sulphate soils
- Salinity systems
- Regolith geoscience and urban Australia
- Environmental geochemistry

CRC LEME's education and training program spans all nine themes.

2. Executive Summary

Chairman's Report

Ross Fardon,
Chairman

The Cooperative Research Centre for Landscape Environments and Mineral Exploration has experienced a mixed year, and we pay a tribute to our executive and researchers for the progress made.

When a CRC is renewed, as CRC LEME was, the first year of the new CRC overlaps with the last year of the previous one. This overlap is an anomalous and damaging situation that the CRC system should abolish. The last and first years are associated with different participants, research needs and strategies, funding, and short-term goals.

Many of our participants, as well as CRC LEME itself, are under funding pressure, and the executive and especially our head office were addressing funding and personnel issues of real concern to the participating organisations.

The biggest issue was the change in Commonwealth funding under the *National Action Plan for Salinity and Water Quality*. The Bureau of Rural Sciences was unable, despite their best efforts, to meet the committed funding to the CRC. This left it very short of funds through the year. In August 2002, the BRS withdrew from the CRC with goodwill on both sides, but leaving a funding shortfall of $2.98 million over four years. This has hurt our research staffing and effort severely, but there are signs that we may recover that funding level within a year. The CRC has a very cooperative attitude and a wealth of expertise to share with the numerous state and other authorities handling salinity and land use issues.

It is widely said that the value of airborne electromagnetic surveys in salinity mapping and research has been oversold. We take the opposite view, that the valuable surveys flown have been starved of even basic interpretation and integration with the wealth of local and State expertise available. We are moving to rectify the situation, in cooperation with scientists and planners across Australia. The knowledge is there, the integration needs improvement.

The other main development of the year was the retirement of our founder and CEO Dr Ray Smith at the end of the year. Ray will return to research and we will establish suitable tributes to one of the founders of the science of regolith in Australia. He is not lost to us. Ray Smith, thank you from all of us. What a legacy you leave in the CRC LEME.

There is a decline of research funding from the mining exploration industry. We hope, by focussing on delivering valuable new methods of exploration, to gain more support in the next few years.

It is a privilege to work with our Executive team, which has evolved over the year to meet new challenges. The transition from CRC LEME 1 to CRC LEME 2 was guided by an interim Executive who laid the sound foundations for our research strategy. I thank CRC LEME 1 stalwarts Dr Charles Butt, Assoc Prof. Graham Taylor and also Dr Brad Pillans, Prof. Stewart Greenhalgh and Dr Rob Fitzpatrick who served on the interim Executive. They remain with CRC LEME as valued researchers and teachers. We welcomed (at various stages) Prof. Norm Uren, Mr Paul Wilkes, Prof. Nigel Radford, Assoc Prof. Pat James, Assoc Prof. Ken McQueen, Mr John Keeling, Dr Ken Lawrie, Dr 'Bear' McPhail. Only Dr Ravi Anand, Dr Colin Pain and Mr Gary Kong remain from the CRC LEME 1 Executive and they provide sterling service under the exceptional organisational pressures on our executive. To all, thank you.

Thank you to all members of our Board for their commitment and generous direction. There have been a number of changes to our Core Participant representatives since the Board formed. I hope that our Board membership has now stabilised.

The drafting of our strategic plan is nearly complete, the Minerals and Land Use Advisory Councils are in place, some university funding issues are resolved, and we are confident of our central contribution to future minerals discovery and to Australia's land use planning and management.

Since the end of the year, I am able to pay tribute to Mr Paul Wilkes, who was invited into the Acting CEO role. We are all in his debt. No one could have guided the Centre in such difficult circumstances and done better. His efforts are appreciated by the researchers, the Executive and the Board.

Finally, we are glad to welcome Dr R Dennis Gee as our new CEO who will commence in early November 2002. When a 'Ray Smith' departs, we are fortunate to have such a person to take over. Dr Gee is currently Director of the Northern Territory Geological Survey and brings a wealth of experience in the mineral industry and government to his new role in CRC LEME. He is a structural geologist by training. He was born and educated in Tasmania.

Chief Executive Officer's Report

Paul Wilkes,
Acting Chief Executive Officer

Following the stepping down of Dr Ray Smith as CEO of CRC LEME at the end of June 2002, I am pleased to present the first annual report of the newly formed Cooperative Research Centre for Landscape Environments and Mineral Exploration, CRC LEME. I pay tribute to our founding CEO who has made an immense contribution to regolith geoscience. Ray has returned to his research interests in CSIRO and CRC LEME.

CRC LEME grew from the strong foundations laid by the previous CRC for Landscape Evolution and Mineral Exploration (1995–2001), and the CRC for Australian Mineral Exploration Technologies (1992–2000).[1]

The year 2001–2002 was marked by the transition between CRC LEME 1 and CRC LEME 2, and increasing integration of the new participants. CRC LEME 1 finished one year earlier than originally planned and this has had significant negative impacts on resourcing the start-up phase of CRC LEME 2.

CRC LEME 2 is wide-ranging both in scope and in geography. Coupled with our ongoing pursuit of improved mineral exploration under cover is our new thrust into the application of regolith geoscience in environmental management. We see these two objectives as being linked as progress in one often benefits the other.

Our Education and Training program is vital to provide the pool of expertise necessary for both the mineral exploration and natural resource management industries in the future. CRC LEME 2 has a wider range of disciplines than its predecessor and includes geologists, geochemists, geophysicists, hydrogeologists, geomorphologists, mineralogists, micro-biologists, soil scientists, GIS and computing specialists, and support staff.

We have established a vigorous education program across the four participant universities and are on target to graduate at least 60 Honours and 60 PhD students during the life of CRC LEME.

Special Thanks

I express special thanks to two of our founding leaders—Dr Charles Butt and Assoc. Prof. Graham Taylor for their contributions to CRC LEME in Mineral Exploration and Education & Training respectively.

CRC First Year Visit

The CRC First Year Visit took place in February 2002 and reported favourably on the first seven months of CRC LEME. The report commented that, 'the major challenge for the Centre is to operate effectively in a much wider, dynamic and high profile environment than its predecessor. The enthusiasm, cohesiveness and competence of the Executive leaves the panel confident that this challenge can be met'.

Strategic Planning

During the year, the Executive formulated strategic directions for CRC LEME and held strategic workshops at all three nodes, Adelaide, Canberra, and Perth. Draft plans were presented and feedback received from the Board, staff and students. The Strategic Plan is expected to be completed in October 2002.

Conference

CRC LEME and CSIRO Exploration and Mining hosted a successful conference, Victoria Undercover, in Benalla, northern Victoria, in April 2002. This successfully brought together researchers in, and users of, mineral exploration and environmental applications. The middle day of this three-day conference was a fascinating field excursion, which helped to put many of the presented papers into context.

Special Publication

I congratulate Dr Ravi Anand and Mr Mark Paine for their special achievement in publishing the 'Regolith geology of the Yilgarn Craton' as the sole paper in the first issue of the 50th anniversary year of the Australian Journal of Earth Sciences. This is the first time that one issue of the journal has been devoted to a single paper and it is a fitting honour for these CRC LEME geologists.

Team Work

The success of CRC LEME to date is the result of excellent teamwork and I thank all the members of the Executive, the Board, the Centre Visitor, Prof. Gerry Govett, and the headquarters staff, for their contributions during 2001–2002.

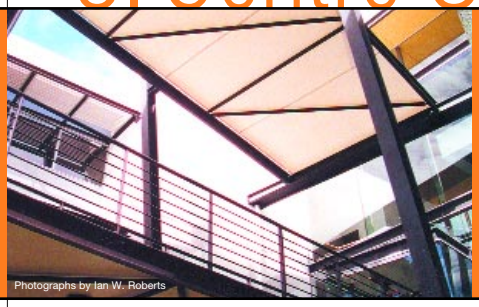
Outlook

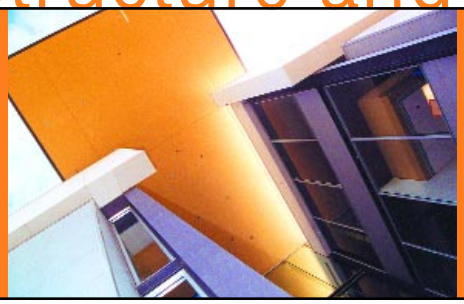
During the coming year we will see the continuing integration of the CRC LEME participants focussed on the strategic directions that we have established. This year will see fieldwork and analysis begin on environmental projects in South Australia and Queensland. We are also planning environmental work in other States. In all these projects the emphasis is on partnerships with State and local agencies. In mineral exploration, we have exciting ongoing work with mineral explorers and are planning new collaborative projects. We are also planning joint projects with the other CRCs working in related areas to that of CRC LEME. Interlinked with all the research programs will be further developments in Education and Training and increased external communication of the work of CRC LEME.

I look forward to a highly successful future for this Centre.

[1] *For convenience, the previous centre is often referred to as 'CRC LEME 1' and the new/current centre as 'CRC LEME 2'. Throughout this Annual Report, 'CRC LEME' and 'CRC LEME 2' are used to refer to the current Centre—the number being added to avoid ambiguity.*

3. Centre Structure and Management






CRC LEME operates as an unincorporated joint venture between its ten participants. CSIRO Exploration and Mining acts as Centre Agent. The headquarters of CRC LEME are in Perth, Western Australia and during August and September 2001 were re-located to the recently completed Australian Resources Research Centre at Technology Park, adjacent to Curtin University of Technology.

Core Participants

The core participants in CRC LEME are signatories to the Commonwealth Agreement under which the Centre is established and undertake its research and management. Under that agreement, the CSIRO Division of Exploration and Mining is appointed as the Centre Agent and takes responsibility for the bulk of administrative responsibilities. The core participants during the reporting period were:

- Bureau of Rural Sciences (BRS)
- CSIRO, Division of Exploration and Mining and the Division of Land and Water
- Curtin University of Technology (CUT)
- Geoscience Australia (GA)
- Minerals Council of Australia (MCA)
- New South Wales Department of Mineral Resources (NSW DMR)
- Primary Industries and Resources South Australia (PIRSA)
- The Australian National University (ANU)
- The University of Adelaide (UofA)
- University of Canberra (UC)

Governing Board

The overall management of CRC LEME is the responsibility of its Governing Board chaired by Dr Ross Fardon who is independent of the Core Participants. All Core Participants are represented on the Governing Board as are a number of other stakeholders in the Centre's activities.

At the end of the reporting period the Governing Board membership was:

- Dr Neville Alley, Primary Industries and Resources, South Australia
- Professor Tim Brown, Australian National University
- Ms Janet Dibb-Smith, The University of Adelaide
- Dr Ross Fardon, Chair (independent)
- Dr David Garnett, Becquerel Laboratories
- Mr Lindsay Gilligan, NSW Department of Mineral Resources
- Mr Kevin Goss, Murray Darling Basin Commission
- Professor Mohamed Khadra, University of Canberra
- Mr Gary Kong, Board Secretary, CRC LEME (Business Manager)
- Mr Adrian Larking, Association of Mining and Exploration Companies
- Dr Peter O'Brien, Bureau of Rural Sciences
- Professor Neil Phillips, CSIRO Division of Exploration and Mining
- Dr Chris Pigram, Geoscience Australia
- Professor Paul Rossiter, Curtin University of Technology
- Dr Ray Smith, CRC LEME (Chief Executive Officer)
- Dr Kevin Tuckwell, Minerals Council of Australia

A number of changes to the membership of the Governing Board occurred during the reporting period. In 2001, Dr Alastair Blake represented the University of Adelaide; Dr Colin Chartres represented BRS; Professor Allan Cripps represented the University of Canberra; Professor Brian Kennett represented the Australian National University; Dr Paul Taufen was an

independent representative of the minerals industry and Dr Neil Williams represented Geoscience Australia.

The inaugural meeting of the Governing Board was held on 20 September 2001 in Perth. Subsequently, the Governing Board met in Adelaide where they hosted the South Australian Minister for Minerals and Energy, the Hon Wayne Matthew MHA, at the CRC LEME official launch on 30 November 2001. In March 2002, the Governing Board and the Executive held a combined Board meeting and strategic planning workshop in Canberra. On each of these occasions, arrangements were made for the Governing Board to meet with representatives from local Core Parties. Arrangements for teleconferencing and electronic voting were made when necessary.

At its first meeting, the Governing Board appointed a Safety Sub-Committee to advise on the areas of field and vehicle safety. The Safety Sub-Committee comprised Dr Chris Pigram (Chair), Prof Neil Phillips, Professor Allan Cripps and Mr Adrian Larking. The Governing Board also established an audit Sub-Committee of Dr Ross Fardon, Dr Ray Smith, Dr David Garnett, Dr Neil Williams and Mr Gary Kong.

Advisory Councils

CRC LEME receives strategic guidance from two Advisory Councils established to provide input from external stakeholders in the work of the Centre. The Minerals Advisory Council met in June 2002 and was convened by Dr David Garnett.

Members are:

Mr Paul Agnew, Rio Tinto Exploration Pty Ltd

Dr Nigel Brand, Anglo American Exploration (Australia) Pty Ltd

Dr David Garnett, Chair, Becquerel Laboratories

Professor Bob Gilkes, University of Western Australia

Dr Jon Hronsky, WMC Exploration Division

Dr Richard Mazzucchelli, Searchtech Pty Ltd

Mr Nick Sheard, MIM Exploration Pty Ltd

Dr Bryan Smith, Bryan Smith Geosciences

Mr Carl Swensson, Normandy Mining Ltd

Dr Paul Taufen (Industry consultant)

Mr Mike Webb, Anglo American Exploration (Australia) Pty Ltd

Professor Peter Williams, University of Western Sydney

Mr Kevin Goss of the Murray-Darling Basin Commission was appointed Chair of the Land Use Advisory Council. This Council did not meet during the reporting period.

Executive

The Executive was chaired by Dr Ray Smith as CRC LEME Chief Executive Officer and was composed of Assistant Directors from Perth, Adelaide and Canberra and Research and Education Program Leaders. Dr D.C. 'Bear' McPhail joined the Executive as an *ad hoc* member in June 2002. Mr Paul Wilkes joined the Executive on his appointment as Operations Manager in November 2001. Mrs Sue Game served as Secretary to the Executive.

The Executive met via teleconference on a monthly basis and took advantage of opportunities as they presented themselves to meet face to face. A planning workshop was held with the Governing Board in March.

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

Dr Ray Smith, Chair (CEO)

Professor Norm Uren (Deputy CEO; Assistant Director, Perth)

Mr Gary Kong (Business Manager)

Mr John Keeling (Assistant Director, Adelaide)

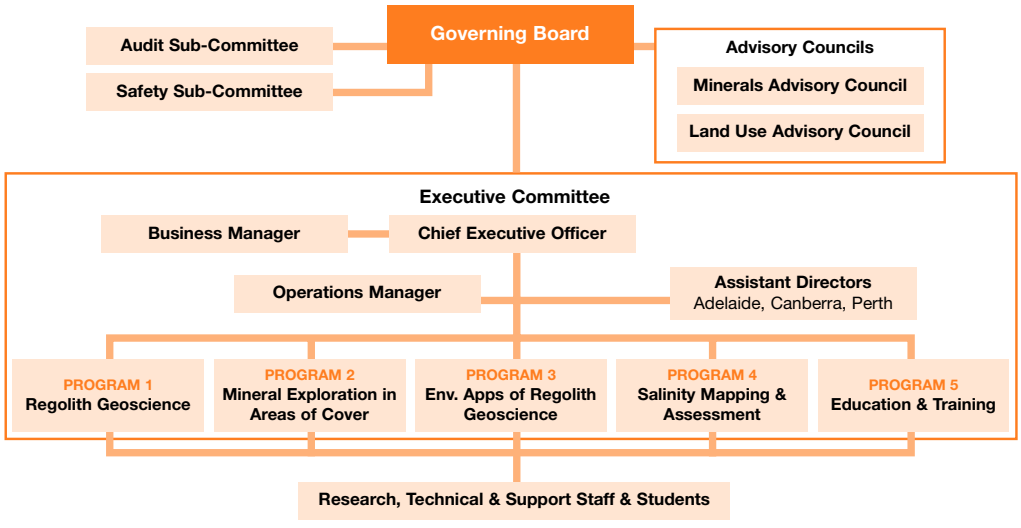
Dr Ken McQueen (Assistant Director, Canberra)

Mr Paul Wilkes (Operations Manager)

Dr Ravi Anand, Professor Nigel Radford, Dr Colin Pain, Dr Ken Lawrie, Assoc. Professor Pat James (Program Leaders)

Dr D.C. 'Bear' McPhail, *ad hoc* member, ANU

Mrs Susan Game, Executive Secretary



Photograph by Steven Hill

A number of changes to the Executive occurred during the reporting period. In 2001, Dr Charles Butt was the interim Leader of Program 2, Professor Stewart Greenhalgh represented the University of Adelaide, Dr Brad Pillans was the Centre's Assistant Director in Canberra and Assoc. Professor Graham Taylor was the interim Education & Training Program Leader.

Centre Culture

CRC LEME research and education efforts are undertaken by staff and students within the Centre's Core Participant organisations. This research is directed towards CRC LEME objectives along a number of strategic themes. Management and support are provided within our four research programs and our education program. This approach encourages cooperation amongst staff and students, collaboration between participants and ensures effective use of resources.

The relocation, in September and October 2001, of the CUT Dept of Exploration Geophysics and CSIRO Exploration and Mining to the new Australian Resources Research Centre (ARRC) in close proximity to the CUT Department of Applied Geology, represents a significant concentration of expertise. More effective collaboration is supported within these superb facilities which were officially opened in November 2001 by the Western Australian Premier, The Hon. Dr Geoff Gallop.

CRC Visits

Professor Gerry Govett was appointed the CRC Visitor for CRC LEME. Professor Govett is a Director of Aurion Gold and a Fellow of both the Association of Exploration Geochemists and the Australasian Institute of Mining and Metallurgy. His role as CRC Visitor is to act as a mentor and independent advisor to the Centre. Professor Govett visited the Centre headquarters in February and contributed to the First Year Visiting Panel report.

In accordance with CRC Australia practice, CRC LEME hosted a First Year Visiting Panel in February 2002. The panel comprised Dr Richard Jones (Chair), Professor Gerry Govett, and Ms Belinda Hughes from the CRC Secretariat. The panel was confident that the enthusiasm, cohesiveness and competence of the executive would allow the Centre to build on its strong national and international reputation and ensure effective operation in its wider, more dynamic and higher-profile area of activity. The panel was particularly pleased to note that one of the program leaders, Professor Nigel Radford, had been recruited directly from the mining industry (Normandy Mining Limited).

The panel reported that the Education and Training component was already well developed and highly successful. It was noted that the integration of new universities into the system had proceeded smoothly and had been clearly beneficial. In addition to the Honours and postgraduate activities, the provision of short courses at a variety of locations is especially welcomed.

Strategic Planning

Strategic planning activities throughout the year have involved Board, Executive and other CRC LEME personnel in the development of objectives and research themes. By reporting CRC LEME output within a number of strategically identified research themes the efforts of the Centre are directed towards desired outcomes. Our nine strategic research themes provide a mechanism through which the outcomes of individual projects are synthesised to substantial science outputs. It is primarily through these themes that our scientific findings are reported and promoted.

Research Programs

For administrative and management purposes, CRC LEME research activities and teaching are organised under five programs. The allocation of resources to, and accountability procedures for, the Centre's activities are provided through these programs. Our programs provide a stable structure to harness the resources of our Core Partners and to provide the requisite flexibility to accommodate our diverse research efforts. The leaders of the Centre Programs were:

Program 1 Regolith Geoscience: Dr Ravi Anand

Program 2 Mineral Exploration Under Cover: Dr Charles Butt (interim), Professor Nigel Radford (from February 2002)

Program 3 Environmental Applications of Regolith Geoscience: Dr Colin Pain

Program 4 Salinity Mapping and Hazard Assessment: Dr Ken Lawrie

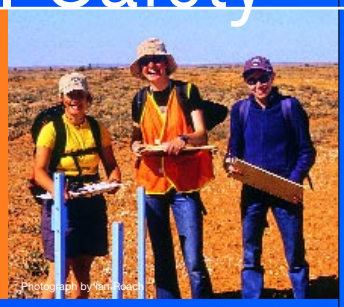
Education and Training: Assoc. Professor Graham Taylor (interim), Assoc. Prof. Pat James (from March 2002).

Centre Communications

In line with the Commonwealth Agreement, CRC LEME appointed a Communication Officer to support and coordinate the promotion the centre's activities via printed and electronic means. The Communication Officer was involved in various Executive-planning activities. The Centre is keen to establish strong and effective methods for communicating its achievements to the industry, research and the broader community.

4. Safety

Photograph by Steven Hill



Photograph by Ian Roach

In carrying out its research activities, CRC LEME frequently needs to operate in remote and difficult environments that could place staff and students in potentially dangerous situations. Consequently, field safety is one of our principal concerns—especially for students who are beginning to learn how to work safely in remote areas and under challenging conditions.

In addition to providing first aid certified leaders for field trips, the participating institutions either require or encourage all students to complete senior first aid certificates and courses in 4WD handling and remote area radio communication. Institutions maintain specially equipped 4WD vehicles for most excursions and field activities. The availability of advanced technologies including Global Positioning System (GPS) and satellite communications helps us to mitigate the risks associated with working in the Australian bush.

Enforcement of field safety rules and safe working in groups is a necessity in conditions experienced in remote areas of Australia. Safety equipment is provided and is required to be used correctly.

In 2001, a Board sub-committee was established to continue to improve CRC LEME safety practices by developing a comprehensive manual for Policy and Procedures on Field Safety for use in CRC LEME. It is anticipated that the manual, which draws together best practice material from core partners and companies in the exploration industry, will provide essential reference material for all participants. The manual will be condensed into a glove box guide to enable critical and key safety information to be taken into the field.

The manual, entitled CRC LEME Policies and Procedures on Field Safety and the glove box guides are nearing completion.

Photograph by Steven Hill

Photograph by Steven Hill

5. Cooperative Linkages

During the year, CRC LEME engaged in strategic planning exercises with four other related CRCs. There were nineteen international visits by CRC LEME staff and four international visitors to the Centre. The co-location of CRC LEME headquarters with staff from CSIRO and staff and students from Curtin University of Technology at the Australian Resources Research Centre in Perth assisted collaboration and resource utilisation.

To meet its objectives, CRC LEME has established productive cooperative links amongst Centre participants and with the users of its research in industry and the scientific research community, including other CRCs.

Effective cooperation is supported by the management structures within which the Centre's research and educational efforts are organised. By involving stakeholders at each level of the organisation (from Governing Board to project team), effective collaboration is fostered. The CRC LEME newsletter and web site have helped to build stronger relationships within and beyond the Centre, as has the active participation of Centre personnel in conferences, workshops and other meetings.

Internal Cooperation

The structure and culture developed within CRC LEME ensures close collaboration between the partners. The arrangement of the research and educational activities into programs and research themes ensures that contributions are coordinated and directed towards Centre goals. Project teams are formed as required—drawing personnel with the requisite expertise from CRC LEME partners and from external organisations.

Links with Users

A range of research projects involving external organisations as clients or collaborators were commenced or continued during the reporting period. Details are provided in the Utilisation and Applications section of this report.

Victoria Undercover: Collaborative Geoscience in Northern Victoria

The 2002 F.L. Stillwell Conference, *Victoria Undercover*, a joint enterprise between CRC LEME and the CSIRO Exploration and Mining, was a valuable opportunity to engage with end-users and other stakeholders in mineral exploration and environmental applications. The conference was held in Benalla, Victoria from April 30 to May 2, and was an excellent opportunity to share research progress and plans with over 100 delegates from a wide range of research and exploration organisations including: 2 CRCs, 11 universities, 13 Government or public sector organisations (including local, state and federal authorities) and 18 commercial stakeholders. Proceedings were distributed at the conference. The conference included a very useful field day.

Mineral Tertiary Education Council

The CRC LEME Education and Training program continues to operate in concert with the Mineral Tertiary Education Council (MTEC). The relationship between CRC LEME and MTEC helps to boost the profile of regolith studies across the country, especially within the National Geoscience Teaching Network.

Collaboration with Other CRCs

Representatives of CRC LEME were invited to participate in a strategic planning meeting in Adelaide with the new CRC for Plant-based Management of Dryland Salinity. Following that engagement, the two Centres have resolved to develop joint projects and to inform each other about their respective education programs and events.

CRC LEME involved the following CRCs in its strategic planning workshops in Canberra, Adelaide and Perth during March 2002:

- CRC for Catchment Hydrology
- CRC for Plant-based Management of Dryland Salinity
- CRC for Freshwater Ecology
- CRC for Predictive Mineral Discovery

International Linkages

Dr Charles Butt (CSIRO) presented an invited paper on nickel laterite deposits at the 2001 Gordon Research Conference on Inorganic Chemistry, held at Proctor Academy, New Hampshire USA, 19–24 August 2001. The meeting brought together about 100 scientists from across the world, had a strong industry representation and focussed on the theme *Formation, modification and preservation of ore deposits: tectonic, climatic and surficial factors*. Several presentations

focussed on surficial enrichment of Ni, Fe, Cu, Au and Al, which are very relevant to CRC LEME interests. This led to intense examination of a number of topics, both scientific and economic. Contacts were made with senior commodity specialists that may lead to research opportunities. Dr Butt is co-authoring a paper on aspects of nickel laterite geology with Dr Sarah Gleeson (University of Alberta) and Mick Elias (CSA Australia Pty Ltd).

Dr Rob Fitzpatrick (CSIRO/UofA) presented three invited papers at the American Society of Soil Science Annual Meeting in Charlotte, North Carolina, 21–26 October 2001. The presentations were made in the following three symposia: *Deep regolith—exploring the lower reaches of soil; Mineral controls in hydric soil processes*; and *Soil Classification—Contributions to Advances in Pedology*. Dr Fitzpatrick also visited Professor Jerry Bigham at Ohio State University from 28–30 October 2001, where they completed writing a major review on iron oxides. Details of this work are listed in the Publications section of this report.

In August 2001, Professor W.K. Fletcher (University of British Columbia) was a guest of Ian Robertson (CSIRO). Professor Fletcher is an internationally recognised geochemist with wide interests. His recent investigations into stream sediment in SE Asia from the points of view of both exploration and environmental impact may have local benefits. Professor Fletcher is a past president of the Association of Exploration Geochemists and is one of their Distinguished Lecturers.

Professor Stewart Greenhalgh (UofA) spent the period September–December 2001 on sabbatical leave at the Department of Physics, University of Toronto, Canada. The University of Toronto is one of the leading centres for training and research in mining geophysics. Professor Greenhalgh undertook extensive preparative work in environmental and groundwater geophysics for several pending CRC LEME projects. During his stay in Canada, Professor Greenhalgh also visited research centres in Ottawa (Geological Survey of Canada), Kingston (Queens University) and Vancouver (University of British Columbia), and gave scientific talks on mineral geophysics. During August 2001, he visited the University of Copenhagen, Denmark, and Imperial College, University of London, UK. In June 2002, Professor Greenhalgh visited the Swiss Federal Institute of Technology in Zurich, which has a very strong program in Engineering and Environmental Geophysics.

Professor Ian Hutcheon (University of Calgary) visited CRC LEME between January and June 2002. Professor Hutcheon's research interests are in low-temperature aqueous geochemical processes in sedimentary basins, including water-rock interaction, weathering, and CO_2 sequestration. During his visit, Professor Hutcheon worked mainly within the *Broken Hill Hydrogeochemistry Project* with Drs Patrice de Caritat and Dirk Kirste. Professor Hutcheon participated in groundwater collection field trips and interpretation of geochemical data. He was also involved in the MTEC short course on hydrogeochemistry given in Melbourne, and in the Victoria Undercover conference.

Dr Anton Kepic (CUT) presented a paper on the art of measuring very low amplitude seismo-electric signals at the 64th Conference of the European Association of Exploration Geophysics in Florence, Italy, 27–30 May 2002.

Dr Ken McQueen (UC) attended the Canadian Quaternary Association biennial conference held in Whitehorse, Yukon Territory Canada, from 20–24 August 2001. Ken presented results of CRC LEME work in eastern and western Australia related to landscape evolution and mineral exploration. Following the conference he visited the Klondike goldfield as part of a one-week post-conference field trip. This was an excellent opportunity to observe, first hand, preserved weathering profiles and placer gold occurrences as well as meet and network with a number of regolith and Quaternary scientists in Canada. Dr McQueen spent several days in Ottawa at the head office of the Geological Survey of Canada (GSC) organising with staff in the Terrain Sciences Division the next stage of the CRC LEME GSC Exchange Program. This program is now in its fourth year and has involved four reciprocal visits by five staff from the two organisations.

The latest exchange, planned in Ottawa and completed this year, involved work by Dr Alejandra Duk-Rodkin (Terrain Science Division of the Geological Survey of Canada based in Calgary, Canada) on a three-month project investigating the drainage history and landscape evolution of the Girilambone-Cobar region in western NSW. Next year it is planned to send a CRC LEME scientist to Canada to work with Dr Duk-Rodkin on a similar project in NW Canada. Reconstruction of the drainage network for different stages of the landscape history will permit a clearer understanding of the source regions for transported regolith. This in turn will improve our knowledge of element dispersion pathways and interpretation of displaced geochemical anomalies with consequent advances in exploration techniques.

CRC LEME Churchill Fellow, Ms Vicki Stamoulis (PIRSA/UofA), undertook an international study tour in 2002 visiting leading hyperspectral mineral mappers from the exploration industry, education institutions and government bodies in South Africa, Europe and North America. Ms Stamoulis had the opportunity to investigate the way major explorers like De Beers, Anglo American Plc, and Falconbridge Ltd are harnessing Hyperspectral Mineral Mapping as a valuable exploration tool.

Professor Michael F Thomas (University of Stirling, Scotland) visited University of Canberra and the CRC LEME headquarters in November. Professor Thomas collaborated with Assoc. Professor Graham Taylor working on the similarities between silcrete and white sands found commonly in tropical terrains and met with personnel from the Perth node.

Urban Regolith

During the year, CRC LEME collaborated with the Urban Geoscience Division of Geoscience Australia on a scoping project in Perth introducing regolith to planning in urban areas. A report on the potential of regolith work in the greater Perth area was prepared, and follow-up studies are planned for the 2002–2003 year. Contact has also been made with the Western Sydney Organisation of Councils, which has particular problems with salinity and urban infrastructure. Work on the incorporation of regolith knowledge into guidelines for urban development of saline soils will form part of next year's work program.

6. Research

Paul Wilkes

Very significant progress has been made in the two major objectives of CRC LEME research:

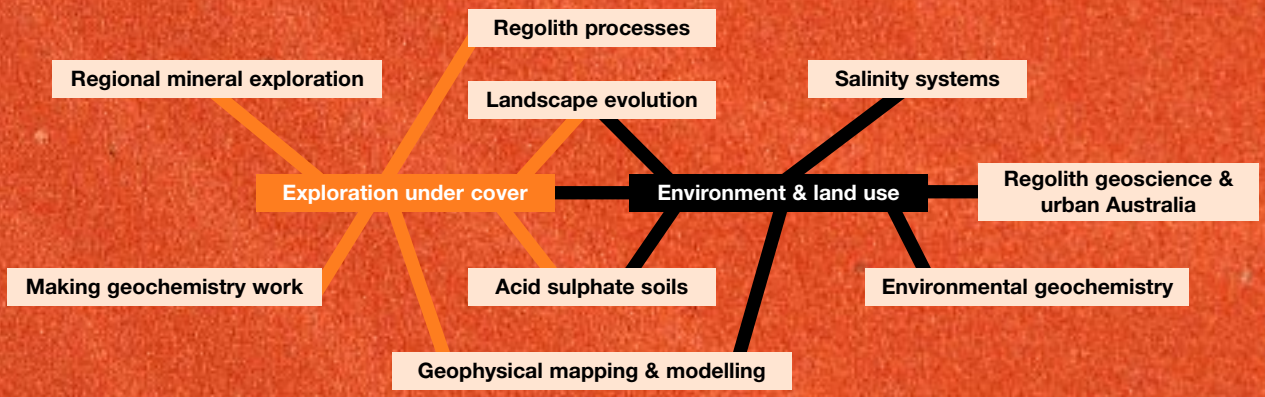
1. Regolith geoscience to aid mineral exploration under cover;

2. Regolith geoscience in environmental management.

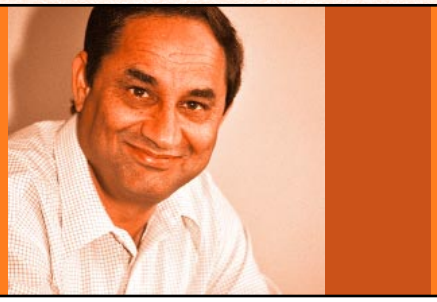
Work is reported under the four CRC LEME research programs but also addresses the nine research themes that we have established as the major thrusts of this Centre. The themes contain multiple projects and commonly encompass work from more than one research program. Much of this research is highly multi-disciplinary and benefits greatly from the wide-ranging and varied skills of the CRC LEME staff.

Research results are reported here on:

- Fundamental regolith geoscience—regolith processes and evolution,
- Mineral exploration under cover—making geochemistry more effective and optimising the use of geophysics,
- Environmental applications and salinity mapping and hazard assessment



Photograph by Steven Hill



Photographs by Ravi Anand

Dr Ravi Anand

Program 1: Regolith Geoscience

While there is an ongoing need to discover new mineral deposits in Australia, regions containing outcrops and *in situ* regolith materials have generally been well explored. Therefore, the greatest potential for further discovery now lies beneath areas of substantial cover, which are largely under-explored. This program aims to understand the fundamental controls on the formation and distribution of Australian regolith and the processes that take place within the regolith. As such, it forms the foundations for ongoing mineral exploration and environmental programs.

These covered areas are complex and future discoveries will rely on our ability to understand 4D regolith and landscape evolution processes. This understanding assists exploration through improved interpretation of chemical dispersion signals related to concealed ore deposits, and aids environmental research and management.

The program objectives are encompassed in two major research themes:

- Models of regolith-landscape evolution;
- Understanding regolith processes.

These themes are being addressed through regional, district and local-scale regolith studies in several exploration regions of Australia, including the Gawler Craton, Curnamona Province, Musgrave Block, western NSW and Yilgarn Craton. Projects are investigating sedimentary and residual regolith to develop a series of 4D models portraying the dynamics of their formation and evolution.

We are documenting the spatial distribution and characteristics of regolith and are addressing the dynamics of regolith-forming processes including clastic, chemical, biological and mineralogical mechanisms. The projects are using a variety of dating techniques to establish the timing of regolith formation. We are compiling case histories for two thematic volumes. Our recent publications include:

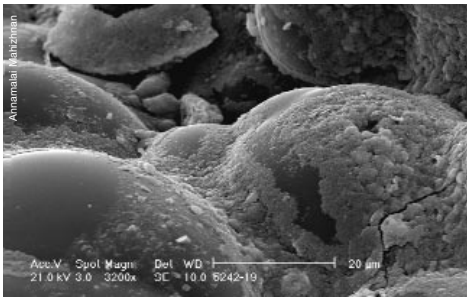
- The regolith geology of the Yilgarn Craton published as a one paper thematic issue in the Australian Journal of Earth Sciences.
- A monograph on calcrete that contains chapters on calcrete classification, distribution, mineralogy, geochemistry and exploration potential.
- A monograph on ferruginous materials which includes discussion on usage of the term ‘laterite’, evolution of principal ferruginous materials, pisolith classification and review of some classification schemes of ferruginous duricrust. A classification scheme of all ferruginous materials is proposed.

Models of Regolith-Landscape Evolution

This theme aims to develop and test 4D regional and local scale models of landscape evolution in various strategic mineral exploration and land management regions.

Reliable numerical dating underpins quantitative models of regolith-landscape evolution and the calculation of process rates. Results of our palaeomagnetic dating from weathering profiles across southern Australia generally cluster into three age ranges. The largest cluster of data at 60±10 Ma is widely represented in weathering profiles on rocks ranging from Archean to Cretaceous. These occur at sites from the eastern Yilgarn through northern South Australia, southern Queensland and northern NSW. At around 60 Ma, the climate was wet, cool temperate and the vegetation was dominated by conifer forests and woodlands. The second cluster at late Tertiary (10 ± 5 Ma), represents climates that were seasonally drier (though rainfall was still higher than present) and warmer, with consequent flora changes, as southern Australia drifted to lower latitudes. Thus, the two major episodes of iron oxide formation in the Tertiary occurred under differing bio-climatic regimes. A small cluster of paleomagnetic ages, represented by fewer sites, is Jurassic (180±10 Ma).

In South Australia, we are putting increased emphasis on understanding the landscape evolution in areas of prospective basement rocks by studying the cover sediments and *in situ* regolith. Investigations are targetted in areas of the Curnamona Province, central Gawler Craton and the Musgrave Block—these have been identified as having high mineral prospectivity and remain the focus of ongoing integrated investigations.



Scanning electron micrograph of secondary manganese oxides precipitated on opaline silica spheres in red-brown hardpan, Yilgarn Craton >

Work in the Curnamona involved assessment of recent drilling, resulting in reconstruction of palaeoenvironments for sediment deposition in the northern Murray Basin, preparation of regolith maps over areas of thin cover on Palaeoproterozoic Willyama bedrock, and compilation of drill hole data for controls on modelling thickness of cover over basement in the Callabonna Sub-basin from airborne magnetics. Agreement between PIRSA and NSW Department of Mineral Resources to increase collaboration and cross-border cooperation through the Broken Hill Exploration Initiative will facilitate ongoing CRC LEME investigations on both sides of the state border and improve the transfer and sharing of information coming from research projects in the region.

In the central Gawler Craton some 170 air-core/percussion holes totalling around 8,500 m were completed in a two phase drilling program designed to confirm extensive ultramafic, mafic and banded iron formations outlined by previous aeromagnetic surveys and mostly hidden beneath regolith. Investigations of the Kingoonya palaeodrainage system and its impact on mineral exploration in the greenstone belt were integrated into a regional synthesis of palaeodrainage to the Eucla Basin, the site of extensive sediment deposition during Tertiary times. Papers on techniques for recognition and mapping palaeodrainage and on the sedimentology and evolution of the drainage systems have been prepared for publication and conference presentations.

Successful negotiations with traditional landowners in the Musgrave region resulted in commencement of reconnaissance drilling which by 30 June 2002, saw completion of over 5,000 m of RC percussion and air core drilling in areas of thin regolith cover on Proterozoic bedrock.

We are making progress in compiling case histories for the two thematic volumes namely: *Regolith-Landscape Evolution* and *Mapping Regolith in 3D*. To date, forty-five case studies have been received for the regolith-landscape evolution volume and one was received for the 3D volume. A collection of papers on *Geophysical and Remote Sensing Methods for Regolith Exploration* has been completed and is in production.

Contributions by Honours and PhD studies form an integral part of this theme. Peter de Broekert completed his PhD thesis on the origin of palaeochannel sediments in the Kalgoorlie region. He developed a 3D lithofacies model to predict the style of the fill within areas of limited exposure and a palaeogeographic reconstruction incorporating the depositional and weathering history of the Kalgoorlie region. Martin Smith, completed his honours thesis (at UNSW) on paleomagnetic dating of regolith in the Cobar region, and began his PhD research at ANU on geochronology and landscape history in western NSW. All fieldwork for Mike Craig's PhD study on landscape evolution of the Eastern Goldfields is now complete. PhD student, Mark Paine, is developing regolith-landscape models for the Dundas Tableland, in Victoria.

Understanding Regolith Processes

Research under this theme contributes to a process-driven understanding of the geochemistry of the regolith and associated dispersion and accumulation of salts.

We have investigated mineral hosts and traps for specific ore-related target and pathfinder elements at three deposits (Boddington, Mt Percy and Golden Grove). This study presents new data on the occurrence and concentration of specific trace elements in a variety of minerals and mineralogical assemblages. This has potential to improve exploration success through modified sampling procedures that target specific mineralogies in regolith-dominated terrains. Mel Lintern commenced his PhD on the role of biological and non-biological factors in the formation of gold-in-calcrete anomalies aimed at making this technique even more effective in discrimination of gold mineralisation.

In intensely weathered terrain, fundamental issues encountered by exploration geologists are discrimination of:

- Bedrock type from its weathered counterpart;
- Transported from *in situ* regolith;
- Position within an *in situ* weathered profile; and
- Discrimination of minerals formed by weathering and those formed by other fluid interactions.

Our understanding of regolith processes will be applied to evaluate techniques to rapidly log and interpret drill hole intersections using key features of mineralogical and physical characteristics of specific rock types and environments of regolith formation. Diagnostic and quantifiable key mineralogical and physical properties that can be measured using non-invasive, rapid techniques are being investigated. Some 6,000 metres of core and chip samples from the Lake Harris Greenstone drilling program in South Australia are included in this study.

The relationship between regolith landform and vegetation was investigated for eleven reference regolith units in the Eastern Goldfields, Western Australia. Results indicate quantifiable differences in species composition and diversity, vegetative cover, vegetation frequency and observable differences in soils and leaf litter accumulation.

We are also applying spectral mapping of minerals to study the influence of geomorphic and regolith processes on surface mineral distribution. Honours and PhD students from the University of Adelaide are involved in projects in the Curnamona Province and at Tarcoola in the Gawler Craton. The relationship between bedrock weathering and inland acid sulphate soils is the subject of a PhD study by Andrew Baker at the University of Adelaide investigating the eastern Mount Lofty Ranges using mineralogical, geochemical and isotopic techniques.

Professor Nigel Radford

Photograph by Steven Hill

Program 2: Mineral Exploration in Areas of Cover

For the first seven months of the review year Dr Charles Butt (CSIRO) was interim Program Leader. Professor Nigel Radford (CUT) took over in mid February. Dr Butt's very significant contributions to the CRC are gratefully acknowledged.

The aim of this Program is to provide new and improved tools for mineral exploration in areas of cover, to be achieved through better understanding of the processes that modify primary geological, geochemical and geophysical signatures in the regolith environment.

Consultation with our customers, the mineral exploration industry and State Government bodies, has encouraged us to tackle, as a first priority, areas of thin cover (<30 m). What we learn from such studies will enhance our ability to study, in later years of CRC LEME, areas of thicker and more saline cover.

Furthermore, stakeholder consultation has guided us towards three major objectives. These are: Regional Exploration studies, Making Geochemistry work in areas of thin cover, and Optimising Geophysical understanding of regolith. Activities under Program 2 are organised under these three objectives and progress reported against the following milestones enumerated in the CRC LEME Commonwealth Agreement (2001):

1. Completion of compilation of case histories and exploration models;
2. Delivery of first results from the integrated regolith geoscience projects in Gawler and Cobar regions;
3. Completion of initial studies integrating three dimensional geochemical and airborne electromagnetic modelling;
4. Completion of first phase of base metal exploration project;
5. Completion of multi-client projects in isotope geochemistry in selective analysis;
6. Initial assessment of use of acid sulphate soils and saline discharges in exploration;
7. Development of major interdisciplinary projects involving staff from several core parties in the principal exploration regions (Curnamona, Gawler, Lachlan and Yilgarn);
8. Expansion of integrated exploration research into key regions elsewhere (eg, Northern Territory, northern Western Australia, Queensland).

Progress towards all these milestones was achieved during the reporting period.

Regional Exploration Studies

These studies are a response to industry demands and to the specific requirements of NSW DMR and PIRSA to enhance perceived prospectivity within their states through enhanced regolith understanding. Three major projects have been launched: the Western NSW project, centred on Broken Hill, the Girilambone project, centred on Cobar in central-west NSW, and the Harris Greenstone Belt project on the Gawler Craton in western South Australia, thus meeting Milestone 7.

Western NSW regolith and landscape evolution project

This project seeks to stimulate mineral exploration in western NSW through greater understanding of the regolith. Five regolith map sheets were released during the reporting period with a further seven sheets to be released by the end of 2002. Landscape evolution models for the area are being developed and refined, and regolith dating is being undertaken. Geochemical characterisation has been undertaken by sampling of various media, including rocks, silcretes, soils, stream sediments, regolith carbonates, ground water, and vegetation. Alternative sampling techniques, enhanced geochemical interpretations of regolith carbonates and an improved understanding of base metal distributions in ground waters are all anticipated to flow from this work. Achievements in this project are set against Milestones 2 and 7.

Girilambone (Cobar-Bourke) Project

This project will provide a new regolith knowledge base and develop methods for improved mineral exploration in areas of regolith cover in central western NSW. The current focus is on the Girilambone Belt between Nyngan, Cobar, Bourke and Nymagee. This area provides the opportunity to gather information from mineralised and weakly mineralised sites,

essential for isolating element associations related to background regolith processes from those associated with mineralisation. The approach involves 3D modelling of the regolith, using surface mapping, geophysics and drilling, as well as sampling of numerous regolith profiles. Regolith-landform interpretation is providing information on the nature and origin of the different regolith components and likely element dispersion pathways. Geochronological techniques are being used to establish age controls on the weathering history.

Following two drilling programs completed during the reporting year, detailed physical, mineralogical and geochemical analyses of the regolith materials are being integrated to provide a framework within which to understand better geochemical dispersion and enhance anomaly detection. A range of different sampling protocols, sample media and selective digestive techniques are being tested.

Regolith data are also being integrated with NSW DMR bedrock analyses to assist the mapping of lithologies, alteration and weathering, and to determine background and anomalous geochemical signatures. A number of significant geological features and geochemical anomalies, worthy of follow up work, have already been identified.

Achievements in this project are set against Milestones 2 and 7.

Harris Greenstone Belt regolith geology project

The Harris Greenstone Belt regolith geology project aims to characterise the residual and transported regolith in the newly discovered Harris Greenstone belt on the Gawler Craton of South Australia as a means of promoting mineral exploration in the region. Phase 1 drilling, analysis and mapping are complete with data compilation and reporting underway. The project is scheduled for completion in December 2002. Achievements in this project are set against Milestone 7.

Laterite geochemical reconnaissance survey of the Yilgarn Craton

In collaboration with the Geological Survey of Western Australia (GSWA), this laterite geochemical reconnaissance survey of the Yilgarn Craton seeks to expand upon a currently available CSIRO-AGE surface dataset by collecting additional samples during routine mapping work conducted by GSWA. Although only limited funds were available, 150 samples from the CSIRO-AGE sample set were re-analysed to bring the available database up to a consistent standard. A better-funded program is anticipated next year. Achievements in this project are set against Milestones 7 and 8.

Making Geochemistry Work in Areas of Thin Cover

Several projects contribute towards achieving this objective.

Partial Leach Isotope Geochemistry

This AMIRA funded project seeks to use the known Pb and S isotopic signatures of buried mineral deposits to determine if anomalies in soils are directly related to blind mineralisation. The objectives are to provide a cost-effective exploration tool and to generate better understanding of the formation of surface anomalies. A reliable technique has been developed to analyse Pb anomalies down to ppb levels and isotopic analysis is clearly adding value to multi-element partial leach data from three case studies. Sample sets from test cases supplied by sponsor companies are being analysed and results remain confidential. Recently, a commercial Pb isotope partial leach facility has been offered to sponsors. Achievements in this project are set against Milestone 5.

Acid sulphate soil and seepages

In a project that links CRC LEME's environmental and exploration investigations, we have sampled acid sulphate soil and seepages, which contribute to degraded saline soil-landscapes and poor stream water quality in the Adelaide Hills, in an area known to host base metal mineralisation. These acidic soils and salt efflorescences have potential as exploration sampling media. Orientation studies have shown that such materials are enhanced in a suite of elements associated with mineralisation and a regional scale study is underway to test the wider applicability of the medium. Achievements in this project are set against Milestone 6.

Aripuana and Dalgaranga

Two projects, completed during the year, have looked at the distribution of base metals in deeply weathered profiles, one at Dalgaranga (Western Australia) and the other at Aripuana in Brazil. The results of the Aripuana study remain confidential to Anglo American Plc. Research at Dalgaranga documents an almost unique example of base metal dispersion from weathered bedrock into overlying clay-rich alluvial sediments, yielding an enhanced response that extends laterally for over 300 metres. This example indicates the potential application of such sediments as exploration sample media in depositional regimes. Achievements in this project are set against Milestone 4.

Effects of Weathering upon Alteration

Alteration and weathering commonly produce similar mineral assemblages and recognising alteration in regolith is therefore




Photographs by Ravi Anand and Mark Paine

difficult. A PhD study using geochemical interpretation techniques to model the various mineral changes is making good progress using the base metal deposits at Elura (western NSW) and Century (NW Queensland) as study sites. At Century the study has been able to project the alteration characteristics of unweathered samples through into the regolith. At Elura the results are less clear cut. Achievements in this project are set against Milestones 4 and 8.

Regolith at Mineral Hill and Ravensthorpe Nickel

During the reporting period, two new industry-funded projects have been started. Triako Minerals have funded a project at Mineral Hill in central NSW which studies the weathering of base metal-rich and base metal-poor styles of gold mineralisation and provides improved sampling strategies. Results to date remain confidential. Achievements in this project are set against Milestones 2 and 7.

BHP Billiton, through Ravensthorpe Nickel Operations Ltd has contracted CRC LEME to investigate aspects of the interaction of process water with the regolith at the Ravensthorpe nickel operations in WA. Achievements in this recently initiated project are set against Milestone 4.

Challenger Gold deposit

A new project looking at the regolith geology of Dominion Mining's Challenger Gold deposit in South Australia is in the final stages of negotiation. The project is a direct result of successful work undertaken in the South Australian Regolith project in the previous CRC LEME and the AEM Gawler Craton project in the present CRC LEME.

Optimising Geophysical Understanding of Regolith

CRC LEME's predecessor had no direct geophysical component, but the introduction of geophysical expertise for mineral exploration and salinity work in the current CRC LEME presents new opportunities. Four new geophysical projects begin in 2002-2003.

AEM Gawler Craton project

This is a cross-discipline study in the Gawler Craton in South Australia investigating relationships between airborne electromagnetic data and regolith geochemistry and geology. Problems with AEM datasets have slowed the project, which should have been completed in June 2002. A finish date in early 2003 is now anticipated. Achievements in this project are set against Milestones 2, 3 and 7.

Application of surface and airborne geophysical methods in the Pilbara, WA

Two commercial projects have been initiated applying surface and airborne geophysical methods in collaboration with Pilbara Manganese Ltd. Initial results indicate that the procedures adopted provide deeper penetration than previously achievable, and have already contributed to new discoveries of ore under cover. Details are confidential to the sponsor. Achievements in this project are set against Milestone 8.

Projects from Previous Centre

Two projects commenced in CRC LEME predecessor were carried through into the first year of the current Centre.

Regolith Expressions of Ore Systems

Progress on this project has been retarded by the slow rate of completion of articles promised by contributors. We propose to limit contributions so that the volume can be completed by March 2003, and published in June 2003. This may result in a smaller than anticipated volume but the alternative, held to be unacceptable, is to allow the project to continue beyond that deadline. This will meet Milestone 1.

South Australian Regolith Project

This project seeks to optimise exploration techniques in the Gawler Craton of South Australia by understanding the relationships between geochemical dispersion patterns, weathering processes and regolith-landform evolution over sites where mineralisation is buried beneath cover. Pilot studies have been undertaken over 16 sites resulting in more than 5000 samples being collected, analysed and placed into a regolith landform context. The ET Gold Prospect was chosen as one site suitable for more intense study and a further 2000 samples were collected and analysed from there. Computer-assisted 3D visualisation software, some specifically developed for this study, has been instrumental in maximising the interpretation of this dataset.

The major achievements are:

1. Identification of new drilling targets at the ET Gold Prospect;
2. Progress towards the prioritisation of surface geochemical anomalies;
3. A better understanding of the benefits and limitations of remote sensing in regolith landform mapping.

A series of recommendations for ongoing exploration in similar environments have been made. Achievements in this project are set against Milestones 2 and 7.

Dr Colin Pain

Program 3: Environmental Applications of Regolith Geoscience

Overview

At the end of December, this Program had identified four themes under which to group its work. Some of these themes will incorporate project work going on in other programs. Within each theme, a number of initial activities were identified. These themes are:

- Salinity systems in regolith and groundwater
- Acid sulphate soils: regolith processes and implications
- Environmental geochemistry and the regolith
- Regolith geoscience and urban Australia

Salinity Systems in Regolith and Groundwater

As dryland salinity becomes more prevalent across Australia, so the need to understand the origins, movement and storage of salt in the landscape becomes more important. Realistic mitigation programs can only be instigated after we understand the processes affecting salt transfer.

Analysis of remotely sensed data, especially radiometrics, together with field verification, suggest that much of the salt in ground water has its origins in upland areas. Catchments between Cootamundra and Goulburn in central NSW are currently under investigation. These areas contribute substantial amounts of salt into the Lachlan and Murrumbidgee rivers. Enhanced gamma-ray spectrometry soil/regolith maps separate thick residual and locally derived regolith/soils from thinner soils over moderately weathered bedrock. In places, combination of the radiometric bands coupled with knowledge of bedrock weathering styles have been used to separate different regolith textures.

The relationships between regolith materials and the concentration/mobility of salts are being explored through a series of DC resistivity traverses and shallow drilling (approx 20 metres).

There has been considerable interest in the project from the land care groups representing landowners and the NSW Department of Land Water Conservation (DLWC). It is planned that DLWC will become an increasingly important partner in the project in terms of sharing data, providing local knowledge for validating results and product customisation and potential cost sharing.

We can now demonstrate that some groundwaters in the Temora area of NSW are highly saline—with salinities up to half that of seawater. The predominantly clay sequences there are punctuated with sandy lenses containing water exhibiting chemistry similar to surface (fresh) waters, and are therefore likely to be transfer paths for groundwaters in the subsurface. Fresh-water values are also seen within the altered bedrock, suggesting that this, too, is acting as a conduit for water transfer.

High levels of ^{36}Cl are strong evidence for most of the salt to be recent in origin, and derived from rainfall. Simple mass balance of incoming salt from rainwater would require only 100,000 years to accumulate the amount of salt seen in this region. This is further evidence for the cyclic origins for salts in the Murray-Darling Basin, and in contrast to models of chloride released from weathering or relict from seawater incursion.

We are also working to improve the interpretability of conductivity-depth transformed (CDT) airborne electro-magnetic (AEM) data. We are developing an improved understanding of the strengths and weaknesses of 1D CDT modelling in various regolith settings characterized by varying conductivity. We are also developing algorithms for generating new, robust CDT related products that relate directly to physical ground parameters (e.g. base of transported material, base of *in situ* weathering, top of bedrock).

We have worked to demonstrate the most common traps for interpreters on conductivity-depth transformed AEM data, so that other team members have a better understanding of what the data mean. The interpretation of CDT and CDI data is not as clear-cut as might, at first, appear to the geologist or


Photograph by Ian Robertson

hydrogeologist. Issues to be considered are being documented, because they have implications for modelling in dispersion studies, and in the definition of bounding layers.

A number of students from the University of Canberra and the University of Adelaide are studying the local-scale impacts of landforms and regolith distribution on salt distribution and management. A number of these studies are being funded by agencies such as the NSW Department of Land and Water Conservation. Most of them involve contact with land use and planning issues, an important element of student education.

Acid Sulphate Soils: Regolith Processes and Implications

Acid sulphate soils are a major environmental hazard in many parts of Australia, both inland and on the coast. At present, we have one project – the South Australian Inventory of coastal Acid Sulphate Soil Risk (Atlas) (Coastal Acid Sulphate Soils Program-funded). A workshop was held on 15–16 November involving staff from CRC LEME, CLW, BRS, DLWC, PIRSA and other SA State government agencies. The objective was to develop the methodology to produce an inventory of acid sulphate soil risk in South Australia (via a series of acid sulphate soil maps of the South Australian coastline on an internet-accessible database).

Initial activity is in the area of acid sulphate soils, with funded project work being brought into CRC LEME by CSIRO Land and Water.

Research work carried out in this theme has implications both for mineral exploration and for environmental degradation (dryland salinity and water quality issues). The composition of some of the saline seeps, containing acid sulphate soils, indicates that some elements (e.g. Zn, Cd, As, Tl and Sn) have dispersed from base-metal mineralisation and are scavenged by iron-rich minerals.

Environmental Geochemistry and the Regolith

This theme aims to assess the variation in regolith and soil geochemistry across Australia. Use will be made of datasets such as the soil geochemistry data available from CSIRO Land and Water and the stream sediment geochemistry data available from NSW DMR. Contact has been made with the Australian Institute of Health and Welfare, the National Centre for Epidemiology and Population Health at ANU, and members of health-related disciplines at the University of Canberra regarding collaboration on a 'geo-medicine' project that will look at connections between surface and near-surface geochemistry and health. Dr Bob Finkleman, coordinator of Human Health Issues at the United States Geological Survey, also visited us.

Regolith Geoscience and Urban Australia

This theme aims to introduce regolith to planning in urban areas. During the year, we collaborated with the Urban Geoscience Division of Geoscience Australia on a scoping project in Perth. A report on the potential of regolith work in the greater Perth area was prepared, and follow-up work is planned for the 2002–2003 year.

Contact has also been made with the Western Sydney Organisation of Councils, which has particular problems with salinity and urban infrastructure. Work on the incorporation of regolith knowledge into guidelines for urban development of saline soils will form part of the 2002–2003 work program.

Outlook

Program 3 is now in a position to make considerable progress, both with ongoing research, and with the development of new projects and strategic alliances.

We continue to gain a better understanding of salt in the landscape and are identifying methods to best assess dryland salinity.

Contact has been made with potential collaborators, and with potential funding agencies, including the Murray-Darling Basin Commission, AIH and Geoscience Australia Urban Geoscience Division.

Dr Ken Lawrie

Program 4: Salinity Mapping and Hazard Assessment

Overview

The 2001–2002 year was characterised by the slower than expected implementation of the Federal Government's National Action Plan for Salinity and Water Quality (NAP). Salinity Mapping & Hazard Assessment Program staff have been engaged in the scoping and technical design of projects in South Australia, Queensland, Victoria and New South Wales, and have been involved in the interpretation of the Honeysuckle Creek airborne geophysics dataset in the Goulburn-Broken Catchment in Victoria. Encouragingly, the data acquisition stages of the first major projects involving the integration of airborne geophysics, regolith and hydrogeology within the NAP commenced in South Australia and Queensland, and it is anticipated that significant new project work will commence early in the 2002–2003 financial year. Discussions with other natural resource management funding bodies have also identified a number of other potential projects.

The year was also one of significant progress for the Salinity Mapping & Hazard Assessment Program in development of methodologies for the 3D mapping of regolith materials, and the mapping and assessment of salinity hazards in a variety of landscapes. The results of this work have been published in a series of papers, and brought together in a national report to be released in 2002–2003. Staff have also been active in the dissemination of our work to peers and potential clients in meetings, seminars, workshops and conferences throughout the year.

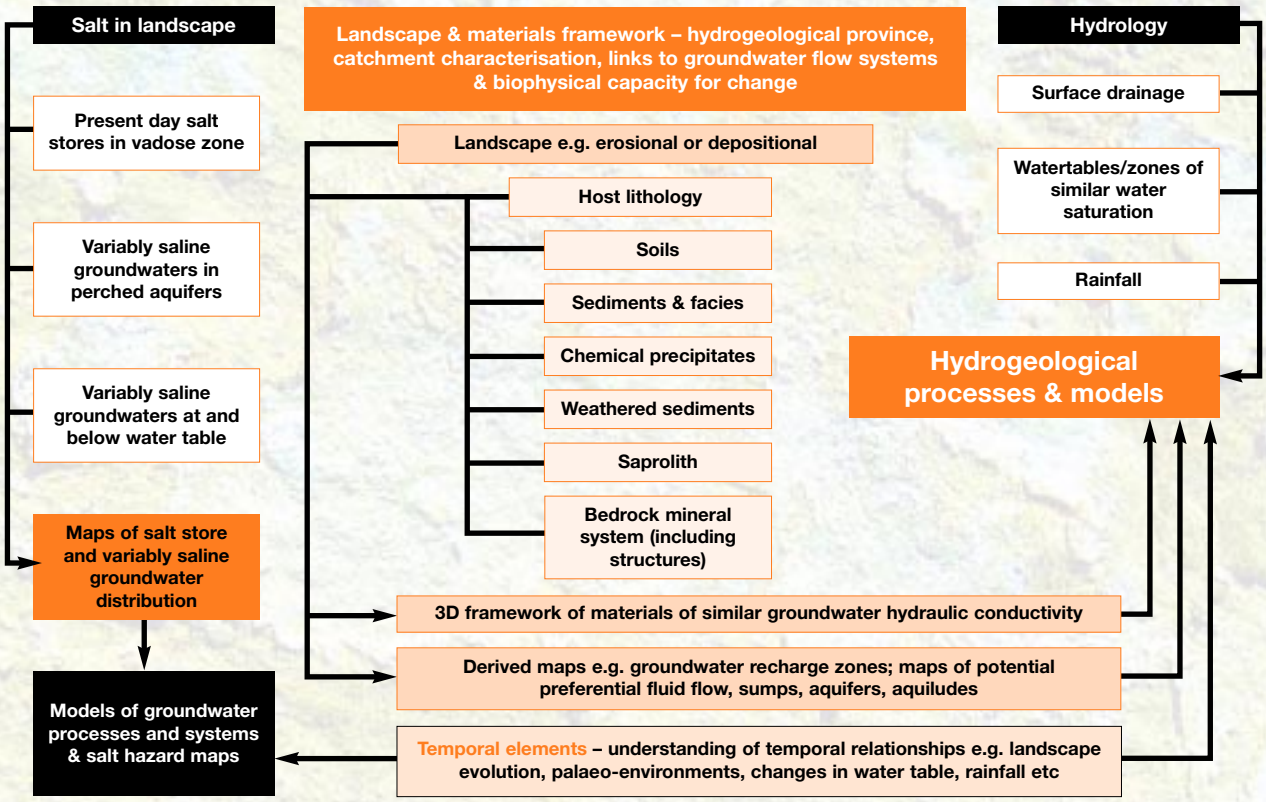
Mapping, Assessing and Predicting Salinity

The mapping, assessment and prediction of salinity require knowledge of the distribution of salt stores and saline groundwaters, and an understanding of the inter-relationship and dynamics between these. An understanding of the regolith and geological framework within which groundwaters flow and within which salt is stored, underpins the framework for these assessments. Recognition of the scale and timeframe over which groundwater flow systems operate provides a hydrogeological framework for assessing the salinity risk, and underpins the development of salinity mitigation and remediation strategies. It is now recognised that knowledge of the regolith is inadequate, and that this is a gap that needs to be filled to assist with land management decision-making in Australia.

In the past year, analysis by program staff of regolith and bedrock geological inputs into existing national and regional hydrogeological frameworks in the Eastern Murray-Darling Basin has shown that significant value can be added to existing frameworks when new surface and sub-surface regolith, geological and geophysical datasets are considered. This additional knowledge may be of particular use where targetted interventions in the landscape are required in order to mitigate salinity, especially where an understanding of the distribution and continuity of aquifers and aquicludes is required. This knowledge may also be of importance in the identification of water resources. In the past year, the team has developed new regolith-based products tailored for a variety of landscapes including upland erosional landscapes, incised valleys, and depositional plains.

Analysis of the Geoscience in Land Management and Ore systems Research for Exploration (GILMORE) and Honeysuckle Creek datasets has also reinforced the findings of regolith studies over the last decade in other areas of Australia that have shown the regolith to be more variable than predicted. For buried landscapes, sediment distribution and composition, and saprolith character are more complex than anticipated, and are often unrelated to present-day materials. Furthermore, mineral systems analysis of bedrock materials in the GILMORE project area and more regionally in the Lachlan Fold Belt has led to the recognition that most solid geology maps usually record only the primary character and mapped boundaries of the materials at deposition or crystallisation. In many terranes, geological maps do not record the distribution

Mapping groundwater processes and systems—critical elements



Photograph by Steven Hill

of significant primary hydrothermal alteration mineral assemblages, and/or zones of metamorphism and deformation. Work on the GILMORE and more regional datasets has shown that there are significant correlations between these secondary overprints and landscapes, and that these can be mapped up to catchment scale in terranes such as the Lachlan Fold Belt. Allied to enhanced knowledge of the regolith, this information has the potential to add significantly to our ability to map and predict hydrogeological boundaries such as the depth to fresh bedrock.

Groundwater Flow and Dryland Salinity

Work on the GILMORE and Honeysuckle Creek datasets has shown that regolith, geomorphology and landscape evolution are important inputs into understanding groundwater flow and the processes that lead to dryland salinity. Groundwater flow in these environments is still poorly understood. However, at a catchment and particularly at a sub-catchment scale, analysis suggests that the effects of complex regolith on intermediate and local groundwater flow systems appear to be particularly significant. Work at a variety of scales shows that groundwater flow networks in the sub-surface are often substantially different to those predicted from surface information. Furthermore, in depositional landscapes airborne geophysics often delineates groundwater flow paths that cannot be predicted from surface datasets. Differences between surface and buried materials have been correlated with palaeo-environmental change, and/or changes in sediment provenance that cannot be interpreted from surface distribution of lithologies.

Many studies in the last decade have also shown that terrestrial sediments in Australia's inland basins have undergone significant weathering subsequent to deposition. A limited number of studies have shown that weathering and low temperature diagenesis can significantly affect the porosity and permeability characteristics of regolith materials. Thus, an understanding of the primary facies distribution may only partly give an answer to the transmissivity of materials. Pump tests on a variety of regolith materials/intervals in GILMORE boreholes, and triaxial core transmissivity tests on regolith materials have demonstrated significant porosity and permeability differences between regolith materials, reinforcing the need for maps of sub-surface hydraulic conductivity to better understand and predict groundwater flow.

Airborne Mapping Systems

Work in the program over the last year has reinforced the experience that, in some landscapes, airborne electromagnetics (AEM) and airborne magnetic datasets can be particularly effective in delineating salt stores, mapping regolith materials and identifying groundwater flow systems. A holistic systems approach has been developed to map and predict salinity hazards at catchment and sub-catchment scales. A systems approach that utilises remotely sensed data and geophysical technologies to map salt stores, regolith structure and groundwater flow systems value-adds to existing models of catchment characterisation and groundwater flow systems, and provides a framework for mapping salinity processes. Critically, the systems approach attempts to provide a better understanding of the groundwater aquifer systems, and their connectivity and spatial variability. In turn, this provides a framework within which the impact of other more variable factors such as land use, vegetation type/condition, climate, palaeoclimate, and groundwater recharge rates can be considered. These datasets should help to constrain groundwater distribution systems, help constrain the water-rock interactions that lead to salinisation in a catchment, and assist with construction of predictive models.

Importantly, work on the GILMORE dataset has demonstrated that in some landscapes there is an excellent statistical correlation between AEM and ground (borehole) data. Furthermore, in the GILMORE dataset, 90% of the AEM conductivity response can be correlated with salt stored in the regolith. These data give confidence in the ability of the technology to replicate ground conductivity patterns that in turn can be related to sub-surface regolith structure, salt stores and ground-waters. However, it is noted that the success of the correlations in GILMORE may not be replicated in other areas and is dependent upon the conductivity structure in each landscape and the application of available inversion routines.

Product Development

Following on from this work, significant advances have been made in product development in the past year. In depositional landscapes, the AEM and borehole data have been used to derive 3D facies maps of regolith materials based on percentage moisture contrasts and conductivity pattern analysis. From this, a methodology has been devised to model and display surface and sub-surface datasets in 3D. This type of analysis and display is providing an improved understanding into:

- The distribution of regolith materials
- Geomorphic and hydrological processes both past and present
- The morphology of the buried landscape

- The characteristics of the sedimentological system and how it has evolved through time
- The nature and extent of weathering overprints and the effects of these on hydraulic conductivities
- The controls on storage and movement of saline ground water
- Assessment of salt stores and saline groundwaters as hazards in these complex environments.

This work has led to identification of products that include:

- Regolith moisture maps that provides information on major textural variation in the regolith;
- 3D models of the regolith (constrained by airborne geophysical datasets and borehole data);
- 3D groundwater flow conduit and barrier maps;
- Salinity hazard maps (constrained by hydrology and hydrogeology data and models).

Significant advances have also been made in our ability to map regolith materials in upland landscapes utilising radiometrics and DEMs. This work has shown good early promise in providing a capacity to map materials and predict potential salt stores in upland erosional landscapes.

The mapping, assessment and prediction of salinity require knowledge of the distribution of salt stores and saline groundwaters, and an understanding of the inter-relationship and dynamics between these.

Photograph by Steven Hill

7. Education and Training

Associate Professor Pat James

With 37 postgraduate students and 37 current Honours students across 5 Australian Universities, CRC LEME's Education and Training program will exceed the Centre's target of graduating at least 60 honours students and 60 PhD students during the life of CRC LEME. All students are assisted by co-supervisors drawn from CRC LEME partners, industry or government departments. Australian regolith geoscience will be strengthened, not only by the research projects undertaken by these students, but also as they complete their studies and move into post graduate employment. The Centre's short course program continues to provide specialised training for students and professional geoscientists. In 2001–2002, CRC LEME committed $300,000 to scholarship support and operating funds for student projects. This will be significantly increased in 2002-2003.

The vision for the CRC LEME Education, Training and Technology Transfer program is to be recognised as an Australia-wide world-class education provider in regolith geoscience. That recognition will be demonstrated by the calibre of the students, staff and visitors that the centre attracts and the status and employability of its graduates.

The renewal of CRC LEME brought two new university participants: The University of Adelaide and Curtin University of Technology. Student numbers have increased substantially in line with our targets of producing 60 PhD and 60 Honours completions during the Centre's seven-year term that began in in July 2001. With our university locations in Canberra, Adelaide and Perth, as well as collaborative links with other universities, we are well placed to carry out activities across the country and, in so doing, meet our education and training objectives.

In 2001, Associate Professor Graham Taylor coordinated the CRC LEME's Education and Training Program. Dr Taylor is a regolith geologist at the University of Canberra and coordinated the education program for the previous CRC LEME since 1995. Graham Taylor's enormous contributions to the Centre as a whole and to the Education and Training program in particular are gratefully acknowledged. In March 2002, Associate Professor Pat James from the University of Adelaide was appointed the Program Leader for this program.

Minerals Tertiary Education Council

2001/2 was a busy year for the CRC LEME/Mineral Tertiary Education Council (MTEC) contribution to the National Geoscience Teaching Network (NGTN). The NGTN is a consortium of eight universities sharing Honours and Masters level short courses to provide better graduates for the minerals industry. Universities include the G3 (University of Tasmania, University of Western Australia and James Cook University), VIEPS (The University of Melbourne, Monash University and La Trobe University) and CRC LEME (Australian National University and University of Canberra).

Dr Ian Roach coordinated (and taught in some of) five separate Honours short courses, which were offered to students from the NGTN consortium universities and to professionals from the mining industry and government research organisations. CRC LEME staff joined staff from the University of Melbourne to teach a range of subjects including GIS, regolith geochemistry, landform evolution, hydrogeochemistry, regolith mapping, hyperspectral remote sensing, field safety and 4WD operation. Details of short courses are provided in an accompanying table.

With planned contributions from CRC LEME participants, an enhanced short course program will offer an integrated range including geology, landforms, geochemistry, hydrology, remote sensing and geophysics of the regolith.

National Undergraduate Regolith School

An initiative of CRC LEME, the National Undergraduate Regolith School (NURGS) is held annually and boosts the regolith content of undergraduate geoscience curricula in Australia. NURGS helps to meet the growing demand for graduates with a background in regolith geoscience and was hosted by the NTGS in Darwin between 27 June and 4 July 2001. Following two days of lectures and presentations, participants undertook field trips around Darwin and to the Pine Creek region, Ranger Uranium Mine and Kakadu. NURGS introduces students to research leaders in the field of regolith geology. CRC LEME provided teaching staff for the course and sponsored twelve third year undergraduate students nominated by the heads of Earth Science departments from around Australia.

The vision for the CRC LEME Education, Training and Technology Transfer program is to be recognised as an Australia-wide world-class education provider in regolith geoscience.


Photograph by Ian Roach

Undergraduate Courses

Studies of the regolith remain poorly addressed in Australian geoscience courses. While the NURGS program has been a significant and effective remedy, CRC LEME also supported other developments.

Amongst the partner universities, the degree programs including the most regolith geoscience are at the University of Canberra and the ANU, where regolith studies, including geomorphology, soil science and Quaternary studies have been covered within the undergraduate curriculum. In October 2001, the Earth and Land Science courses at the University of Canberra were accredited by the Australasian Institute of Mining and Metallurgy.

At Curtin University, strong industry support has been given recently to the Regolith and Exploration course, with the donation of extensive drill chip samples and associated geochemical data. These resources have allowed students to develop skills in the logging of drill chips, plotting the geochemistry and the interpretation of regolith and geochemical dispersion.

CRC LEME participation by the University of Adelaide is resulting in the incorporation of more regolith geoscience in the undergraduate curriculum. This development will accelerate following the anticipated appointment of specialist staff. The recent merger of the Departments of Geology and Geophysics and Soil and Water into a new School of Earth and Environmental Sciences has allowed the inclusion of much regolith-related material into the curriculum.

Student Highlights

- CRC LEME students attended and received awards at the 15th Victorian Universities Earth Sciences Conference (VUESC) in September.
- Australasian Institute of Mining and Metallurgy student bursaries were awarded to Kristy Bewert, Andrew Christian and Paul Southwell for “excellence in academic achievement” in their undergraduate degree programs.
- Andrew Christian continued with his studies to become a CRC LEME scholar with the award of a CRC LEME Honours scholarship for 2002.
- Kathleen Harvey, another CRC LEME 2002 Honours scholarship winner, also won the Canberra and Central/West NSW Branch AusIMM Student Presentation Competition for her presentation about her work on "Regolith Landform Mapping for Dryland Salinity Hazard Mitigation at Warrandale, near Cowra in Central West NSW".

Details of student awards and prizes are provided in the awards section of this report.

Students and Scholarships

With the increase in size of CRC LEME and the number of Universities and core partners, there has been a significant increase in student activity and scholarships. CRC LEME’s aim is to produce 60 PhDs and 60 Honours graduates in seven years. In 2001–2002, CRC LEME committed $300,000 to scholarship support and operating funds for student projects. This will be significantly increased in 2002-2003.

Sixteen Honours students completed their degrees in 2001 (see Table). Four of these students continued with postgraduate studies within CRC LEME.

There are currently 29 CRC LEME PhD students. Following competitive applications in late 2001, 15 PhD candidates were awarded CRC LEME scholarships and commenced their studies. Nine of those students also won University, Australian Postgraduate Award (APA), or international scholarships. These students received $5000 top up scholarships in line with equivalent (eg CSIRO) awards. Four other students were offered full CRC LEME scholarships to begin their PhD studies in 2002.

As well as the PhD students, there are eight current Masters students studying in CRC LEME, with six of them having started during the reporting period.

Postgraduate students

These details apply to postgraduate students associated with CRC LEME who completed, commenced or continued their PhD and MSc studies during the 2001/02 reporting period.

CRC LEME Postgraduate Students 2001/02

Candidate	Project	Program	Supervisor(s)	Funding	Year	Institution
Doctor of Philosophy (PhD)—graduated						
Brett Harris	Transient electromagnetic methods and their application to the delineation and assessment of groundwater resources in the Eastern Goldfields; Western Australia	-	Norm Uren J A McDonald B M Hartley P-F Siew Dr R Martin (Anaconda)		1995-2002	CUT
Doctor of Philosophy (PhD)—commenced						
Andrew Baker*	Metal geochemistry of regolith in the Mount Lofty Ranges and associated alluvial fans of the Adelaide Plains	1	Rob Fitzpatrick (CSIRO) Andreas Schmidt Mumm (UofA)	APA + CRC LEME top-up	2002-	UofA
Aaron Brown*	Improved reconstruction of primary rock composition from major, trace and rare earth element composition, using numerical modelling procedures	1	Andreas Schmidt Mumm (UofA) Pat James (UofA) Martin Williams (UofA)	CRC LEME	2002-	UofA
Chris Gunton*	Element dispersion and mobility in the regolith	2	'Bear' McPhail (ANU)	APA + CRC LEME top-up	2002-	ANU
Donald Hunter*	Applications of nuclear magnetic resonance in groundwater studies	2	Anton Kepic (CUT)	APA + CRC LEME top-up	2002-	CUT
Kamal Khider*	Regional chemical dispersion processes in the regolith of Cobar Nymagee area, Central West, NSW	2	Ken McQueen (UC)	CRC LEME	2002-	UC
Ian Lau*	Minerals, lithologies and structural mapping using integrated techniques incorporating hyperspectral, AEM, radiometrics, magnetics and ground gravity for regolith covered basement terrains, Olary District, Gawler Craton and Musgrave Block, SA	1	Pat James (UofA) Graham Heinson (UofA) Alan Mauger (PIRSA)	(UofA + CRC LEME + CRC LEME top-up)/2	2002-	UofA
Margarita Norvill*	The use of distributed sensor arrays in electromagnetic imaging	2	Anton Kepic (CUT)	APA + CRC LEME top-up	2002-	CUT
Frank Reith*	Influence of prokaryotes on rock weathering, metals solubilisation & precipitation in Australian regolith profiles in tropical & moderate climates	1	Bradley Opdyke (ANU) 'Bear' McPhail (ANU)	IPRS + CRC LEME top up	2002-	ANU
Mark Thomas*	New landscape analysis approaches for soil-regolith patterns and their salinity types in South Australia	3	Graham Heinson (UofA) Rob Fitzpatrick (CSIRO)	CRC LEME + DWLBC	2002-	UofA
Melvyn Lintern	The role of biological and non-biological factors in the formation of Au anomalies	2	Mehrooz Aspandiar (CUT) Ravi Anand (CSIRO)		2001-	CUT
Mark Paine*	Regolith and landscape evolution of the Dundas Tableland with implications for salinity management and heavy mineral exploration	1	Mehrooz Aspandiar (CUT) Rob Fitzpatrick (CSIRO) Ravi Anand (CSIRO) Peter Dalhous (UB)	CRC LEME	2001-	CUT
Mohammad Rosid	Groundwater investigations using the seismo-electric method	3	Anton Kepic (CUT)		2001-	CUT
Suzanne Simmons*	U-Th-Pb systematics of opaline silica: implications for the dating of surface processes	1	Alexander Nemchin (CUT)	CRC LEME	2002-	CUT
Martin Smith*	Landscape evolution of Western NSW: A framework for comparison of regolith dating methods	1	Brad Pillans (ANU)	ANU + CRC LEME top-up	2002-	ANU


Photograph by Ian Robertson

CRC LEME Postgraduate Students 2001/02 (cont'd)

Candidate	Project	Program	Supervisor(s)	Funding	Year	Institution
Juan-Pablo Bernal	Assessment of U-decay series isotopes as a geochronometer for weathering processes	1	Tony Eggleton (ANU) Malcolm McCulloch (ANU)		1999-	ANU
Phil Bierwirth*	Hyperspectral remote sensing: applications to surface mineralogy	3	Prame Chopra(ANU) Tom Cudahy (CSIRO)	APA + CRC LEME top-up	1999-	ANU
Peter de Broekert*	The nature of sedimentary regolith on the Yilgarn Craton	1	Ravi Anand (CSIRO) Tony Eggleton (ANU)	CRC LEME	1996-	ANU
Stephen Cotter*	The nature, origin and geochemistry of chert breccias at Mt Isa	1	Graham Taylor (UC) Ravi Anand (CSIRO) Leah Moore (UC)	APA + CRC LEME top-up	1998-	UC
Mike Craig	Regional regolith and landscape evolution in the eastern Goldfields, Yilgarn Craton—Western Australia	1&2	Ken McQueen (UC) Graham Taylor (UC) Colin Pain (GA)	AGSO	1998-	UC
Luke Foster*	Landscapes, geochemistry, and GIS at Marlborough, Queensland	2	Tony Eggleton (ANU) Colin Pain (GA) Brad John (QDME)	CRC LEME	1997-	ANU
Jonathan Higgins	Palaeochannels of the Kingoonya system, Gawler Craton, South Australia	1	Larry Frakes (UofA)		1998-	UofA
Leanne Hill*	Chemical dispersion pathways in a variety of landscapes	1	Tony Eggleton (ANU) Patrice de Caritat (GA) John Field (ANU)	APA + CRC LEME top-up	1999-	ANU
Annamalai Mahizhnan*	Red-brown hardpans on the Yilgarn	1	Simon Wilde (CUT) Ravi Anand (CSIRO)	APA + CRC LEME top-up	1997-	CUT
Wendy McLean*	Groundwater quality, recharge & sustainability in the lower Namoi Valley	3	Jerzy Jankowskim (UNSW) Patrice de Caritat (GA)	APA + Cotton Growers/DLWC + CRC LEME top-up	1999-	UNSW
Andrew McPherson*	Salt sources and storage—Billabong Creek, SE NSW	3	Tony Eggleton (ANU) Ken Lawrie (GA)	CRC LEME	2000-	ANU
Greg Shirtliff*	Weathering of waste rock at Ranger Uranium Mine, Northern Territory, Australia	1	Tony Eggleton (ANU) David Jones (ERA) Patrice de Caritat (GA)	ERA + CRC LEME top-up	1999-	ANU
Melissa Spry*	Landscape evolution at Cobar	1	Ken McQueen (UC) Graham Taylor (UC) Colin Pain (GA)	CRC LEME	1997-	UC
Greg Street	Interpretation of geophysics for catchment management	3	Norm Uren (CUT)	APAI Farm map Consulting Pty Ltd Tesla 10 Pty Ltd	2000-	CUT
Michael Whitbread*	Using lithogeochemistry to map cryptic alteration: Elura and Century case studies	2	Ken McQueen (UC) Leah Moore (UC)	Pasminco + CRC LEME top-up	1999-	UC

CRC LEME Postgraduate Students 2001/02 (cont'd)

Candidate	Project	Program	Supervisor(s)	Funding	Year	Institution
Master of Science (MSc)						
John Angeloni	Acid sulphate soils in metropolitan Perth	3	Ron Watkins (CUT)		2002-	CUT
Brian Barrett*	Development of river based geophysical methods for saline hydrogeology studies	3	Graham Heinson (UofA)	APA +	2002- AWE/Zonge + CRC LEME top-up	UofA
Hashim Carey	Exploration of mineralisation beneath cover using applied and natural potential methods	2	Graham Heinson (UofA) Stewart Greenhalgh (UofA) Mike Sexton (Newmont)	Newmont	2002-	UofA
Troy Cook	Urban catchment and pollution in Metropolitan Perth	3	Ron Watkins (CUT)		2002-	CUT
Rolan Eberhard	Withdrawn	4	Tony Eggleton (ANU)			ANU
Anousha Hashemi	Constraints on inversion of Tdhem data for near surface conductivity mapping	3	Jason Meyers (CUT)		2002-	CUT
Bobak Willis-Jones	A scoping study of urban geochemistry and mapping in the Perth metro area for pollution risk assessment and land use management	3	Ron Watkins (CUT)		2002-	CUT
Michael Holzapfel	Dryland salinity hazard mitigation along the Booberoi – Quandialla Transect, Central West NSW	3	Leah Moore (ANU)	NSW DLWC	1999-	UC
Vicki Stamoulis	Using hyperspectral and multiple data sets for mineral mapping in basement areas of South Australia	1	Pat James (UofA) Alan Mauger (PIRSA)	PIRSA	2000-	UofA

APA = $18K pa, CRC LEME scholarships = $18K pa; CRC LEME top-up = $5K pa; DWLBC = $13.5K + $6.5K pa
CRC LEME scholarships and top-ups also provide $10K pa operating funds
*denotes CRC LEME scholar

Honours students

The current (2002) Honours students represent the largest cohort of CRC LEME students. All CRC LEME partner Universities have large CRC LEME contingents within their Honours student classes. Thirty-seven Honours students were enrolled across all Universities, with twelve each at Curtin and Adelaide Universities, seven at the University of Canberra and six at the ANU. The students study a wide range of topics, from very general and broad remote sensing, salinity and regolith mapping through regolith characterisation, to specialised geochemical and geophysical investigations of regolith terrains.

These details apply to students associated with CRC LEME who commenced or continued their Honours studies during the 2001/02 reporting period.

CRC LEME Honours Students 2001/02

Candidate	Project	Program	Supervisor	Outside funds	Institution
Honours Degree—completed in 2001/02					
Brian Barrett	Geophysical techniques in groundwater studies	-	Graham Heinson (UofA) Mike Hatch (Zonge) Andrew Telfer (Australian Water Environments Ltd)	Australian Water Environments Ltd Zonge, ASEG	UofA
Bronwyn Calleja	Soil mapping using high resolution radiometrics	-	Paul Wilkes (CUT)		CUT
Tristan Campbell	The role of geophysics in the monitoring of soil moisture and the zone of influence of trees	-	Anton Kepic (CUT)		CUT
Hashim Carey	Optimum location of mise-à-la-masse electrodes in mineral exploration	-	Graham Heinson (UofA) Mike Sexton (Newmont) Andrew Foley (Newmont)	Normandy	AU
Tessa Chamberlain	Regolith & landscape evolution of the Tibooburra Inlier NSW	3	Steve Hill (UC) Ken McQueen (UC)		UC
Troy Cook	Geological engineering significance of swelling clays of the Brigadoon area within the Perth metropolitan region WA	-	Mehrooz Aspandiar (CUT)		CUT

CRC LEME Honours Students 2001/02 (cont'd)

Candidate	Project	Program	Supervisor	Outside funds	Institution
Honours Degree—completed in 2001/02 (cont'd)					
Rodney Dann*	Groundwater evolution of Stephens Creek, Broken Hill	3	Steve Hill (UC) Patrice de Caritat (GA)	CRC LEME	UC
Osvaldo Gonzalez	The geology and landscape history of the El Capitan area near Cobar	2	Ken McQueen (UC) Leah Moore (ANU) Ian Roach (UC)		UC
Matthew Jones	Physical and mineralogical chararcteristics of the Ravensthorpe Nickel Project	-	Charter Mathison (UWA) Charles Butt (CSIRO)		UWA
Margarita Norvill	A geophysical investigation of the relationship between gravity ridges and ironstone hosted gold/copper mineralisation in the northern Tennant Creek region of the Northern Territory, and the implications for further exploration	-	Paul Wilkes (CUT)		CUT
Matt Noteboom	The effectiveness of dipole-dipole time domain IP in the presence of conductive overburden	-	Anton Kepic (CUT)		CUT
Karen Pittard	The contribution of magnetite to the induced polarisation response of the Centenary ore body	-	Anton Kepic (CUT)		CUT
Paul Southwell	Regolith geology and landscape evolution of the Upper Tyagong Creek catchment: Implications for dryland salinity and land management	2	Leah Moore (ANU)	NSW DLWC	UC
Michael Wall	Land management & water rock interactions in the Murray Basin limestones—Part 1	-	Yvonne Bone (UofA) Ben Hopkins (AWA) Vic Gostin (UofA)	Australian Water Environments Ltd	AU
Toby Wellman	Mine site rehabilitation	-	Alexander Nemchin (CUT)		AU
Helene Wipf	Land management & water rock interactions in the Murray Basin limestones—Part 2	-	Yvonne Bone (UofA) Ben Hopkins (AWA) Vic Gostin (UofA)	Australian Water Environments Ltd	AU
Honours Degree—commenced or continuing in 2001/02					
Ian Anderson*	Regolith and groundwater at Balladonia	3	Jonathan Clarke (ANU) Patrice de Caritat (GA)	BPA + CRC LEME	ANU
Gabriel Anderson*	Biological factors in regolith formation	-	John Field (ANU)	CRC LEME	ANU
Ben Austin	Regolith and salinity mapping (NSW salt action)	3	Leah Moore (ANU)		UC
David Baker	Ground penetrating radar, DC resistivity and visualisation techniques	2	Graham Heinson (UofA)	PIRSA	UofA
Barrett Cameron	Rapid acquisition of audio frequency magnetotellurics	2	Anton Kepic (CUT)		CUT
Carly Chor	Reconstruction of late Quaternary climates in semi-arid north east of South Australia	3	Martin Williams (UofA)	PIRSA	AU
Andrew Christian*	4D regolith-landform mapping and environmental change of the Shoalhaven River delta, NSW	1	Steve Hill (UC) Ian Roach (UC) Colin Pain (GA)	CRC LEME	UC
Brendan Coleman	Innovative electrical geophysical methods for exploration beneath cover	2	Graham Heinson (UofA) Mike Sexton (Newmont) Stewart Greenhalgh (UofA)	UofA Newmont	AU
Berlinda Crowther*	An integrated remote sensing approach to regolith mapping: An example from the Cootamundra region NSW	1,2,&3	Prame Chopra (ANU) Jonathan Clarke (ANU) Richard Greene (ANU)	CRC LEME	ANU
Tania Dhu	Environmental monitoring using electrical resistivity tomography	2	Graham Heinson (UofA) Stewart Greenhalgh (UofA)	ASEG + CRC LEME	AU
Katie Dowell	Origin of precious black opal, Lightning Ridge NSW	1	John Mavrogenes (ANU)		ANU
Reece Foster*	The use of SASW methods to image the regolith	3	Anton Kepic (CUT)	CRC LEME	CUT

CRC LEME Honours Students 2001/02 (cont'd)

Candidate	Project	Program	Supervisor	Outside funds	Institution
Honours Degree—commenced or continuing in 2001/02 (cont'd)					
Cassie Gabell	Characterisation of regolith through hyperspectral analysis of Fe species	1	Pat James (UofA) Alan Mauger (PIRSA)		AU
Karen Gilgallon	Geophysical investigations of palaeochannels in the Lake Bryde area, WA	3	Paul Wilkes (CUT)	DAWA + CALM	CUT
Vanessa Groecki	Regolith and salinity mapping (NSW salt action)	3	Leah Moore (ANU)		UC
Peter Haddrill	Surface and groundwater flow system development in central West New South Wales: Implications for dryland salinity hazard	3	Leah Moore (ANU)		UC
Emma Halligan	Inland acidic groundwater, Swan Avon catchment, WA	3	Mehrooz Aspandiar (CUT) David Gray (CSIRO)	DAWA	CUT
Kathleen Harvey*	Groundwater flow systems on Ordovician sediments	3	Colin Pain (GA) Leah Moore (ANU)	CRC LEME	UC
Philip Heath	Study of potential field gradient methods for exploration beneath cover	2	Stewart Greenhalgh (UofA) Graham Heinson (UofA) Pat Cuneen (GPX Pty Ltd)	ASEG + PIRSA	AU
Brad Hewson	Genesis of nickel laterites at Murrin-Murrin WA	-	Mehrooz Aspandiar (CUT)		CUT
Karen Hulme	Mt Gunson waste tailings a future reserve?	3	Andreas Schmidt Mumm		AU
Carey Johnston	The potential hydrogeochemical effects on the local environment from seepage of Ni laterite process effluent near Bandalup Hill, Ravensthorpe	3	David Gray (CSIRO) Mehrooz Aspandiar (CUT)	BHP Billiton	CUT
Amy Kernich*	Major and trace element mobilisation and fixation in regolith profiles and drainage systems at the Luxembourg site, Curnamona Province	1	Andreas Schmidt Mumm Martin Williams (UofA)		AU
William Kimber*	Regolith geology and groundwater of the Pinjarra Lakes South Australia	1	Jonathan Clarke (ANU) 'Bear' McPhail (ANU)		ANU
Gemma King*	A comparison of three-dimensional gravity inversion techniques over the Laverton region of Western Australia	2	Paul Wilkes (CUT)	Anglogold Australia + CRC LEME	CUT
Adam Kroll	Comparative study between AEM systems using data for the West Musgrave Complex, WA	3	Jason Meyers (CUT)		CUT
Jane Larsen	Hydrogeological investigations, Lake Bryde, WA	3	Qadir Rathur (CUT) Mehrooz Aspandiar (CUT)	CALM	CUT
Sean Mahoney	Remote sensing techniques for geological mapping and interpretation of basement and thinly covered terrains adjacent to the Tarcoola mine site, NW South Australia	1	Pat James (UofA) Graham Heinson (UofA) Alan Mauger (PIRSA)		AU
Sam McHarg	Regolith distribution and Au geochemistry in salt lake overlying Au deposit	2	Lindsay Collins (CUT) Mehrooz Aspandiar (CUT)	Goldfields Australia	CUT
Andrew McMahon	Morphotectonics & landscape Evolution of the Long Plain fault region, SE Australia	1	Ian Roach (UC) Steve Hill (UC)	APA SPIRT + PIRSA	UC
Geoff Merrill	Alteration types and magnetite minor and trace element chemistry of a porphyry copper-gold intrusive complex, Cadia NSW	2	Ken McQueen (UC) Graham Taylor (UC)		UC
Rebecca Morgan	Regolith expression of a massive sulphide deposit	1	Mehrooz Aspandiar (CUT) Ravi Anand (CSIRO)	Sons of Gwalia	CUT
Nick Nitschke	To determine if the present stage of erosion and sedimentation in the Flinders Ranges and Olary Region is or is not tectonic, climatic or anthropogenic in origin	-	Martin Williams (UofA)	PIRSA	AU
Daniel Radulovic	Environmental assessment and mine site rehabilitation of tailings, Mt Gunson	3	Andreas Schmidt Mumm (UofA)		AU
Angela Ratchford	Surface and groundwater-flow system development in Hovell Creek, Central West NSW: Implications for dryland salinity hazard mitigation in granitic landscapes	3	Leah Moore (ANU) Ken McQueen (UC)		UC

CRC LEME Honours Students 2001/02 (cont'd)

Candidate	Project	Program	Supervisor	Outside funds	Institution
Honours Degree—commenced or continuing in 2001/02 (cont'd)					
Katherine Selway*	Using CSAMT, GPR and electrical resistivity to develop improved targeting in conducting ground	2	Graham Heinson (UofA) Steve Busuttil, Terry Ritchie (MIM Exploration)	MIM + ASEG + CRC LEME	AU
Jarad Townsend	Time domain electromagnetics in conductive environments—comparison of sensors for best late time response	2	Anton Kepic (CUT)		CUT

*denotes CRC LEME scholar; CRC LEME = $5K; PIRSA = $3K; ASEG = $2K-$5K
CRC LEME Honours scholarships provide $5K pa operating funds
-Honours courses completed in 2001 commenced under the previous CRC LEME and were organised under that Centre's programs.

Short Courses and Conferences

CRC LEME and the Australian Association of Natural Resource Management hosted a workshop in July 2001 at the ANU. Talks were presented on Landscape variability and recharge control, regolith and a holistic approach to dryland salinity, groundwater flow systems for catchment decisions and predicting biophysical capacity for change.

Staff and students contributed to the biennial Australian Clay Mineral Society (ACMS) conference 29 April-1 May 2002. Many CRC LEME researchers presented major results from their research.

The major northern Victoria Traverse, Benalla Workshop, which ran from 30 April to 2 May 2002, brought together many scientific groups with research activities in the area.

Six other short courses were run by CRC LEME during the reporting period. CRC LEME staff, students and guest lecturers participated. Details are provided in the accompanying table.

CRC LEME Shortcourses 2001/02

Short course title	Presenter(s)	Format	Venue	Date	Participants
Introduction to MapInfo GIS	Ian Roach (MTEC/UC/ANU)	2-day (x2)	UC	12-13/7/2001	15
Hydrogeochemistry workshop	Patrice de Caritat (GA), Dirk Kirste (GA)	2-day	ANU	29-30/11/2001	15
Regolith geology and geochemistry*	Bernie Joyce (UM), Andrew Kotsonis (UB), Ian Robertson (CSIRO), Graham Taylor (UC)	5-day	UM	4-8/3/2002	13
Regolith mapping and field techniques*	Glen Fisher (UC), Kylie Foster (GA), Steve Hill (UC), Ian Roach (MTEC/UC/ANU)	7-day	Silverton NSW	29/03-4/04/02	21
Introduction to hydrogeochemistry*	Patrice de Caritat (GA), Dirk Kirste (GA)	5-day	UM	15-19/04/02	18
Hyperspectral remote sensing	Megan Lewis (UofA), Alan Mauger (PIRSA), Vicki Stamoulis (PIRSA)	5-day	UofA	15-19 April 2002	15

* MTEC Honours short course

Future Plans and Activities

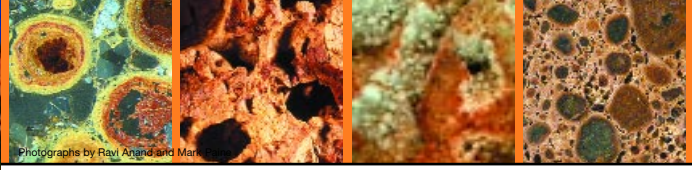
The CRC LEME Education and Training Program addresses a number of challenges including:

- Improving the regolith knowledge and skills of current students and working scientists;
- Educating professionals in areas other than regolith geoscience;
- Informing decision-makers at Federal, State and Local Government levels on how improved regolith knowledge is important to solving many fundamental issues in Australia;
- Providing a dynamic and vibrant communication environment for education and technology transfer using innovative and emerging information and communication technologies.

The future success of the Program will rely on effective communication amongst its widely separated staff and students and on its successful articulation with education and training programs of its participants and other organisations. The application of up-to-date Information and Communication Technology will play a vital role in the future of the program by overcoming many of the disadvantages of geographical remoteness of its participants and locations.

The program will deliver to its participants virtual learning environments allowing students and staff to communicate reliably and to share securely educational and research resources. In recent years, participating institutions have made substantial investments in several commercial and in-house online learning systems. The Program will need to find ways to integrate these resources as far as is possible to maximise the learning outcomes of our students.

Photograph by Steven Hill



Photographs by Ravi Anand and Mark Paine

8. Research Utilisation and Applications

The Victoria Undercover conference, held in Benalla at the end of April, was an excellent opportunity for CRC LEME staff and students to meet with a diverse range of researchers and land users with interests in Victoria. This conference was highly multi-disciplinary and showed how progress could be made by extending beyond the normal bounds of a geoscientific conference. The Centre engaged with 47 external collaborators in research projects during the reporting period. Innovations in data acquisition, field sample analysis and high sensitivity magnetic sensors represent significant advances for Australian and international exploration companies.

CRC LEME engages with the end users of its research outcomes in a number of ways.

The Governing Board and Advisory Councils participate with the Executive in strategic planning and assist the Centre in setting strategic objectives. By including key stakeholders from industry and the broader scientific community, the Centre's activities are informed by and guided towards the needs of end-users.

Collaborative research projects may be initiated by Centre staff or by clients. Program Leaders and the Centre Executive approve such initiatives after ensuring that they advance the Centre's research strategies. Commissioned work is often covered by confidentiality agreements. The results of these projects are presented to the client through reports, formal presentations and client briefings.

Current and recent research results are published to the scientific community as soon as possible once any confidentiality agreements have expired. The normal publication avenues are used including: Open File Reports, scientific journals, manuals, textbooks, atlases and GIS applications. Short training courses are presented to allow the research community and industry to benefit directly from recent advances. Centre staff and students are active participants at local, national and international conferences.

The *Victoria Undercover—collaborative Geoscience in Northern Victoria* conference held in Benalla was a major initiative of CRC LEME with CSIRO Exploration and Mining and was attended by over 100 delegates representing government, industry and academic institutions. Proceedings of the conference were published containing 46 papers (16 by CRC LEME personnel).

Six atlases were published during the reporting period including two GIS applications available on CD-ROM. In addition, CRC LEME Open File Report 73, *Genesis, Classification and Atlas of Ferruginous Materials, Yilgarn Craton* by Anand, Paine & Smith extensively covers the topic and includes over 130 colour sample photographs.

Assoc. Prof Jayson Meyers (CUT) designed and developed an innovative data acquisition system that proved effective in the identification of new ore prospects by field electromagnetic survey. A trial survey was immediately successful with a conductive target discovered on the first day. Follow-up drilling on the target showed it to be a high-grade manganese ore zone. Many more prospective targets were generated by this survey and a number of commercial prospects are expected.

Dr Anton Kepic (CUT) used Energy Dispersive X-Ray Fluorescence spectrometer (EDXRF) methods to measure on-site Ni and Cu content of ore and drill samples. A prototype field-portable instrument was tested. The grade of mineralisation of a sample may now be determined on-site within minutes, avoiding delays in awaiting chemical analysis from a laboratory. Anaconda Nickel appears to have adopted the instrument for mine grade control and other companies are now evaluating the instrument as a rapid and effective exploration tool.

Dr Anton Kepic developed high sensitivity magnetic sensors for transient electromagnetic and other geophysical surveys. A factor of three improvement over the best commercially available sensor has been demonstrated and a new sensor with another factor of three improvement is currently under test. These sensors may be commercially manufactured in Western Australia in the near future for mineral exploration systems.

Land-care groups and authorities (including the NSW Department of Land Water Conservation) demonstrated considerable interest in CRC LEME geochemical investigations of relationships between regolith materials and the concentration and mobility of salt. This knowledge is useful in the reliable interpretation of conductivity-depth transformed AEM data, DC resistivity traverses and shallow drilling and has applications in the monitoring of environmental degradation including dryland salinity and water quality.

During the year, CRC LEME collaborated with the Urban Geoscience Division of Geoscience Australia on a scoping project in Perth. A report on the potential of regolith work in the greater Perth area was prepared, and follow-up work is planned for the 2002-2003 year. Contact has also been made with the Western Sydney Organisation of Councils, which has particular problems with salinity and urban infrastructure. Work on the incorporation of regolith knowledge into guidelines for urban development of saline soils will form part of next year's work program.

Enhanced understanding of leaching processes will assist in the interpretation of regolith geochemistry data and the discovery of underlying mineralisation. A reliable Partial Leach technique has been developed to analyse Pb anomalies down to ppb levels and isotopic analysis is adding value to multi-element partial leach data. Sample sets from test cases supplied by sponsor companies are being analysed and results remain confidential. Recently, a commercial lead isotope partial leach facility has been offered to AMIRA P618 sponsors for their use within exploration programs.

CRC LEME Open File Reports

Open File Reports include data and interpretation of results and support industry, on-going research and teaching. CRC LEME published 36 Open File Reports during the reporting period—details are provided in the Publication section of this report. Open File Reports were promoted at conferences, on the web and via newsletters and are sold at cost from the Centre.

Research Collaborators and Users

The following table lists external companies and other organisations that were end-users of CRC LEME research outcomes during the year or collaborated in some manner with the centre to secure those outcomes.

Research Collaborators and Users

Research User	Activity	Interaction	CRC LEME Personnel
Large Companies			
Anglo American plc	Distribution of base metals in deeply weathered profiles, Aripuana, Brazil	Research collaboration	Matthias Cornelius
Anglogold Australia	A comparison of three-dimensional gravity inversion techniques over the Laverton Region of WA	Student research	Gemma King
BHP Billiton	The potential hydrogeochemical effects on the local environment from seepage of Ni laterite process effluent near Bandalup Hill, Ravensthorpe	Student research	Carey Johnston
Energy Resources of Australia Ltd	Weathering of waste rock at Ranger Uranium Mine, NT, Australia	Student research	Greg Shirtliff
MIM Holdings Ltd	Using CSAMT, GPR and electrical resistivity to develop improved targeting in conducting ground*	Student research	Katherine Selway
Newmont Mining Corporation	Exploration of mineralisation beneath cover using applied and natural potential methods	Student research	Hashim Carey
	Innovative electrical geophysical methods for exploration beneath cover	Student research	Brendan Coleman
	Mineral hosts for Au and trace elements in the regolith	Research collaboration	Ravi Anand, M Gleuher
Pasminco Ltd	Regolith studies on soils and gossans, Cobar region	Research collaboration	Keith Scott
	Using lithogeochemistry to map cryptic alteration: Elura and century case studies	Student research	Ken McQueen, Leah Moore, Michael Whitbread
Peak Gold Mines Pty Ltd	Documentation of regolith profiles at the New Cobar Cu-Au deposit	Research collaboration	Ken McQueen, Keith Scott
Sons of Gwalia	Regolith expression of a massive sulphide deposit	Student research	Rebecca Morgan

Research Collaborators and Users (cont'd)

Small to Medium Enterprises			
Anaconda Nickel	Field EDXRF	Research collaboration	Anton Kepic
Australian Water Environments Ltd	Land management & water rock interactions in the Murray Basin limestones—Part 1	Student research	Michael Wall
	Land management & water rock interactions in the Murray Basin limestones—Part 2	Student research	Helene Wipf
	Development of river based geophysical methods for saline hydrogeology studies	Student research	Brian Barrett
Basin Minerals	Regolith and landscape evolution of the Dundas Tableland with implications for salinity management and heavy mineral exploration*	Student research	Mark Paine
Dominion Mining Ltd	Production of open file report discussing geochemical exploration techniques for Au in Gawler Craton	Research collaboration	George Gouthas, Mel Lintern, Malcolm Sheard
Goldfields Australia	Regolith distribution and Au geochemistry in salt lake overlying Au deposit	Student research	Sam McHarg
Iluka NL	Regolith and landscape evolution of the Dundas Tableland with implications for salinity management and heavy mineral exploration*	Student research	Mark Paine
Kalgoorlie Consolidated Gold Mines	Regolith dating at Mt Percy Mine	Research collaboration	Brad Pillans
Pilbara Manganese Ltd	Application of surface and airborne geophysical methods in the Pilbara of WA	Research collaboration	Jayson Meyers
Pima Mining NL	Geochemical dispersion, Mt Torrens area, SA	Research collaboration	Rob Fitzpatrick, M.S. Skwarnecki
Striker Associates	Project on Gold Chemistry	Research collaboration	Ravi Anand, Nikita Sergeev
Triako Resources Ltd	Improved exploration strategies from insights into the weathering of base metal-rich and base metal-poor styles of gold mineralisation	Research collaboration	Keith Scott
Zonge Engineering*	Development of river based geophysical methods for saline hydrogeology studies	Student research	Brian Barrett
Government Organisations and Universities			
Corangamite Catchment Management Authority*	Characterising and mapping salinity in regolith	Research collaboration	Rob Fitzpatrick
Cotton Growers*	Groundwater quality, recharge and sustainability in the Lower Namoi valley	Student research	Wendy McLean
CSIRO (Office of Space Science and Applications)	PacRim2 Airborne Synthetic Aperture Radar (AIRSAR) Program	Research collaboration	Ian Tapley
Dept for Environment and Heritage, South Australia*	Characterising and mapping coastal acid sulphate soils	Research collaboration	Phil Davies, Rob Fitzpatrick, Richard Merry
Dept of Agriculture, Western Australia	Geophysical investigations of palaeochannels in the Lake Bryde area, WA	Student research	Karen Gilgallon
	Inland acidic groundwater, Swan Avon catchment, WA	Student research	Emma Halligan
Dept of Conservation and Land Management, Western Australia	Geophysical investigations of palaeochannels in the Lake Bryde area, WA	Student research	Karen Gilgallon
	Hydrogeological investigations, Lake Bryde, WA	Student research	Jane Larsen
Dept of Environment, Australia*	Characterising and mapping coastal acid sulphate soils	Research collaboration	Phil Davies, Rob Fitzpatrick, Richard Merry
Dept of Land and Water Conservation, New South Wales	Dryland salinity hazard mitigation along the Booberoi – Quandialla Transect, Central West NSW	Student research	Michael Holzapfel

Research Collaborators and Users (cont'd)

Dept of Land and Water Conservation, New South Wales	Regolith geology and landscape evolution of the Upper Tyagong Creek Catchment: Implications for dryland salinity and land management	Student research	Paul Southwell
	Groundwater quality, recharge and sustainability in the Lower Namoi valley	Student research	Wendy McLean
Dept of Mineral Resources, New South Wales	Girilambone Belt (Cobar-Bourke): Improving exploration in the western Lachlan Fold Belt, NSW, by understanding regolith processes	Research collaboration	Peter Buckley, M Hicks
	Western NSW regolith and landscape evolution	Research collaboration	Patrice de Caritat, Steve Hill, Dirke Kirste
Glenelg Hopkins Catchment Management Authority*	Characterising and mapping salinity in regolith	Research collaboration	Rob Fitzpatrick
Natural Resources & Environment, Victoria	Characterising and mapping salinity in regolith	Research collaboration	Rob Fitzpatrick
Northern Territory Geological Survey	Ferricretes of the Darwin region, NT	Student research	Angela Harrison
Forensic Science SA	World-class research facility for the *in situ* study of particle and material interfaces*	Research collaboration	Andreas Schmidt Mumm
South Australian Museum	World-class research facility for the *in situ* study of particle and material interfaces*	Research collaboration	Andreas Schmidt Mumm
University of Ballarat	Regolith dating in Western Victoria	Research collaboration	Brad Pillans
	Regolith geology and geochemistry (Honours shortcourse)*	Education	Graham Taylor, Ian Robertson, B Joyce, A Kotsonis
The University of Melbourne	Introduction to hydrogeochemistry (Honours shortcourse)	Education	Dirke Kirste, Patrice de Caritat
	Regolith geology and geochemistry (Honours shortcourse)*	Education	Graham Taylor, Ian Robertson, B Joyce, A Kotsonis
University of Newcastle	World-class research facility for the *in situ* study of particle and material interfaces*	Research collaboration	Andreas Schmidt Mumm
University of South Australia	Paleomagnetic dating of regolith in southern SA	Research collaboration	Brad Pillans
	Radar and GIS—salinity and waterlogging mapping	Research collaboration	Phil Davies, Mark Thomas, Rob Fitzpatrick
	World-class research facility for the *in situ* study of particle and material interfaces*	Research collaboration	Andreas Schmidt Mumm
University of Western Australia	Regolith dating in Perth area	Research collaboration	Brad Pillans
University of Wollongong	Dating of regolith in southern Australia	Research collaboration	Brad Pillans
Western Australian School of Mines	Regolith geology and mineral exploration (Masters shortcourse)	Education	Ravi Anand, Charles Butt, *et al.*
Cooperative Research Centres			
CRC for Plant-based Management of Dryland Salinity	Characterising and mapping salinity in regolith and soils	Research collaboration	Rob Fitzpatrick, Graham Heinson, Mark Thomas
Industry Associations			
AMIRA International	Isotopic discrimination of partial leach geochemical anomalies in covered terrains (CRC LEME/AMIRA Project 618)	Research collaboration	Geoff Denton, David Gray, Keith Scott
ASEG	Study of potential field gradient methods for exploration beneath cover	Student research	Philip Heath
	Using CSAMT, GPR and electrical resistivity to develop improved targeting in conducting ground*	Student research	Katherine Selway
Balladonia Progress Association	Regolith and groundwater at Balladonia	Student research	Ian Anderson

*denotes multiple listing

Mr Gary Kong, Business Manager

9. Staffing and Administration

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

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

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

CRC LEME has assembled world-class expertise in regolith geoscience. The Centre had 73.3 full-time equivalents (FTEs) staff at the end of this reporting period—the Centre's first year of funding. There were 127 staff, of whom 117 were professional scientists. Additionally, skilled staff provide technical, administrative, cartographic, illustrative, laboratory and field support. Further, students made a valuable contribution to the Centre's research during this time. Staffing resources, in terms of FTEs, are shown in Tables 9.2–9.5.

Specified Personnel

Specified personnel, contributed by the Core Parties as set out in the Commonwealth Agreement, are shown in Table 9.1.

Workplace Safety and Environmental Policy

CRC LEME fully endorses the occupational health and safety policies and procedures of its Core Participants. In particular, first aid training is mandatory for staff involved in fieldwork. Additionally, the Centre has its own Motor Vehicle and Field Safety Checklists and daily safety planning meetings before fieldwork are standard procedure. Similarly, the Centre endorses the environmental policies of the Core Participants with environmental awareness in the field, as well as recycling, being standard practice.

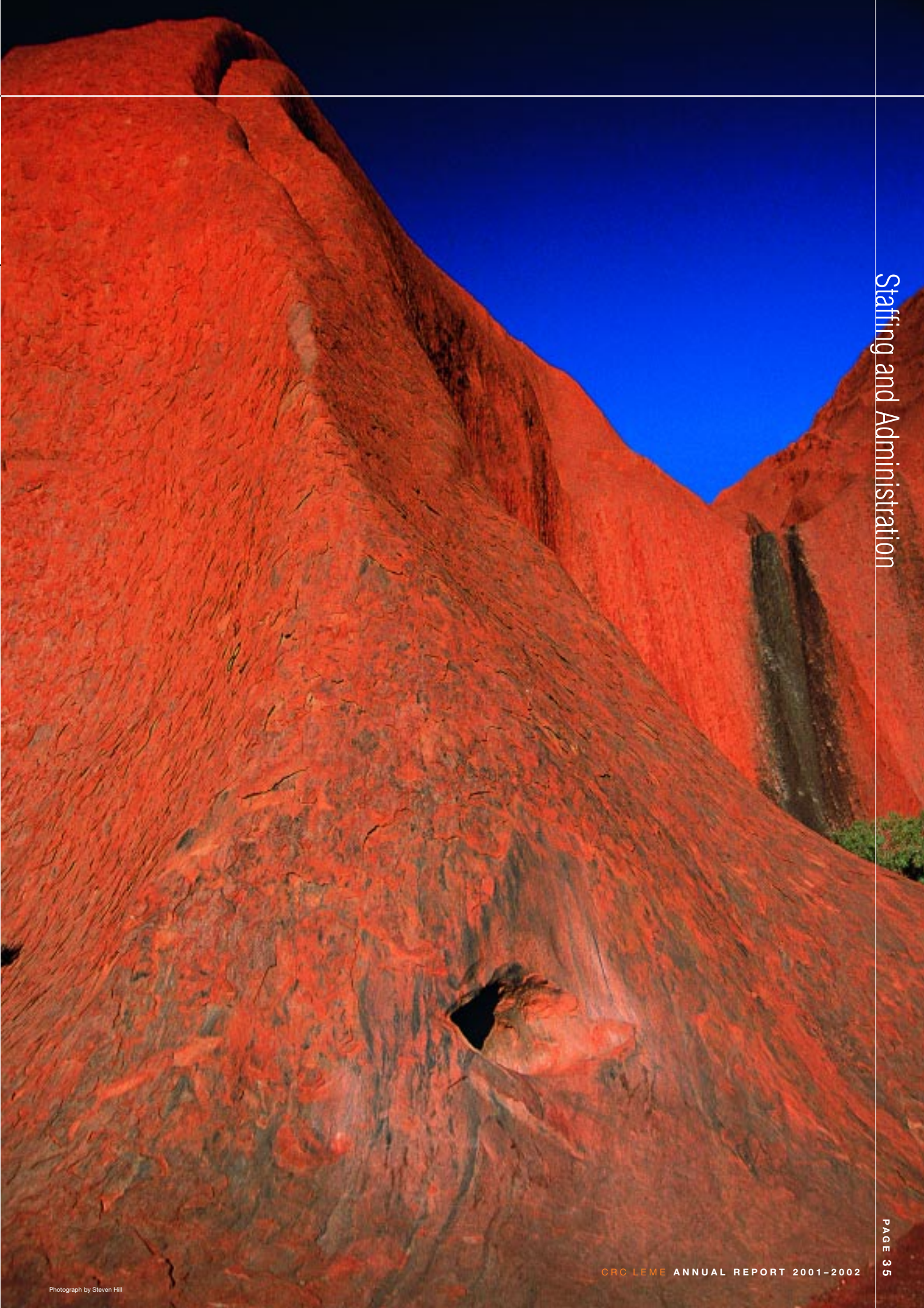
There were no reports of work-related lost-time injuries affecting staff or students within the reporting period.

Staff and Team Development

The Centre's staff and students are encouraged to undertake training and attend conferences, meetings and workshops relevant to their professional development. Development of the Centre culture is encouraged through team planning and execution of research, movement of staff, conference representation and the Centre's newsletter, LEME News.

New Equipment and Computing

No major items of capital expenditure (individual items exceeding $20,000) were incurred in the reporting period.



Staffing and Administration

Photograph by Steven Hill

Table 9.1 Specified Personnel Contributed by Core Participants

Name	Proportion of Time	Role in Centre
Commonwealth Scientific and Industrial Research Organisation		
Anand, R.	100%	Program Leader: Regolith Geoscience
Butt, C.	100% to 31 Jan 2002	Program Leader: Mineral Exploration
Smith, R.	100%	Chief Executive Officer
Curtin University of Technology		
Radford, N.	100% from 4 Feb 2002	Program Leader: Mineral Exploration
The University of Adelaide		
James, P.	70% from 27 Feb 2002 (Previously 40%)	Program Leader: Education
University of Canberra		
Taylor, G.	100% to 31 Jan 2002	Program Leader: Education
Geoscience Australia		
Lawrie, K.	100%	Program Leader: Salinity Mapping
Pain, C.	100%	Program Leader: Environmental Applications

Table 9.2 Research staff in-kind contribution

Name	Main activity	FTE	Research Program (FTEs)				Total on research (FTEs)	Other CRC activities (FTEs)		
			Regolith geoscience	Mineral exploration	Env. applications	Salinity mapping		Education	Commer-cialisation	Admin.
Commonwealth Scientific and Industrial Research Organisation										
Longman, D.	R	1.00	-	1.00	-	-	1.00	-	-	-
Butt, C.	R	1.00	-	0.95	-	-	0.95	0.05	-	-
Robertson, I.	R	1.00	0.10	0.85	-	-	0.95	0.05	-	-
Anand, R.	R	1.00	0.90	0.05	-	-	0.95	0.05	-	-
Phang, C.	R	1.00	1.00	-	-	-	1.00	-	-	-
Cornelius, M.	R	0.97	-	0.97	-	-	0.97	-	-	-
Tapley, I.	R	0.95	0.75	0.20	-	-	0.95	-	-	-
Lintern, M.	R	0.85	0.30	0.55	-	-	0.85	-	-	-
Gray, D.	R	0.80	0.05	0.75	-	-	0.80	-	-	-
Munday, T.	R	0.80	-	-	0.40	0.40	0.80	-	-	-
Denton, G.	R	0.55	-	0.55	-	-	0.55	-	-	-
Fitzpatrick, R.	R	0.50	0.25	0.20	0.05	-	0.50	-	-	-
Scott, K.	R	0.40	-	0.40	-	-	0.40	-	-	-
Herczeg, A.	R	0.30	0.30	-	-	-	0.30	-	-	-
Davies, P.	R	0.30	0.10	-	0.20	-	0.30	-	-	-
Merry, R.	R	0.30	0.20	-	0.10	-	0.30	-	-	-
Raven, M.	R	0.25	0.25	-	-	-	0.25	-	-	-
Bui, E.	R	0.20	-	-	0.20	-	0.20	-	-	-
Rogers, S.	R	0.20	0.20	-	-	-	0.20	-	-	-
Wildman, J.	R	0.19	0.19	-	-	-	0.19	-	-	-
Law, A.	R	0.15	-	0.15	-	-	0.15	-	-	-
Korsch, M.	R	0.15	-	0.15	-	-	0.15	-	-	-
Gatehouse, S.	R	0.15	-	0.15	-	-	0.15	-	-	-
Andrew, A.	R	0.10	-	0.10	-	-	0.10	-	-	-
	Total	13.11	4.59	7.02	0.95	0.40	12.96	0.15	-	-
Australian National University										
Clarke, J.	R	1.00	1.00	-	-	-	1.00	-	-	-
Pillans, B.	R	0.50	0.25	-	-	0.25	0.50	-	-	-
Chappel, J.	R	0.50	0.50	-	-	-	0.50	-	-	-
Magee, J.	R	0.50	0.25	-	0.25	-	0.50	-	-	-
McPhail, D.	R	0.33	0.33	-	-	-	0.33	-	-	-
Greene, R.	R	0.30	-	0.10	0.10	0.10	0.30	-	-	-
Fabel, D.	R	0.25	0.25	-	-	-	0.25	-	-	-
Spooner, N.	R	0.25	0.25	-	-	-	0.25	-	-	-
Opdyke, B.	R	0.20	0.20	-	-	-	0.20	-	-	-
Seeley, J.	R	0.20	-	-	-	-	-	-	-	0.20
Chopra, P.	R	0.20	0.20	-	-	-	0.20	-	-	-
Ellis, D.	R	0.15	0.05	-	0.10	-	0.15	-	-	-
Christie, A.	R	0.10	0.10	-	-	-	0.10	-	-	-
Westcott, R.	R	0.80	0.80	-	-	-	0.80	-	-	-
Field, J.	R	0.10	0.05	-	-	0.05	0.10	-	-	-
	Total	5.38	4.23	0.10	0.45	0.40	5.18	-	-	0.20

Table 9.2 Research staff in-kind contribution (cont'd)

Name	Main activity	FTE	Research Program (FTEs)				Total on research (FTEs)	Other CRC activities (FTEs)		
			Regolith geoscience	Mineral exploration	Env. applications	Salinity mapping		Education	Commer-cialisation	Admin.
Curtin University of Technology										
Wilkes, P.	R	0.60	-	0.15	-	-	0.15	0.25	-	0.20
Nemchin, A.	R	0.50	0.30	0.10	-	-	0.40	0.10	-	-
Aspandiar, M.	R	0.50	0.20	-	-	-	0.20	0.30	-	-
Kepic, A.	R	0.40	0.10	0.10	0.10	-	0.30	0.10	-	-
Uren, N.	R	0.40	-	-	-	-	-	0.10	-	0.30
Arne, D.	R	0.20	-	-	-	-	-	0.20	-	-
Watling, J.	R	0.20	0.10	0.05	-	-	0.15	0.05	-	-
Collins, L.	R	0.20	0.10	-	-	-	0.10	0.10	-	-
Watkins, R.	R	0.20	-	-	0.10	-	0.10	0.10	-	-
Meyers, J.	R	0.15	0.05	0.10	-	-	0.15	-	-	-
Fagan, R.	R	0.10	0.10	-	-	-	0.10	-	-	-
	Total	3.45	0.95	0.50	0.20	-	1.65	1.30	-	0.50
The University of Adelaide										
James, P.	R	0.70	0.20	0.10	-	-	0.30	0.10	-	0.30
Heinson, G.	R	0.55	0.15	0.10	0.10	-	0.35	0.20	-	-
Foden, J.	R	0.50	-	0.30	-	-	0.30	0.20	-	-
Greenhalgh, S.	R	0.50	0.05	0.05	-	-	0.10	0.05	-	0.35
Schmidt Mumm, A.	R	0.45	0.20	0.15	-	-	0.35	0.10	-	-
Bone, Y.	R	0.30	0.10	-	0.10	-	0.20	0.10	-	-
Brugger, J.	R	0.10	-	-	-	-	-	0.10	-	-
Williams, M.	R	0.10	0.10	-	-	-	0.10	-	-	-
	Total	3.20	0.80	0.70	0.20	-	1.70	0.85	-	0.65
University of Canberra										
McQueen, K.	R	0.75	-	0.50	-	-	0.50	0.25	-	-
Chen, X.	R	0.50	0.10	-	0.20	-	0.30	0.20	-	-
Moore, L.	R	0.50	-	-	-	-	-	0.50	-	-
Cartledge, O.	R	0.30	-	-	0.30	-	0.30	-	-	-
Otieno-Alego, V.	R	0.30	-	-	0.30	-	0.30	-	-	-
Benger, S.	R	0.20	0.05	-	0.15	-	0.20	-	-	-
Taylor, G.	E	0.75	0.10	-	-	-	0.10	0.65	-	-
	Total	3.30	0.25	0.50	0.95	-	1.70	1.60	-	-
Geoscience Australia										
Apps, H.	R	1.00	-	-	-	1.00	1.00	-	-	-
Chan, R.	R	1.00	0.40	0.60	-	-	1.00	-	-	-
Craig, M.	R	1.00	0.75	0.25	-	-	1.00	-	-	-
Gibson, D.	R	1.00	-	-	0.20	0.80	1.00	-	-	-
Kilgour, P.	R	1.00	-	-	0.50	0.50	1.00	-	-	-
Lawrie, K.	R	1.00	-	-	0.20	0.80	1.00	-	-	-
Pain, C.	R	1.00	0.40	-	0.40	0.20	1.00	-	-	-
Wilford, J.	R	1.00	-	-	0.20	0.80	1.00	-	-	-
Worral, L.	R	1.00	-	0.50	0.50	-	1.00	-	-	-
Brodie, R.	R	0.40	-	-	0.20	0.20	0.40	-	-	-
Hone, I.	R	0.30	-	-	-	0.30	0.30	-	-	-
Lane, R.	R	0.30	-	-	-	0.30	0.30	-	-	-
Neumann, N.	R	0.30	-	-	-	0.30	0.30	-	-	-
Williams, N.	R	0.20	-	-	-	0.20	0.20	-	-	-
Kilby, M.	R	0.15	-	-	-	0.15	0.15	-	-	-
Lewis, A.	R	0.15	-	-	-	0.15	0.15	-	-	-
King, A.	R	0.05	-	-	-	0.05	0.05	-	-	-
Lambert, I.	A	0.60	-	-	0.30	0.30	0.60	-	-	-
	Total	11.45	1.55	1.35	2.50	6.05	11.45	-	-	-
Bureau of Rural Sciences										
Cresswell, R.	R	1.00	-	-	1.00	-	1.00	-	-	-
Coram, J.	R	0.60	-	-	0.60	-	0.60	-	-	-
Sims, J.	R	0.50	-	-	0.50	-	0.50	-	-	-
Pestov, I.	R	0.40	-	-	0.40	-	0.40	-	-	-
	Total	2.50	-	-	2.50	-	2.50	-	-	-

Table 9.2 Research staff in-kind contribution (cont'd)

Name	Main activity	FTE	Research Program (FTEs)				Total on research (FTEs)	Other CRC activities (FTEs)		
			Regolith geoscience	Mineral exploration	Env. applications	Salinity mapping		Education	Commer-cialisation	Admin.
Primary Industries and Resources South Australia										
Fabris, A.	R	1.00	1.00	-	-	-	1.00	-	-	-
Hou, B.	R	1.00	1.00	-	-	-	1.00	-	-	-
Gouthas, G.	R	1.00	-	1.00	-	-	1.00	-	-	-
Sheard, M.	R	1.00	0.15	0.85	-	-	1.00	-	-	-
Rogers, P.	R	1.00	1.00	-	-	-	1.00	-	-	-
Mauger, A.	R	0.80	0.80	-	-	-	0.80	-	-	-
Keeling , J.	R	0.80	0.55	-	-	-	0.55	-	-	0.25
Stamoulis, V.	R	0.50	0.50	-	-	-	0.50	-	-	-
Painter, J.	R	0.30	-	0.30	-	-	0.30	-	-	-
Crooks, A.	R	0.10	0.10	-	-	-	0.10	-	-	-
Total		7.50	5.10	2.15	-	-	7.25	-	-	0.25
NSW Department of Mineral Resources										
Hicks, M.	R	1.00	-	1.00	-	-	1.00	-	-	-
Buckley, P.	R	1.00	-	1.00	-	-	1.00	-	-	-
Barrett, R.	R	0.40	-	0.40	-	-	0.40	-	-	-
Fleming, G.	R	0.30	-	0.30	-	-	0.30	-	-	-
Mills, K.	R	0.20	-	0.20	-	-	0.20	-	-	-
Stevens, B.	R	0.10	-	0.10	-	-	0.10	-	-	-
Total		3.00	-	3.00	-	-	3.00	-	-	-
Total research staff in-kind contributions		52.89	17.47	15.32	7.75	6.85	47.39	3.90	-	1.60

FTEs expressed as person years

Table 9.3 Research Staff CRC LEME-funded

Name	Employer	Main Activity	Full-time equivalent	Research Program (FTEs)				Total on research	Other CRC activities (FTEs)		
				Regolith geoscience	Mineral exploration	Env. applications	Salinity mapping		Education	Applications	Admin.
CRC Grant-funded											
Killick, M.	CSIRO	R	1.00	1.00	-	-	-	1.00	-	-	-
Sergeev, N.	CSIRO	R	1.00	-	1.00	-	-	1.00	-	-	-
Hunter, D.	CSIRO	R	0.67	-	-	0.49	0.18	0.67	-	-	-
Britt, A.	CSIRO	R	0.43	0.43	-	-	-	0.43	-	-	-
Bryce, A.	CSIRO	R	0.15	-	0.15	-	-	0.15	-	-	-
Green, A.	CSIRO	R	0.10	-	-	0.05	0.05	0.10	-	-	-
Gardner, B.	CSIRO	R	0.10	-	0.10	-	-	0.10	-	-	-
de Caritat, P.	GA	R	1.00	-	0.60	0.40	-	1.00	-	-	-
Harrold, B.	ANU	R	0.50	0.20	0.20	0.10	-	0.50	-	-	-
Pillans, B.	ANU	R	0.50	0.50	-	-	-	0.50	-	-	-
le Gleuher, M.	ANU	R	0.33	0.33	-	-	-	0.33	-	-	-
Papp, E.	ANU	R	0.15	0.15	-	-	-	0.15	-	-	-
Skwarnecki, M.	UC	R	1.00	0.35	0.60	0.05	-	1.00	-	-	-
Kirste, K.	UC	R	1.00	-	0.55	0.45	-	1.00	-	-	-
Roach, I.	UC	R	1.00	-	-	-	-	-	1.00	-	-
Tan, K.	UC	R	1.00	-	-	0.20	0.80	1.00	-	-	-
Hill, S.	UC	E	1.00	0.05	0.40	-	-	0.45	0.55	-	-
Aspandiar, M.	CUT	R	0.50	0.25	0.05	-	-	0.30	0.20	-	-
Radford, N.	CUT	R	0.50	-	0.50	-	-	0.50	-	-	-
Wilkes, P.	CUT	R	0.50	-	-	-	-	-	-	-	0.50
		Total	12.43	3.26	4.15	1.74	1.03	10.18	1.75	-	0.50
Industry or Externally Funded											
Scott, K.	CSIRO	R	0.30	-	0.30	-	-	0.30	-	-	-
Gray, D.	CSIRO	R	0.20	-	0.20	-	-	0.20	-	-	-
Lintern, M.	CSIRO	R	0.15	-	0.15	-	-	0.15	-	-	-
Carr, G.	CSIRO	R	0.10	-	0.10	-	-	0.10	-	-	-
Tapley, I.	CSIRO	R	0.05	0.05	-	-	-	0.05	-	-	-
Cornelius, M.	CSIRO	R	0.03	-	0.03	-	-	0.03	-	-	-
		Total	0.83	0.05	0.78	-	-	0.83	-	-	-
CRC Grant and external funds											
	Total research staff		13.26	3.31	4.93	1.74	1.03	11.01	1.75	-	0.50

FTEs expressed as person years

Table 9.4 Summary of research staff resources

Item	Total years	Research Program (FTEs)				Total on research	Other CRC activities (FTEs)		
		Regolith geoscience	Mineral exploration	Env. applications	Salinity mapping		Education	Applications	Administration
Total in-kind contributed	52.9	17.5	15.3	7.8	6.9	47.4	3.9	-	1.6
CRC grant funded	12.4	3.3	4.2	1.7	1.0	10.2	1.8	-	0.5
Industry funded	0.8	0.1	0.8	-	-	0.8	-	-	-
Total funded by CRC Leme	13.3	3.3	4.9	1.7	1.0	11.0	1.8	-	0.5
Grand total	66.2	20.8	20.3	9.5	7.9	58.4	5.7	-	2.1
proportion of total research staff resources in each activity	100%	31.4%	30.6%	14.3%	11.9%	88.3%	8.5%	-	3.2%

FTEs expressed as person years

Table 9.5 Administration and technical staff

Funding source	Organisation	Position	Main activity	FTE
CRC Grant funded				
	Commonwealth Scientific and Industrial Research Organisation			
	Smith, R.	Chief Executive Officer	A	1.00
	Phillips P./Campbell, J.	Applications Support Officer	A	0.73
	Naughton, T.	Visual Resources Unit Officer	T	1.00
	Mills, J.	Financial Accountant	A	0.87
	Lilley, A.	Program Support Officer	A	0.14
	Kong, G.	Business Manager	A	1.00
	Hink, H.	Program Support Officer	A	1.00
	Game, S.	PA to CEO/Centre Support Officer	A	1.00
	Davidson, M.	Communications Officer	A	0.38
			Total	7.12
	Geoscience Australia			
	McMurray, G.	Program Support Officer	A	0.50
			Total	0.50
	Australian National University			
	Crowther, B.	Research Support Officer	T	0.50
			Total	0.50
	University of Canberra			
	Kovacs, B.	Education Support Officer	A	1.00
			Total	1.00
			Total	9.12
Industry or externally funded				
	Commonwealth Scientific and Industrial Research Organisation			
	Steel, C.	Visual Resources Unit Manager	T	1.00
	Vartesi, A.	Visual Resources Unit Officer	T	1.00
			Total	2.00
Total administration and technical staff:			11.12	

FTEs expressed as person years

10. Publications and Patents

Publications by CRC LEME staff or students published during the reporting period are listed below. The centre lodged no patents or provisional patents during the reporting period.

Journal Papers

Alfred, C., Fitzpatrick, R., Maschmedt, D., Thomson, K., Dowley, A. & Van Goor, S. 2002. Soils of the Australian Rootstock Trials. *The Australian and New Zealand Grapegrower & Winemaker (Annual Technical issue)*, 461A: pp. 40-49.

Anand, R.R. 2001. Evolution, classification and use of ferruginous regolith materials in gold exploration, Yilgarn Craton, Western Australia. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 221-236.

Anand, R.R., Wildman, J.E., Varga, Z.S. & Phang, C. 2001. Regolith evolution and geochemical dispersion in transported and residual regolith-Bronzewing gold deposit. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 265-276.

Brand, N.W. and Butt, C.R.M. 2001. Weathering, element distribution and geochemical dispersion at Mt. Keith, Western Australia: implication for nickel sulphide exploration. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 391-407.

Braun, J., Heimsath, A. & Chappell, J. 2001. Sediment transport mechanisms on soil-mantled slopes. *Geology* 29: pp. 683-686.

Butt, C.R.M. and Scott, K.M. 2001. Geochemical exploration for gold and nickel in the Yilgarn Craton, Western Australia—an introduction. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 179-182.

Butt, C.R.M. 2001. Dispersion of gold and associated elements in the lateritic regolith, Mystery Zone, Mt. Percy, Kalgoorlie, Western Australia. Geochemistry: Exploration, Environment, Analysis, 1: pp. 291-306.

Chappell, J. 2001. Geomorphology and Holocene geology of coastal and estuarine plains of northern Australia. *Geological Society of Australia Special Publication* 21: pp. 303-314.

Chappell, J. 2001. Coral terraces, sea level changes, ice sheets and isotopes. *Nova Acta Leopoldina* 88 (331): pp. 195-204.

Chappell, J. 2002. Sea level changes forced ice breakouts in the Last Glacial Cycle: new results from coral terraces. *Quaternary Science Reviews* 21:pp. 1229-1240.

Clarke, J.D.A. & Pillans, B. 2002. Comment on "Onset of aridity in southern Western Australia preliminary palaeomagnetic appraisal" by Zheng et al. [*Global and Planetary Change*, 18 175-187]. *Global and Planetary Change*, 32(2): pp. 279-282.

Clarke, J.D.A., Bone, Y., Cann, J.H., Davies, M., MacPhail, M.K., & Wells, F. 2001. Post-glacial biota from the inner part of southwest Joseph Bonaparte Gulf. *Australian Journal of Earth Sciences*, 48: pp. 63-79.

Cornelius, M., Smith, R.E. & Cox, A.J. 2001. Laterite geochemistry for regional exploration surveys—a review, and sampling strategies. *Geochemistry: Exploration, environment, analysis*: pp. 211-220.

Craig, M.A. 2001. Regolith Mapping for geochemical exploration in the Yilgarn Craton, Western Australia. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 383-390.

Crooks, A.F. 2002. Regolith mapping on the Mingary 1:100 000 map area, Curnamona Province. *MESA Journal*, 25: pp. 42-45.

Davies, P.J., Fitzpatrick, R.W., Bruce, D.A., Spouncer, L.R. & Merry, R.H. 2002. Land degradation assessment in the Mount Lofty Ranges: upscaling from points to regions via toposequences. In: McVicar, T.R., Rui, L., Walker, J., Fitzpatrick, R.W. and Liu Changming (eds), *Regional Water and Soil Assessment for Managing Sustainable Agriculture in China and Australia*. ACIAR Monograph 84. CSIRO Publishing, Melbourne, Australia, pp. 291-303.

Dogramaci, S.S., Herczeg, A. L., Schiff, S. L., & Bone, Y. 2001. Controls on d34S and d18O of dissolved sulfate in aquifers of the Murray Basin, Australia and their use as indicators of flow processes. *Applied Geochemistry*, 16(4): pp. 475-488.

English, P., Spooner, N.A., Chappell, J. Questiaux, D.G. & Hill, N.G. 2001. Lake Lewis basin, central Australia: environmental evolution and OSL chronology. *Quaternary International* 83-85: pp. 81-101.

Fabris, A.J. 2002. Thermal satellite imagery — an aid to heavy mineral discoveries. MESA Journal 24: pp. 24-26.

Frakes, L.A. & Barron, EJ. 2001. Phanerozoic general circulation model results and quantitative climate data for Australia. *Australian Journal of Earth Sciences*, 48(5): pp. 643-655.

Glen, R.A., Korsch, R.J., Direen, N.G., Jones, L.E.A., Johnstone, D.W., Lawrie, K.C., Finlayson, D.M. & Shaw, R.D. 2002. Crustal structure of the Ordovician Macquarie Arc, Eastern Lachlan Orogen, based on seismic-reflection profiling. *Australian Journal of Earth Sciences*, 49, pp. 323-348.

Greene, R.S.B., Eggleton, R.A. & Rengasamy, P. 2002. Relationships between clay mineralogy and hardsetting properties of soils in the Carnarvon Horticultural District of Western Australia. *Applied Clay Science*, 20: pp. 211-223.

Hahesy, P., Heinson, G. & Endres, A.L. 2001. Geophysical quantification of a moisture content profile in the near surface. *Exploration Geophysics* 32(1): pp. 70-74.

Harris, M.A. 2001. The effect of sewage sludge and green manure on the erodibility of two mine tailings materials. *Environmental Geology*, 40 (11/12): 1367-1376.

Harris, M.A. & Ragusa, S. 2001. Bioremediation of acid mine drainage using decomposable plant material in a constant flow bioreactor. *Environmental Geology*, 40(10): pp. 1192-1204.

Harris, M.A., & Megharaj, M. 2001. The effects of sludge and green manure on hydraulic conductivity and aggregation in pyritic mine tailings materials. *Environmental Geology*, 41(3/4): pp. 285-296.

Harvey, C.C. & Keeling, J.L. 2002. Categorization of industrial clays of Australia and New Zealand. *Applied Clay Science*, 20: pp. 243-253.

Hayne, M. & Chappell, J. 2001. Cyclone frequency during the last 5000 years at Curacoa Island, north Queensland, Australia. *Palaeogeography, Palaeoclimatology, Palaeoecology* 168: pp. 207-219.

Heimsath, A.M., Chappell, J., Spooner, N.A. & Questiaux, D.G. 2002. Creeping soil. *Geology* 30: pp. 111-114.

Hou, B., Frakes, L. & Dodds, S. 2001. Recent drilling in the Garford Palaeochannel, Gawler Craton – testing of a model derived from interpreted geological, geophysical and spectral methods. *MESA Journal*, 20: pp. 24-27.

James, P.N., Bone, Y., Collins, B.L. & Kyser, T.K. 2001. Surficial sediments of the Great Australian Bight: facies dynamics and oceanography on a vast Cool-Water Carbonate Shelf. *Journal of Sedimentary Research*, 71(4): pp. 549-567.

Johnson, C.B. & McQueen, K.G. 2001. The nature of gold-bearing palaeochannel sediments in the Gidji area north of Kalgoorlie, Western Australia. *Quaternary International*, 82: pp. 51-62.

Kepic, A., Russell, R.D., Maxwell, M., & Butler, K.E. 2001, Underground tests of the radio pulsed effect seismoelectric method at the Lynx Mine, Canada: *Exploration Geophysics*, 32: pp. 107-112.

Lambeck, K. & Chappell, J. 2001. Sea level change through the last glacial cycle. *Science* 292: pp. 679-686.

Lambert, I.B. 2001. Sustainable Development: Strategic issues for Australia's minerals sector. *Bulletin of the Australasian Institute of Mining and Metallurgy*, No. 6: pp. 22-29.

Lambert, I.B., Lawrie, K.C. & Pain, C.F. 2001. Mapping and understanding salinity. *Water*, Oct. 2001: pp.27.

Lintern, M.J. 2001. Exploration for gold using calcrete – lessons from the Yilgarn Craton, Western Australia. *Geochemistry: Exploration, Environment and Analysis*, 1: pp. 237-252.

Polito, P.A., Bone, Y., Clarke, J.D.A. & Mernagh, K. 2001. Compositional zoning of fluid inclusions in the Archaean Junction gold deposit, Kambalda, Western Australia. *Australian Journal of Earth Science,* 48: pp. 833-855.

Rahimpour-Bonab, H. & Bone, Y. 2001. Isotopic Signature of the Diagenetic Fluids and Cement in the Tortachilla Limestone, South Australia. *Iranian International Journal of Science*, 2(1): pp. 33-54.

Scott, K.M. & Howard, R.W. 2001. Hydrothermal alteration and geochemical dispersion in the regolith at Panglo, Eastern Goldfields, Western Australia. Geochemical exploration for gold and nickel in the Yilgarn Craton, Western Australia /Eds: C.R.M. Butt and K.M. Scott. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 313-322.

Scott, K.M. 2001. Weathering in the Parkinson Pit and its implications for exploration in the Mt Magnet Mining District, Western Australia Geochemical exploration for gold and nickel in the Yilgarn Craton, Western Australia /Eds: C.R.M. Butt and K.M. Scott. *Geochemistry: Exploration, Environment, Analysis*, 1: pp. 341-352.

Sircombe, K.N. & McQueen, K.G. 2000. Zircon dating of Devonian-Carboniferous rocks from the Bombala area, New South Wales. *Australian Journal of Earth Sciences*, 47: pp. 1041-1051. (not reported in 2001 annual report).

Stamoulis, V. 2002. Use of radiometric data for mineral exploration in SA. *MESA Journal*, 25: pp. 26-27.

Street, G. 2001. Old MacDonald needs a geophysicist. *AIG Bulletin,* 33: pp. 53-55.

Street, G. 2001. Airborne Geophysics: Better information for land management. *Water*, pp. 30-33.

Street, G. 2001. Geophysical applications in agricultural and land management: Butsuri-Tansa, *Journal of the Society of Exploration Geophysics Japan*, 54(5): pp. 347-351.

Twidale, C.R., Prescott, J.R., Bourne, J.A. & Williams, F.M. 2001. Age of desert dunes near Birdsville, southwest Queensland. *Quaternary Science Reviews*, 20: pp. 1355-1364.

Valzano, F.P., Greene, R.S.B., Murphy, B.W., Rengasamy, P. & Jawal, S.D. 2001. Effects of gypsum and stubble management on the chemical and physical properties of a sodic grey vertosol in Western Victoria. *Australian Journal of Soil Research*, 39: pp. 1333-1347.

Valzano, F.P., Murphy, B. W. & Greene, R.S.B. 2001. The long-term effects of lime (CaCO3), gypsum (CaSO4.2H2O), and tillage on the physical and chemical properties of a sodic red brown earth. *Australian Journal of Soil Research*, 39: 1307-1331.

Wang P-X & Chappell, J. 2001. Foraminifera as Holocene environmental indicators in the South Alligator River, Northern Australia. *Quaternary International* 83-85: pp. 47-62.

Wilford, J., Dent, D., Braaten, R. & Dowling, T. 2001. Running down the salt in Australia 2: Smart interpretation of airborne radiometrics and digital elevation models. *The Land*, 5.2: pp. 79-100.

Williams, M., Prescott, J.R., Chappell, J., Adamson, D., Cock, B., Walker, K. & Gell, P. 2001. The enigma of a late Pleistocene wetland in the Flinders Ranges, South Australia. *Quaternary International* 83-85: pp. 129-144.

Zhou, B. & Greenhalgh, S.A. 2001. Finite element three-dimensional direct current resistivity modelling: accuracy and efficiency considerations. *Geophysical Journal International*, 145(3): pp. 679-688.

Zhou, B. & Greenhalgh, S.A. 2002. Rapid 2-D/3-D cross-hole resistivity imaging using the analytic sensitivity function. *Geophysics* 67: pp. 755-765.

Books or Chapters

Anand, R.R. & Pain, M. 2002. Thematic Issue—Regolith geology of the Yilgarn Craton. *Australian Journal of Earth Sciences*, 49(1): pp. 162.

Bigham J.M. Fitzpatrick, R.W. & Schulze, D.G. 2002. Iron Oxides. In: Dixon, J.B. and Schulze, D.G. (eds), *Soil Mineralogy with Environmental Applications*. Soil Science Society America Book Series No 7. SSSA, Madison, Wisconsin, pp. 323-366.

Butt, C.R.M. & Scott, K.M. 2001. (Editors). Geochemical exploration for gold and nickel in the Yilgarn Craton, Western Australia. *Geochemistry: Exploration, Environment, Analysis*, 1: 179-288; pp. 291-407.

Chappell, J. 2001. Climate before agriculture. In Anderson, A. Lilley, I. & O'Connor, S. (eds.), *Histories of Old Ages: Essays in honour of Rhys Jones*, pp. 171-184. Canberra: Pandanus Books, The Australian National University.

Clarke, J.D.A. 2001. Ancient Landforms of Kambalda and their significance. In V. A. Gostin (ed.) *Gondwana to Greenhouse: Australian Environmental geoscience.* Geological Society of Australia Special Publication 21. GSA, Australia, pp. 49-57.

Eggleton, R.A. 2001. (Editor). *The Regolith Glossary—surficial geology, soils and landscapes.* CRC Landscape Evolution and Mineral Exploration, pp. 144.

Fitzpatrick, R.W. & Chittleborough, D.J. 2002. Titanium and Zirconium Minerals. In: Dixon, J.B. and Schulze, D.G. (eds), *Soil Mineralogy with Environmental Applications.* Soil Science Society America Book Series No 7. SSSA, Madison, Wisconsin, pp. 667-690.

Fitzpatrick, R.W. & Merry, R.H. 2002. Soil-regolith models of soil-water landscape degradation: development and application. In: McVicar, T.R., Rui, L., Walker, J., Fitzpatrick, R.W. and Liu Changming (eds), *Regional Water and Soil Assessment for Managing Sustainable Agriculture in China and Australia.* ACIAR Monograph 84. CSIRO Publishing, Melbourne, Australia, pp. 130-138.

Fitzpatrick, R.W., Slade, P.M. & Hazelton, P. 2001. Chapter 3 – Soil-related engineering problems: identification and remedial measures. In V. A. Gostin (ed.) *Gondwana to Greenhouse: Australian Environmental Geoscience.* Geological Society of Australia Special Publication 21. GSA, Australia, pp. 27-36.

Fitzpatrick, R.W. 2002. Land degradation processes. In: McVicar, T.R., Rui, L., Walker, J., Fitzpatrick, R.W. and Liu Changming (eds), *Regional Water and Soil Assessment for Managing Sustainable Agriculture in China and Australia*. ACIAR Monograph 84. CSIRO Publishing, Melbourne, Australia, pp. 119-129.

Fitzpatrick, R.W., Cox, J.W., Munday, B., B Bourne, J.C. & Chunsheng Hu 2002. Transferring scientific knowledge to farmers. In: McVicar, T.R., Rui, L., Walker, J., Fitzpatrick, R.W. and Liu Changming (eds), *Regional Water and Soil Assessment for Managing Sustainable Agriculture in China and Australia.* ACIAR Monograph 84. CSIRO Publishing, Melbourne, Australia, pp. 173-186.

Gostin, VA. 2001. Introduction. In: Gostin, VA. (Editor), *Gondwana to Greenhouse: Australian Environmental Geoscience.* Special Publication 21, Geological Society of Australia, pp. xi-xvi.

Gostin, VA. 2001. (Editor) *Gondwana to Greenhouse: Australian Environmental Geoscience.* Special Publication 21, Geological Society of Australia.

Greene, R.S.B. 2001. Hardsetting soils. In: Lal, R. Ed., *The Encyclopedia of Soil Science*. Marcel Dekker, Inc.

Greene, R.S.B., Valentin, C. & Esteves, M. 2001. Runoff and erosion processes. In: Valentin, C. Tongway, D., Seghieri, J. and d'Herbes, J.M. eds, *Banded Vegetation Patterning in Arid and Semi-arid Environment-Ecological Processes and Consequences for Management.* Springer-Verlag. Ecological Studies 149, pp. 52-76.

Merry, R.H., Spouncer, L.R., Fitzpatrick, R.W., Davies, P.J. & Bruce, D.A. 2002. Regional prediction of soil profile acidity and alkalinity. In: McVicar, T.R., Rui, L., Walker, J., Fitzpatrick, R.W. and Liu Changming (eds). *Regional Water and Soil Assessment for Managing Sustainable Agriculture in China and Australia.* ACIAR Monograph 84. CSIRO Publishing, Melbourne, Australia, pp. 155-164.

Pain, C.F., Craig, M.A., Gibson, D.L., & J.R. Wilford 2001. Regolith Landform Mapping: An Australian Approach. In: Bobrowsky, P.T., *Geoenvironmental Mapping, Method, Theory and Practice*, A.A. Balkema, Swets and Zeitlinger Publishers, The Netherlands, pp. 29-56.

Taylor, G. & Eggleton, R. A. 2001. *Regolith Geology and Geomorphology*, John Wiley & Sons, Chichester, UK, pp. 375.

Taylor, G. & McNally, G. 2001. The Regolith: its History and Environmental Importance with particular reference to some engineering examples. In V.S. Gostin (Ed), *Gondwana to Greenhouse: Australian Environmental Geoscience*. Geological Society of Australia Special Publication No. 21, GSA, Australia, pp. 13-25.

Taylor, G. 2001. Regolith Terminology In Buckman, D.A., (ed), *Field Geologists Manual* Australian Institute of Mining and Metallurgy Monograph 9, pp. 57-59.

Conference Papers

Anderson-Mayes, A., & Street, G. 2001. Making the most of your data: Presented at the Salinity Land Management and New Technology Conference, 18-21 February, Bendigo, Victoria.

Butt, C.R.M., Brand, N.W. & Elias, M. 2001. Nickel laterites: old and new; wet and dry; green and brown Gordon Research Conference. Presentation only.

Clark, I., Zeegers, Y. & James, P. 2001. Evaluating constructivist based methods to teach senior undergraduate geoscience classes. Proceedings of Research and Development into University Science Teaching and Learning Workshop, April 20 2001. UniServe Science, pp. 29-35.

Eggleton, T. Tan, K.P. & Lawrie, K.C. 2002. Mineral quantification in clay-rich sediments. In Greene, R., (ed.). Australian Clay Minerals Society 18th Biannual Conference. Abs., pp. 44.

Fabris, A. 2002. Northern Murray Basin, South Australia: Stratigraphy, geomorphology and strandline identification. Proceedings, Australian Mineral Sands Conference, Mildura April 11-12 2002. (CD published by Sunraysia Institute of TAFE, Mildura, Victoria).

Fitzpatrick R.W., Raven, M., Bonifacio, E., Self, P.G., Merry, R.H., & Skwarnecki, M. 2001. Origin and Significance of Sideronatrite, Tamarugite and other Mineral Precipitates in Sulfaquepts. Symposium on Mineral Controls in Hydric Soil Processes, American Society of Agronomy Annual Meeting in Charlotte, North Carolina. File reference for abstract is s09-fitzpatrick115153-O (http://www.soils.org).

Fitzpatrick, R.W., Powell, B., McKenzie, N., Maschmedt, D. J., Schoknecht N. & Jacquier, D. 2001. Demands of Soil Classification in Australia. Abstracts from the Symposium "Soil Classification Contributions to Advances in Pedology" at 2001 American Society of Agronomy Annual Meeting in Charlotte, North Carolina. October, 21-23 Agronomy. File reference for abstract is: s05-fitzpatrick094825-O (http://www.soils.org).

Fitzpatrick, R.W., Raven, M. & Skwarnecki, M.S. 2002. Mineral products formed by oxidation of iron sulfides in Australian upland fresh water acid sulfate soils: Genesis and significance. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp. 5-6.

Fitzpatrick, R.W., Rengasamy P., Merry R.H. & Cox J.W. 2001. Is dryland soil salinisation reversible? National Dryland Salinity Program (NDSP). NDSP Web site: (http://www.ndsp.gov.au/), pp. 15.

Greene, R.S.B., Eggleton, R.A., Nettleton, W.D., Mason, J.A. & Gatehouse, R. 2002. Stability of clay microaggregates in aeolian sediments. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp. 37.

Greenhalgh, S.A., Zhe, J. & Zhou, J. 2001. A trial of cross-hole electric imaging for monitoring aquifer artificial recharge: Presented at 31st Congress of International Association of HYdrogeologists, Munich, 10-14 September 2001.

Hou, B., Frakes, L.A., Alley, N.F. & Gray, D.J. 2001. Development of integrated exploration methods: an inspiration derived from the study of palaeodrainage on the Gawler Craton, South Australia Computer applications in the minerals industries: proceedings of the 29th International Symposium on Computer Application in the Minerals Industries (APCOM2001), Beijing, China, 25-27 April 2001, Lisse: A.A. Balkema Publishers, pp. 107-110.

Hunter, D. & MacNae, J. 2001. Subsurface conductivity structure as approximated by conductivity-depth transforms: Extended Abstract, ASEG Conference, Brisbane, August 2001.

Keeling, J.L., Self, P.G. & Raven, M.D. 2002. Halloysite-alunite in sediments east of Maralinga, South Australia: a record of acid drainage in the post early Tertiary landscape. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp. 22-23.

Kepic, A. & Butler, K. 2002. The art of measuring very low amplitude seismoelectric signals: Presented at the 64th Conference and Tech. Exh., European Association of Geoscientists & Engineers, Florence, Italy, 27-30 May.

Kepic, A., & Howman, D. 2002. The application of geophysical methods to detecting sub-surface cavities under roads: Presented at the 64th Conference and Tech. Exh., European Association of Geoscientists & Engineers, Florence, Italy, 27-30 May.

Kirste, D. & de Caritat, P. 2001. Groundwater processes in the metallogenic Curnamona Province, New South Wales and South Australia: major element, trace element and isotopic evidence. Abstracts, Seventh Australasian Conference on Isotopes in the Environment (Robertson, NSW, 24-26 September 2001): pp. 25.

Lambert, I.B., Lawrie, K.C. & Pain, C.F. 2001. Integrated studies for more effective management of salinity in rural areas. National Local Government Salinity Summit, Moama-Echuca, July 17-19 2001. Official Proceedings (CD published by Murray-Darling Association).

Lawrie, K.C., Pain, C., Wilford, J., & Gibson, D. 2001. Regolith: a critical component in a holistic systems approach to mapping and assessing dryland salinity hazards. In AARNMS workshop on regolith and salinity. July 2001, pp. 24-28.

Lawrie, K.C., T.P. Mernagh, D. L. Gibson, J.Wilford & T.J. Munday 2001. Assessing mineral prospectivity in areas of complex regolith cover: testing a holistic systems approach in the GILMORE project. Victorian Chamber of Mines Annual Conference, pp. 2, August 2001.

Mauger, A.J., Stamoulis, V. & Cocks, P. 2002. Hyperspectral Airborne Survey for Geological Mapping, Musgrave Ranges, South Australia. 5th International Airborne Remote Sensing Conference, Miami, May 2002.

McQueen, K.G. & Johnson C. 2001. Palaeochannel sediments and their implications for landscape history and gold exploration at Gidji, Kalgoorlie, Western Australia. Canadian Quaternary Association Meetings 2001 Program and Abstracts, Yukon Heritage Branch Occasional Papers in Earth Sciences No. 1, pp. 55.

McQueen, K.G., Gonzalez, O. & Roach, I. 2001. El Capitan palaeovalley: Implications for understanding the Miocene to Quaternary landscape history of the Cobar region, NSW Australia. Canadian Quaternary Association Meetings 2001 Program and Abstracts, Yukon Heritage Branch Occasional Papers in Earth Sciences No. 1, pp. 54-55.

Michael, H., Fitzpatrick, R.W. & Ellison, K. 2002. Soils ain't soils – how mineralogy helped solve a double murder. 16th International Symposium on the Forensic Sciences; 15th May 2002, Canberra.

Rengasamy, P. & Greene, R.S.B. 2002. Dispersive potential of soil clays as influenced by exchangeable magnesium. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp. 13-14.

Schmidt, R. & Bone, Y. 2001. Late Eocene Bryozoan assemblages of the St Vincent Basin, South Australia-preliminary results. In: Wyse-Jackson, P. & Spencer-Jones, M., Abstracts from the International Bryozoology Association 12th International Conference, Trinity College, Dublin, 16-20 July 2001, pp. 94.

Smith, R.J., & Street, G. 2001. Geophysical tools in land management: Presented at the Salinity Land Management and New Technology Conference, 18-21 February, Bendigo, Victoria.

Street, G. 2001. Extracting information for land management decisions: Presented at the Salinity Land Management and New Technology Conference, 18-21 February, Bendigo, Victoria.

Street, G. 2001. Spatial tools for land management: 5th Annual Symposium of Geospatial Information & Agriculture, GIA 2001, NSW Agriculture, pp. 2-16.

Street, G. 2001. New resource for local government: National Local Government Salinity Summit, Moama-Echuca, July. Proceedings published on CD.

Street, G. 2001. Geophysics for waste management: Waste & Recycle 2001 Conference, From Waste to Resources: Planning for a Change, pp. 211-218.

Tan, K.P., Gibson, D., Lawrie, K.C. & Wilford, J. 2002. Unravelling the natural gamma response of sediments and saprolith in a complex regolith environment. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp.10-11.

Turner, M., Greene, R.S.B., Knacksteadt, M., Senden, T., & White, I. 2002. Characterisation of pore structures in deep regolith materials. In Eggleton, R., and Greene, R.S.B. (Eds.). Australian Clay Minerals Society 18th Biennial Conference Program and Abstracts. Canberra, ACT. 29 April–1 May 2002, pp. 17-18.

Wilford, J., Dent, D., Braaten, R. & Dowling, T. 2002. Predicting salt stores using airborne radiometrics and digital elevation models. Sydney University Conference.

Phillips, G.N. & Ely, K.S., (eds.) 2002. Victoria Undercover: collaborative geoscience in Northern Victoria. Benalla 2002 Conference proceedings and field guide. CSIRO Publishing, Collingwood, pp. 292.

Apps, H.E., Lawrie, K.C., Gibson, D.L., Brodie, R.C., Wilford, J., Tan, K.P., Chan, R.A. & Highet, L.M. 2002. GILMORE Project GIS – providing a 3D framework for mapping and assessing mineral prospectivity and the risk of dryland salinity, pp. 271-274.

de Caritat, P., Kirste, D., Dann, R. & Hutcheon, I. 2002. Groundwater composition in the Broken Hill area: salinity and mineral exploration applications, pp. 275-278.

Dent, D., Munday, T., Brodie R. & Lawrie K. 2002. A preliminary interpretation of high-resolution airborne geophysical data, and implications for salinity and land management – Honeysuckle Creek, Victoria, Australia, pp. 1-10.

Dent, D., Munday, T.J., Brodie, R.C. & Lawrie, K.C. 2002. Implications for salinity and land management—Honeysuckle Creek, Victoria: a preliminary interpretation of high-resolution airborne geophysical data, pp. 223-233.

Ely, K.S., Lawrie, K.C., Phillips, G.N., Gibson, D.L., Tan, K.P. & Heislers, D. 2002. Victoria Undercover – Benalla 2002 field excursion guide, pp. 281-284.

Gibson, D.L. & Wilford, J. 2002. Aspects of regolith and landscape of the Strathbogie-Caniambo-Dookie area: the need for interpretation of detailed geophysical datasets in the light of regional data and models, pp. 235-247.

Gibson, D.L., Wilford, J., Tan, K.P. & Lawrie, K.C. 2002. Palaeogeography, a predictive tool in environmental studies – applications to the margins of the Murray Basin, pp. 183-192.

Kilgour, P.L. & Pain, C.F. 2002. National regolith data—present status and work to be done pp. 123-130.

Lawrie, K.C., Pain, C.F., Gibson, D., Munday, T.J., Wilford, J. & Jones G. 2002. Regolith – a missing link in mapping salinity processes and predicting dryland salinity hazards, pp. 167-173.

Lawrie, K.C., Munday, T.J., Gibson, D.L., Mernagh, T., Wilford, J., Williams, N.C., Brodie, R.C. & Apps, H. 2002. The role of airborne electromagnetics in a multi-disciplinary approach to mapping mineral systems under cover – an example from the eastern Lachlan Fold Belt, central west NSW, pp. 107-120.

Meyers, J. 2002. Geophysical overview of the Euroa region, North Victoria, pp. 17-23.

Paine, M.A. 2002. Preliminary report on Tertiary regolith evolution of the Dundas Tableland, pp. 161-164.

Phillips, G.N., Hughes, M.J. & Lawrie, K.C. 2002. Victoria Undercover 2002, and the Victorian Geotraverse, pp. 1-9.

Phillips, G.N. & Anand, R.R. 2002. Yandal Project (1999-2000) – an overview, p. 121-122.

Tan, K.P., Kirste, D., Cresswell, R., Jones, G. & Gibson, D.L 2002. Investigation into the association of groundwater chemistry and lithology from a bore-hole in the GILMORE project area, central New South Wales, pp. 265-270.

Wilford, J., Gibson, D.L., Lawrie, K.C., & Tan, K.P. 2002. Extending regolith-landform maps into the third dimension – unravelling the palaeogeography story for mineral exploration and environmental applications, pp. 193-202.

Articles and Newsletters

Keeling, J.L 2001. CRC LEME Adelaide Launch. MESA Journal 24:16.

Game, S. (ed) 2002. LEME News No. 22. January 2002. Cooperative Research Centre for Landscape Environments and Mineral Exploration News letter, CRC LEME Perth, pp. 20.

Hill, S.M. 2001. New maps for old exploration challenges in the regolith at Broken Hill. Minfo 72 (November 2001), New South Wales Department of Mineral Resources, pp. 23-24.

Open File Reports

Anand, R.R., Wilford, J., Munday, T.J., Phang, C., Wildman, J.E. & Scott, K.M., 1995. Mt Isa Field Trip. CSIRO Exploration and Mining Restricted Report 156R. Reissued as CRC LEME Open File Report 142 2002, CRC LEME, Perth, pp. 46.

Anand, R.R., Phang, C., Wilford, J., Wildman, J.E., Li Shu, Robertson, I.D.M. & Munday, T.J., 1996. Regolith-landscape characteristics, evolution and regional synthesis of the Mt Isa Region, Progress Report. CSIRO Exploration and Mining Restricted Report 158R. Reissued as CRC LEME Open File Report 125 2002, CRC LEME, Perth, pp. 47.

Anand, R.R., Fraser, S.J., Jones, M.R., Li Shu, Munday, T.J., Phang, C., Robertson, I.D.M., Scott, K.M., Vasconcelos, P., Wildman, J.E., Wilford, J., 1997. Geochemical exploration in regolith dominated terrain, North Queensland. CSIRO Exploration and Mining Restricted Report 447R. Reissued as CRC LEME Open File Report 120 2002, CRC LEME, Perth, 142 pp + 3 CDs.

Anand, R.R., Paine, M.D., Smith, R.A. 2002. Genesis, classification and atlas of ferruginous materials, Yilgarn Craton. CRC LEME Open File Report 73, pp. 90.

Dell, M.R., 1998. Regolith-landforms of the Mt Isa Geodynamic Transect. CSIRO Exploration and Mining Restricted Report 451R. Reissued as CRC LEME Open File Report 138 2002, CRC LEME, Perth, pp. 46 + CD.

Fraser, S.J., 1997. A regional overview of the Charters Towers – North Drummond Basin Region: Geomorphic Landform Provinces. CSIRO Exploration and Mining Restricted Report 366R. Reissued as CRC LEME Open File Report 137 2002, CRC LEME, Perth, pp. 32 + map (digital).

Fraser, S.J., Skwarnecki, M.S. & Robertson, I.D.M. 2000. Regional regolith mapping around Alice Springs, Northern Territory. CSIRO Exploration and Mining Restricted Report 746R. Reissued as CRC LEME Open File Report 82 2002, CRC LEME, Perth, pp. 17 + 2 maps + CD.

Gibson D.L. 2001. Wonnaminta regolith-landforms. CRC LEME Open File Report 114, pp. 47.

Hou, B., Frakes, L.A. & Alley, N.F. 2001. Development of geoscientific models for the exploration in Tertiary palaeochannels draining the Gawler Craton, SA. Report Book 2001/021, pp. 133, published by Publishing Services, PIRSA, Adelaide.

Jones, M.R., 1997. Alluvial landscapes of the Maronan area, Cloncurry – McKinlay District, Queensland. CSIRO Exploration and Mining Restricted Report 374R. Reissued as CRC LEME Open File Report 129 2002, CRC LEME, Perth, pp. 43.

Jones, M.R., 1997. Alluvial landscapes of the Northern Kennedy Gap Area, Mt Isa District, Queensland. CSIRO Exploration and Mining Restricted Report 382R. Reissued as CRC LEME Open File Report 130 2002, CRC LEME, Perth, pp. 42.

Lintern, M.J., Sheard, M.J. & Gouthas, G. 2002. Preliminary regolith studies at ET, Monsoon, Jumbuck, South Hilga and Golf Bore Gold Prospects, Gawler Craton, South Austrtalia. CRC LEME Open File Report 115, pp. 43 (v1) + pp. 262 (v2) + CD.

Li Shu & Robertson, I.D.M., 1997. Surficial geology around the Eloise Cu-Au Mine and dispersion into Mesozoic cover from the Eloise mineralisation, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 382R. Reissued as CRC LEME Open File Report 135 2002, CRC LEME, Perth, pp. 76 + map + disk.

Li Shu, 1998. Landscape evolution and regolith development over the Mt Coolon Area, Central East Queensland. CSIRO Exploration and Mining Restricted Report 448R. Reissued as CRC LEME Open File Report 141 2002, CRC LEME, Perth, pp. 26 + map.

Phang, C., Anand, R.R., Wildman, J.E. & Robertson, I.D.M., 1998. Atlas of ferruginous and siliceous materials, North Queensland. CSIRO Exploration and Mining Restricted Report 450R. Reissued as CRC LEME Open File Report 136 2002, CRC LEME, Perth, pp. 73 + disk.

Phang, C., Munday, T.J. & Wildman, J.E. 1997. Regolith landform relationships and geochemical dispersion around Tringadee and Brumby prospects, North Queensland. CSIRO Exploration and Mining Restricted Report 429R. Reissued as CRC LEME Open File Report 140 2002, CRC LEME, Perth, pp. 35 + map + disk.

Robertson, I.D.M., Phang, C. & Munday, T.J., 1995. Regolith geology and soil geochemistry of the Little Eva Copper prospect, Quamby District, NW Queensland. CSIRO Exploration and Mining Restricted Report 128R. Reissued as CRC LEME Open File Report 123 2002, CRC LEME, Perth, pp. 115 + disk.

Robertson, I.D.M., 1997. Dispersion into the Southern Cross Formation around the Scott and Cindy Lodes, Pajingo, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 449R. Reissued as CRC LEME Open File Report 121 2002, CRC LEME, Perth, pp. 46 + disk.

Robertson, I.D.M., Li Shu & Wildman, J. E., 1997. Geochemical dispersion around the Maronan Cu-Au Prospect, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 409R. Reissued as CRC LEME Open File Report 134 2002, CRC LEME, Perth, pp. 23 + map + disk.

Robertson, I.D.M. 2002. CRC LEME Open File Reports 120-143: Abstracts, Index and Database. CRC LEME Open File Report 119R, pp. 100 + maps + CD.

Scott, K.M., 1995. The geochemistry of transported soils and weathered bedrock at Police Creek, Drummond Basin, Qld – A progress report. CSIRO Exploration and Mining Restricted Report 157R. Reissued as CRC LEME Open File Report 124 2002, CRC LEME, Perth, pp. 34.

Scott, K.M., 1995. Secondary dispersion about the Waterloo polymetallic deposit, Mt Windsor Sub-province, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 168R. Reissued as CRC LEME Open File Report 126 2002, CRC LEME, Perth, pp. 30.

Scott, K., Li Shu, Fraser, S., Campbell, I.D., Anand R.R. & Robertson, I.D.M., 1996. Charters Towers – North Drummond Basin Field Excursion, Field Guide. CSIRO Exploration and Mining Restricted Report 286R. Reissued as CRC LEME Open File Report 122 2002, CRC LEME, Perth, pp. 74.

Scott, K.M., 1997. Soil, bedrock and profile geochemistry at Police Creek, Drummond Basin, Queensland. CSIRO Exploration and Mining Restricted Report 323R. Reissued as CRC LEME Open File Report 127 2002, CRC LEME, Perth, pp. 45 + map.

Scott, K.M., 1997. The significance of Campaspe-dominated terrains in exploration within the Mt Windsor Sub-province, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 422R. Reissued as CRC LEME Open File Report 133 2002, CRC LEME, Perth, pp. 38.

Scott, K.M. & Fraser, S.J., 1997. Mineralogical and geochemical aspects of the regolith at the Brahman Au Prospect, Charters Towers area, N.E. Queensland. CSIRO Exploration and Mining Restricted Report 434R. Reissued as CRC LEME Open File Report 143 2002, CRC LEME, Perth, pp. 36.

Skwarnecki, M., Fitzpatrick R.W., & Davies P.J. 2002. Geochemical dispersion at the Mount Torrens lead-zinc prospect, South Australia, with emphasis on acid sulfate soils. Cooperative Research Centre for Landscape Environments and Mineral Exploration (CRC LEME) Report 174, pp. 68 (plus 13 appendices).

Skwarnecki, M., Li Shu, Fraser, S.J. & Robertson, I.D.M. 2000. Geochemical orientation surveys and regolith geology in the S.W. Arunta Province, Northern Territory (Argos Project). CSIRO Exploration and Mining Restricted Report 677R. Reissued as CRC LEME Open File Report 82 2002, CRC LEME, Perth, pp. 75 (v1) + pp. 152 (v2) + pp. 45 (v3) + 5 maps + data disk.

Skwarnecki, M.S. & Fraser, S.J. 2000. Geochemical orientation soil-lag traverse at the Garland Gold Mine, Winnecke Goldfield, Northern Territory. CSIRO Exploration and Mining Restricted Report 740R. Reissued as CRC LEME Open File Report 83 2002, CRC LEME, Perth, pp. 34 + data disk.

Skwarnecki, M.S. & Fraser, S.J. 2000. Geochemical orientation soil-lag traverse at the Edwards Creek Base Metal Prospect, Strangways Range, Northern Territory. CSIRO Exploration and Mining Restricted Report 747R. Reissued as CRC LEME Open File Report 84 2002, CRC LEME, Perth, pp. 28 + data disk.

Skwarnecki, M.S., Li Shu & Lintern, M.J. 2001. Geochemical dispersion in the Olary District, South Australia: Investigations at Faugh-a-Ballagh Prospect, Olary Silver Mine, Wadnaminga Goldfield and Blue Rose Prospect. CSIRO Exploration and Mining Restricted Report 794R. Reissued as CRC LEME Open File Report 113 2001, CRC LEME, Perth, pp. 384.

Vasconcelos, P., 1998. Geochronology of weathering in the Mount Isa and Charters Towers Regions, Northern Queensland. CSIRO Exploration and Mining Restricted Report 451R. Reissued as CRC LEME Open File Report 139 2002, CRC LEME, Perth, pp. 185.

Wildman, J.E., 1997. The geochemical discrimination of mineralised and barren ironstones from the Selwyn Au-Cu Deposit, NW Queensland. CSIRO Exploration and Mining Restricted Report 341R. Reissued as CRC LEME Open File Report 128 2002, CRC LEME, Perth, pp. 29 + disk.

Wilford, J.R., 1997. Regolith-landform characteristics, evolution and implications for exploration over the Selwyn Region, Mt Isa. CSIRO Exploration and Mining Restricted Report 372R. Reissued as CRC LEME Open File Report 131 2002, CRC LEME, Perth, pp. 89 + maps.

Wilford, J.R., 1997. Regolith-landform characteristic, evolution and implications for exploration over the Buckley River – Lady Loretta Region, Mt Isa. CSIRO Exploration and Mining Restricted Report 407R. Reissued as CRC LEME Open File Report 132 2002, CRC LEME, Perth, pp. 95 + maps.

Wilford, J., Craig, M.A., Tapley, I.J. & Mauger, A.J., 1998. Regolith-landform mapping and its implications for exploration over the Half Moon Lake Region, Gawler Craton, South Australia. CRC LEME Restricted Report 92R. Reissued as CRC LEME Open File Report 80 2001, CRC LEME, Perth, pp. 98.

Field Guide Notes

Eggleton, T., Greene, R., Jenkins, B. & Davy, M. 2002. ACMS Inc. 18th Biennial Conference Field Guide: The Central Shoalhaven Plain. Australian Clay Minerals Society Inc. 18th Biennial Conference, Tuesday 30th April 2002 ACMS Inc, pp. 14.

Roach, I. 2001. Landscape evolution and regolith of the Monaro Volcanic Province Australian National University field trip to the Monaro Volcanic Province, NSW, 25 August 2001 CRC LEME/ANU.

Ely, K.S., Lawrie, K.C., Phillips, G. N., Gibson, D. L., Tan, K.P. & Heislers, D. 2002. Victoria Undercover – Benalla 2002 field excursion guide In Phillips, G.N. & Ely, K.S., (eds.), Victoria Undercover: Benalla 2002 Conference proceedings and field guide: collaborative geoscience in northern Victoria, pp. 281-284.

Shortcourse and Workshop Notes

Fisher, G. 2002. Field Safety, 10 April 2002, University of Canberra. CRC LEME Report No. 173, pp. 50.

Gibson, D. 2001. Regolith landscape evolution in the Goulburn-Broken Catchment–some preliminary observations from the Honeysuckle Creek airborne geophysics datasets. Honeysuckle Creek Airborne Geophysics Technical Workshop, November 2001.

Green, A. 2001. Honeysuckle Creek JLATs – preliminary observations on the M-DBC-funded airborne geophysics datasets. Honeysuckle Creek Airborne Geophysics Technical Workshop, November 2001.

Heinson, G., James, P., Schmidt Mumm, A. & Smith, A. 2002. Digital teaching and learning website and CR-ROM incorporating the Tate Museum.

Heinson, G.S.(ed), Barber, C. & Armstrong, D. 2001. Australian Groundwater School 2001. Fundamentals of Groundwater Science, Technology and Management Volume 2, pp. 339.

Kirste, D., de Caritat, P. & Hutcheon, I. 2002. Introduction to Hydrogeochemistry MTEC Honours shortcourse, 15-19 April 2002, University of Melbourne. CRC LEME Report pp. 172.

Lambert, I. B. 2002. A case for multi-disciplinary, multi-agency regional studies to underpin salinity mitigation decisions. Solutions for Catchment Management–Collaborative Workshop, BRS, Canberra.

Lawrie, K.C. 2001. Geology and regolith framework in Riverland and Tintinara areas – S.A. NAP SMMSP technical scoping workshop, Adelaide, September 2001.

Lawrie, K.C. 2001. Bedrock, structural geological and regolith framework on Wangarrata and Nagambie 1:250,000 mapping sheets – implications for Honeysuckle Creek airborne geophysics datasets, Victoria, Honeysuckle Creek Airborne Geophysics Technical Workshop, November 2001.

Lawrie, K.C. 2001. Mapping and Assessing Salinity Hazards – GILMORE Project overview. BRS-CRC LEME workshop, November 2001.

Lawrie, K.C. 2002. A systems approach to mapping and assessing salinity – value-adding to existing frameworks. Presentation to NSW NAP technical committee., May 2002.

Lewis, M., Mauger, A. & Stamoulis, V. 2002. ENVI/Hyperspectral Workshop for Geologists. CRC LEME Course, University of Adelaide, April 2002.

Munday, T.M. 2001. Results of forward modelling – Tintinara and Riverland. Presentation to SA NAP technical committee workshop, September 2001.

Roach, I. 2001. Beginning MapInfo: A shortcourse covering basic to intermediate skills for the MapInfo GIS MTEC Honours shortcourse, 10-11 & 12-13 July 2001, University of Canberra CRC LEME Report 161.

Roach, I., Hill, S., Fisher, G. & Foster, K.I. 2002. Regolith Mapping and Field Techniques MTEC Honours shortcourse, 29 – March-4 April 2002, Broken Hill, NSW CRC LEME Report 171.

Taylor, G., Robertson, I., Joyce, B. & Kotsonis, A 2002. Regolith Geology and Geochemistry MTEC Honours shortcourse, 4-8 March 2002, University of Melbourne, VIC. CRC LEME Report 170.

Maps and GIS Products

Brodie, R.C., Mackey, T.E. 2001. GILMORE GIS Volume 1 (5 CD volume).

Chamberlain, T. & Hill, S.M. 2002. Tibooburra Inlier Regolith-Landforms (1:25,000), CRC LEME. Canberra/Perth.

Craig, M.A. 2001. Regolith Landforms Map ET Gold Prospect, Gawler Craton, South Australia (1:50,000) CRC LEME, Perth WA.

Lawrie, H.E., K.C Gibson, D.L. Brodie, R.C. Wilford, J. Tan, K.P. Chan, R.A., Highet, L.M. 2001. GILMORE GIS Volume 2 (6CD volume). In Qa/Qc.

Lewis, A.C., Foster, K.A. & Hill, S. M. 2002. Mt Gipps Regolith-Landforms (1:25,000), CRC LEME, Canberra/Perth.

Senior, A.B., Debenham, S.C. & Hill, S.M. 2002. Pinnacles. Regolith-Landforms (1:25,000), CRC LEME, Canberra/Perth.

Confidential Reports and Maps

Brouwer, J. & Fitzpatrick, R.W. 2001. Characterisation of nine soils down a salt-affected toposequence near Gatum on the Dundas Tablelands in south-west Victoria: Application of the structural approach for constructing soil-water-landscape models. CSIRO Land & Water Technical Report. 21/00, pp.48.

Cornelius, M. & Porto, C.G. 2001. Interpretation of two geochemical traverses across base metal mineralization at the Aripuana Prospect, Mato Grosso, Brazil. Prepared for Anglo American plc. CRC LEME Restricted Report No 169R, pp. 22.

Eggleton, T. 2001. Quantitative XRD mineralogy of borehole materials from the GILMORE Project area, pp. 40.

Emerson, D. 2001. Petrophysics of bedrock and regolith materials in the GILMORE Project area. A report to Goldfields Exploration, pp. 20.

Green, A. 2001. AEM Modeling to choose an AEM system for the Riverland area. A report to the SA NAP technical committee, Oct. 2001, pp. 9.

Green, A. 2001. Tempest Modeling over Riverland and Tintinara Clay Holes. A report to the SA NAP technical committee, Sept. 2001, pp. 5.

Green, A. 2002. Analysis of Hoistem Calibration Data. A report to the SA NAP technical committee, March 2002, pp. 11.

Green, A., Brodie, R.C., Gibson, D., Lawrie, K.C. & Munday, T.J. 2001. Honeysuckle Creek airborne geophysics project – summary of technical workshop findings, November 2001. A report to M-DBC.

Hunter, D. & Munday, T.J. 2001. Interpretation of conductivity depth transform (CDT) visualisation products. A report to BRS/AFFA, pp. 8.

Lane, R., Brodie, R.C. & Gibson, D. 2002. A comparison of AEM and borehole conductivity data in the GILMORE Project area.

McPhail, D.C. 2002. Zinc Mobility and Low-Temperature Zinc Oxide Deposits. Report to Teck Cominco Ltd, Vancouver, B.C. Canada, pp. 36.

Neumann, N. & Lawrie, K.C. 2002. A report on the XRD mineralogy and geochemistry of saprolith materials from selected drillholes in the GILMORE Project area. A report to Goldfields Exploration.

Neumann, N. & Lawrie, K.C. 2001. Geochemistry of the volcanic and intrusive rocks of the Gidginbung Volcanic Belt. A report to Goldfields Exploration.

Scott, K.M. & McQueen, K.G. 2001. The mineralogy and geochemistry of New Cobar Au-Cu mineralisation in the oxidate and supergene zones, Cobar district, western NSW. Prepared for Peak Gold Mines Pty Ltd. CRC LEME Restricted Report No. 167R, pp. 36.

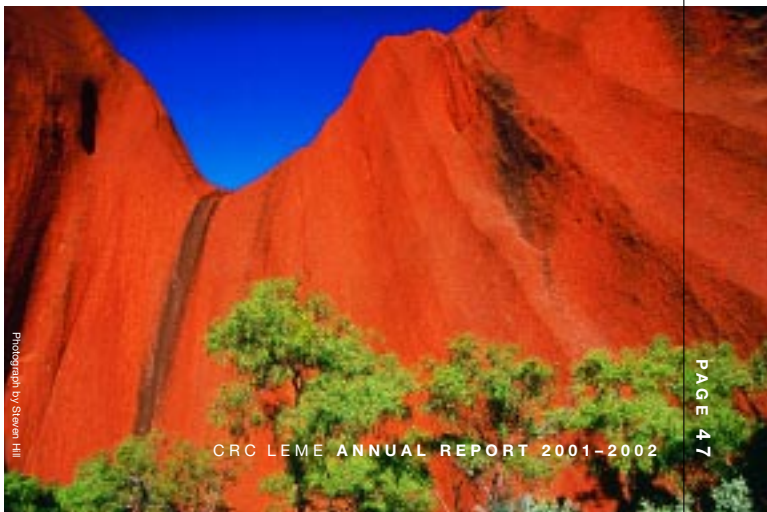
Shirtliff, G. 2001. Auxiliary Report: Identification of minerals in samples of suspended sediment from Ranger Uranium Mine, Northern Territory, Australia. Prepared for EWLS Pty.Ltd. and ERA – Rio Tinto, pp. 16.

Shirtliff, G. 2001. Progress Report: Weathering of wasterock at Ranger Uranium Mine, Northern Territory, Australia. Prepared for EWLS Pty.Ltd. and ERA – Rio Tinto.

Shirtliff, G. 2002 Ph.D. Mid-term Report Prepared for EWLS Pty.Ltd. and ERA – Rio Tinto, pp. 76.

Wells, M.A. & Scott, K.M. 2001. Mineralogy of the Mn-Ni-Co association in the Syerston Ni-Co-Pt deposit, New South Wales. Prepared for Black Range Minerals Ltd. CRC LEME Restricted Report No 165R, pp. 31.

Wilford, J. 2001. 3D modelling of hydromorphic dispersion of Cu and Au in the GILMORE Project area, NSW. A report to Goldfields Exploration.



Photograph by Steven Hill

11. Communication and Public Relations

Photograph by Ian Robertson

Photograph by Steven Hill

CRC LEME was launched in Adelaide on 30 November by the South Australian Minister for Minerals and Energy, The Hon. Wayne Matthew MHA. The *Victoria Undercover* conference, held in Benalla at the end of April, was an excellent opportunity for CRC LEME staff and students to meet with a diverse range of researchers and land users with interests in Victoria. Dr Rob Fitzpatrick and Dr Richard Greene were invited to deliver keynote addresses at international conferences.

Communication of CRC LEME's activities, results and major events is an essential component of the Centre's strategic plan. The Centre aims to communicate its work to industry, the scientific and broader communities by:

- Creating awareness among industry, governments, research and educational institutions and the public of CRC LEME's activities, outcomes and future directions;
- Informing CRC LEME stakeholders about CRC LEME developments that will aid the discovery of new mineral deposits and support the mapping and control of salinity problems in Australia;
- Informing CRC LEME stakeholders about the Centre's activities and the assistance that it can provide.

During the year CRC LEME appointed Martin Davidson as Communications Officer and the Centre's website was substantially redeveloped. Martin left the Centre at the end of June 2002 and will be replaced by a new Communications Officer.

Launch

A ceremony to mark the launch of CRC LEME was held in Adelaide on 30 November 2001. South Australian Minister for Minerals and Energy, The Hon. Wayne Matthew MHA officiated. Staff and students from various CRC LEME partners and members of the Governing Board joined invited guests at the launch.

Victoria Undercover

A major achievement and highlight of the year was the *Victoria Undercover: collaborative geoscience in Northern Victoria* conference held in Benalla, Victoria from 30 April to 2 May 2002. This event brought together representatives from 2 CRCs, 11 universities, 13 Government or public sector organisations (incuding local, state and federal authorities) and 18 commercial stakeholders. Regolith geoscience and the activities of CRC LEME in particular formed a major portion of the program.

Conferences, Seminars and Meetings

CRC LEME personnel were active participants in regional, national and international conferences related to regolith geoscience. Notably:

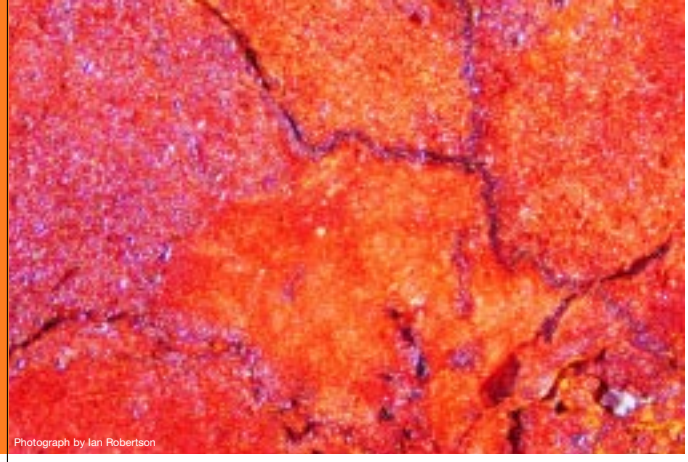
- Dr Rob Fitzpatrick (PIRSA/UofA) delivered three keynote papers at the 2001 American Society of Agronomy Annual Meeting in Charlotte, North Carolina in October 2001;
- Dr Richard Greene (ANU) was invited to deliver a keynote address at an international symposium on the significance of soil surface characteristics in soil erosion at the University Louis Pasteur, Strasbourg, France in September 2001.

In addition to the major events listed in the accompanying table, CRC LEME participants hosted 21 seminars during the year. Presented by Centre personnel and by visiting speakers, these events were well-attended and either contributed to regular departmental seminar programs or where scheduled as special events.

< The launch of CRC LEME. Left to right: Dr Neville Alley, Mr John Keeling, Dr Ray Smith, The Hon. Wayne Matthew MHA, Dr Ross Fardon.

Conferences, Seminars and Meetings

Event	Venue/Location	Date	Participants	Role
Regolith functions in dryland salinity—seminar	ANU, ACT	4/7/2001	Richard Greene, Andrew McPherson, Ray Smith	Coordinators, Participant, Co-host
Regolith dating, erosion rates and the antiquity of Australian landscapes—seminar	CSIRO Floreat	10/7/2001	John Chappell, Brad Pillans	Speakers
National Local Government Salinity Summit	Moama-Echuca, Victoria	17–19/7/2001	Colin Pain, Ian Lambert, Ken Lawrie	Participants
Victorian Exploration Workshop	University of Ballarat, Victoria	27/7/2001	Keith Scott	Participant
Biogeochemistry of Trace Elements	Guelph, Ontario, Canada	29/7/2001 –2/8/2001	Patrice de Caritat	Presenter
Gordon Research Conference on Inorganic Geochemistry	New Hampshire, USA	19–24/8/2001	Charles Butt	Invited speaker
Canadian Quaternary Association conference	Whitehorse, Yukon, Canada	20–24/8/2001	Ken McQueen	Presenter
The significance of soil surface characteristics in soil erosion—international symposium	University Louis Pasteur, Strasbourg, France (organised by COST 623)	20/9/2001	Richard Greene	Keynote Presenter
7th Australasian Conference on Isotopes in the Environment	Robertson, NSW	24–26/9/2001	Dirk Kirste, Patrice de Caritat	Presenters
4th International Archaean Symposium	University of WA, Perth	24–28/9/2001	Ray Smith	Participant
ASEG (WA) Technical Meeting – Annual Students' Night	Celtic Club, West Perth	17/10/2001	Bronwyn Calleja, Tristan Campbell, Margarita Norvill, Karen Pittard	Presenters
2001 American Society of Agronomy Annual Meeting	Charlotte, North Carolina	21–23/10/2001	Rob Fitzpatrick	Keynote Presenter
Sydney Mineral Exploration Discussion Group Symposium	Sydney, NSW	14/11/2001	Ray Smith	Presenter
Gawler Craton Explorers' meeting	PIRSA, Adelaide	12–14/112001	Many CRC LEME personnel attended	Participants
New Generation Gold 2001	Perth, WA	26–27/11/2001	Ravi Anand, Charles Butt	Participants
Annual Conference of the New Zealand Geological Society	Hamilton, New Zealand	27–29/11/2001	Brad Pillans	Presenter
Cohesion in Soils of Coastal Tablelands—work meeting	Aracaju, Sergipe, Brazil (organised by Embrapa)	28/11/2001	Richard Greene	Invited Presenter
Geological Survey of WA In-house Regolith Course	Perth, WA	6/3/2002	Ian Robertson	Presenter
Salt of the Earth: Mapping and Management of the Murray Basin	South Australian Bee-Keeping Association, Adelaide	7/3/2002	Graham Heinson	Guest Presenter
UWA Geology Department Honours Class seminar	UWA	23/4/2002	Nigel Radford	Guest Presenter
18th Australian Clay Minerals Society Conference	ANU, Canberra	29/4/2002 – 1/5/2002	Many CRC LEME personnel participated	Presenters, Attendees
Victoria Undercover: collaborative geoscience in Northern Victoria	Benalla, Victoria	30/4/2002 – 2/5/2002	Many CRC LEME personnel participated	Speakers, Attendees, Co-host
ASEG WA Technical Seminar	Celtic Club, West Perth, WA	15/5/2002	Don Hunter	Presenter
Exploration NSW Data Release	Parliament House, Sydney, Australia	23/5/2002	Keith Scott	CRC LEME Representative
12th International Soil Conservation Organisation Conference	Beijing, China	26–31/5/2002	Rob Fitzpatrick	Invited Presenter, Guest Author for book launch



Photograph by Ian Robertson

Conferences, Seminars and Meetings (cont'd)

Event	Venue/Location	Date	Participants	Role
64th Conference and Technical Exhibition, European Association of Geoscientists & Engineers	Florence, Italy	27–30/5/2002	Anton Kepic, Dominic Howman	Presenters
AusIMM Branch Meeting	Cobar Branch of the AusIMM, NSW	30/5/2002	Nigel Radford	Guest Presenter
IGARSS 2002—24th Canadian Symposium on Remote Sensing: Remote Sensing: Integrating Our View of the Planet	Toronto	24–28/6/2002	Vicki Stamoulis	Participant

Media Releases and Reports

A number of media releases were distributed during the year. Details and subsequent media response is listed in the following table.

Media Releases and Reports

Subject	CRC LEME Talent	Publication	Date
Dust storms and salinity	Richard Greene	ANU Reporter	28/3/2002
		Canberra Times	31/3/2002
		ABC Online News	2/4/2002
		Weekly Times	1/5/2002
Down to earth with regolith —Broken Hill MTEC regolith mapping Honours short course	Ian Roach	Barrier Daily Truth	4/4/2002
Red earth's secrets revealed —Broken Hill MTEC regolith mapping Honours short course		University of Canberra Monitor	30/4/2002
Startrack	Mel Lintern	Slattery's Internet Watch	6/5/2002
CSIRO/CRC LEME crime fighters —involving the forensic regolith work by staff in Adelaide who assisted detectives to conclude a major homicide case	Rob Fitzpatrick, Mark Raven & Richard Merry	ABC TV Stateline	14/6/2002

12. Grants and Awards

Photograph by Ian Robertson

CRC LEME personnel received several prestigious awards during the year including a Churchill Fellowship. Australian Research Council grant success was marked by two ARC Linkage Grants and an ARC Linkage Infrastructure Grant. Staff have contributed to exploration and research communities through their service on a number of committees and working groups. Centre personnel were invited to deliver four keynote addresses.

The efforts of CRC LEME staff and students were recognised in a number of ways during the reporting period.

In 2001, PIRSA Research Scientist and CRC LEME MSc student, Ms Vicki Stamoulis won a Churchill Fellowship that allowed her to advance her expertise in hyperspectral mineral mapping. The fellowship funded an international study tour in 2002 including South Africa, Europe and North America where Vicky met and shared expertise with leading hyperspectral mineral mappers from the exploration industry, education institutions and government bodies.

In May 2002, Dr Charles Butt, CRC LEME Interim Program Leader, was awarded the Gibb-Maitland Medal by the Geological Society of Australia—Western Australian Division for his international contribution to geoscience (regolith geology and exploration geochemistry).

Greg Street won the inaugural Lindsay Ingall Memorial Award in 2001. This award was established to recognise achievements in the promotion of geophysics in the wider community. Greg is well known in the exploration industry, a part-time PhD student at CUT and now works for Sinclair, Knights and Merz Pty Ltd.

David Gibson, Roslyn Chan, Lindsay Highet and Penny Kilgour from Geoscience Australia won an award for Excellence in Cartography at the 20th International Cartographic Conference in Beijing for their Forbes First Edition 1:250,000 scale regolith-landform map.

ARC Linkage Grants

CRC LEME staff were successful in winning three Australian Research Council (ARC) grants during the reporting period.

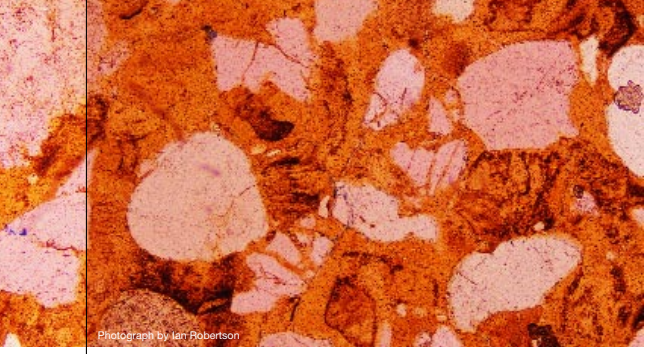
At Curtin University of Technology, Dr Anton Kepic will receive almost $67,000 over three years (from 2001–2004) for a project investigating the use of distributed sensor arrays in enhancing electromagnetic and induced polarisation geophysical surveys. Funding for this project includes an APAI scholarship and MIM Exploration Pty Ltd is the industry partner.

At the University of Adelaide, Professor Stewart Greenhalgh and Dr Graham Heinson will receive $47,000 over three years (2002–2005) to research signal processing techniques to improve signal-to-noise ratio of electrical and electromagnetic data. Zonge Engineering Pty Ltd is the industry partner in that project.

Also at the University of Adelaide, Dr Andreas Schmidt Mumm, shared an ARC Linkage Infrastructure Grant of $480,000 to establish a world-class research facility for the *in situ* study of particle and material interfaces. The University of South Australia, The University of Adelaide and the University of Newcastle formed a team to bid for these funds and were supported by South Australian Museum and Forensic Science, SA as industry partners.

Appointments

Name	Position
Rob Fitzpatrick	President, Australian Clay Minerals Society (2002–4) Affiliate Associate Professor, School of Earth Sciences; The University of Adelaide (2002–7) Associate Editor, Soil Systems, The Scientific World (2001–)
Stewart Greenhalgh	Member, Stage1 5th year Review Team, CRC Centre for Mining Technology and Equipment in June 2002.
Jayson Meyers	Associate Professor of Mineral Geophysics, Centre of Excellence for Exploration and Production Geophysics, Curtin University of Technology
Colin Pain	Member, Working Group on Land Resource Assessment/Steering committee, Australian Collaborative Land Evaluation Program
Mark Raven	Treasurer, Australian Clay Minerals Society (2002–4)
Norm Uren	Board Member, ASEG Research Foundation Member, SEG International Affairs Committee
Paul Wilkes	Member, Airborne Geophysical Technical Advisory Group, WA Vice Chairman, ASEG Technical Standards Committee



Photograph by Ian Robertson

CRC LEME Student Prizes

Name	Prize
Brian Barrett (UofA)	Best Geophysics Poster, Geophysical Methods for Fresh Water Detection in Saline Ground Water Environments, Victorian Institute of Earth and Planetary Sciences (sponsored by Specialty Group in Solid Earth Geophysics), 15th Victorian Universities Earth Science Conference 27/9/2001
Hashim Carey (UofA)	Best Geophysics Oral Presentation, Numerical Modelling of the Mise-à-la-Masse Method: The near-miss scenario, 15th Victorian Universities Earth Science Conference 27/9/2001
Karen Pittard (CUT)	Best Minerals Paper, ASEG (WA Branch) Student Night, October 2001.
Greg Shirtliff (ANU)	2001 ATSE Symposium Fellowship, Short essay and research relevance to the academy, The Australian Academy of Technological Sciences and Engineering, November 2001
Michael Wall (UofA)	Best overall poster, Stratigraphy and Salt Interception Schemes, River Murray, Waikerie Area, South Australia, Victorian Institute of Earth and Planetary Sciences (sponsored by La Trobe Earth Sciences), 15th Victorian Universities Earth Science Conference 27/9/2001

CRC LEME Grant recipients

Recipient	Project title	Grant type	Period	Source	Amount
Ken McQueen (UC)	CANQUA Conference in Whitehorse, Canada	Travel Grant	2001	UC	$1200
Anton Kepic (CUT)	The use of distributed sensor arrays in enhancing electromagnetic and induced polarisation geophysical surveys	ARC Linkage	2001–2003	ARC	$66,876
				MIM Exploration	
Graham Heinson (UofA), Andreas Schmidt Mumm (UofA), Patrick James (UofA)	Development and Implementation of web-based resources for fieldwork, laboratory specimens and student research projects in the geosciences	Faculty Development	2001–2002	UofA	$9,700
Graham Heinson (UofA), Stewart Greenhalgh (UofA), M Hatch (Zonge)	Signal processing techniques to improve signal-to-noise ratio of electrical and electromagnetic data	ARC Linkage	2002	ARC	$47,000
				Zonge Engineering	$10,000
Stewart Greenhalgh (UofA)	A theoretical study of potential field gradient methods for exploration beneath cover	Project support	2002	ASEG Research Foundation	$2,200
Dr Andreas Schmidt Mumm (UofA) University of South Australia University of Newcastle	World-class research facility for the *in situ* study of particle and material interfaces	ARC Linkage Infrastructure Grant	2001–4	ARC	$480,000
				South Australian Museum	
				Forensic Science SA	

13. Performance Indicators

The following performance indicators form part of the agreement between CRC LEME and the Commonwealth. These indicators measure progress towards the objectives of the Centre (see front cover).

Since this report relates to the first year of operation of CRC LEME, it has not been possible to provide longitudinal data series. These will build over the years of operation of the Centre. In addition, it has not been possible to produce valid baseline figures. Figures from the Centre's predecessor were not considered to provide a meaningful comparison due to the extended size, broadened scope and change of focus of CRC LEME.

Objectives of the Centre

This section lists broad indicators of the Centre's progress towards its objectives.

- The Centre will increase the number of companies, user agencies and institutions requesting and/or participating in CRC LEME projects and activities.
- To ensure that the work of the Centre is maintained at a global standard and to build its worldwide reputation, international collaboration is vital. In particular, the CRC LEME will:
  - Attract overseas researchers working in CRC LEME and encourage visits by CRC LEME staff to counterpart institutions overseas
  - Develop research projects overseas with clear benefits to Australia
  - Encourage requests for CRC LEME collaboration from companies, user agencies and institutions overseas

Quality and Relevance of the Research Program

To ensure the quality and relevance of its research program, CRC LEME will:

- Increase 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 to present keynote addresses, papers, and workshops at national and international conferences
- Increase the number of eminent scholars choosing to undertake sabbatical visits to CRC LEME centres
- Ensure appropriate recognition of the significance of the Centre's research by the granting of honours and awards upon Centre staff
- Increase the number of companies and agencies using the CRC LEME-developed protocols for exploration in covered and regolith-dominated terrains
- Promote CRC LEME innovations in airborne salinity mapping for management and remediation of dryland salinity and in other land care issues
- Obtain acknowledgment of the roles played by CRC LEME concepts, methods and technologies in mineral discoveries by exploration and mining companies
- Obtain acknowledgment of the roles played by CRC LEME concepts, methods and technologies in environmental issues by Commonwealth, state and local government bodies and by environmental and engineering companies
- Implement internal peer review of research and education programs after year 1
- Implement independent external peer review of research and education programs during year 4

Objectives of the Centre

Performance indicator	2001/02
Number of annual student class hours of regolith-related lectures and lab/field work	600
Number of short courses and student course hours per year	7/320
Number of student class hours on environmental topics	200
Number of sponsors and the annual value of sponsorship	13/$756,540
Number of overseas researchers visiting CRC LEME sites	4
Number of overseas visits by CRC LEME staff	19
Number and value of overseas research projects	1/$27,489
Number of external research collaborators	47

Quality and Relevance of the Research Program

Performance indicator	2001/02
Number of published journal articles per year	54
Number of conference papers presented per year	50
Number of books or chapters in books	20
Other forms of publications/maps etc	28
Number of open file reports completed	36
Number of confidential reports, maps, etc	18
Number of keynote addresses given	4
Number of sabbatical leaves taken by overseas personnel at CRC LEME sites	3
Number of awards to CRC LEME researchers and educators	3

cont'd overpage

Quality and Relevance of the Research Program (cont'd)

Performance indicator	2001/02
Number of ARC Grants awarded to CRC LEME researchers	3 ($694k)
Number of CRC LEME outputs applied to salinity/environment issues	73
Number of CRC LEME outputs applied to exploration issues	65
Number of acknowledgments to CRC LEME by companies and Government	8

Strategy for Utilisation and Commercialisation of Research Outputs

In order to realise the benefits flowing from CRC LEME research, the centre will:

- Increase 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, textbooks and other materials
- Ensure that concepts, methods and technologies developed within the Centre are adopted by industry, university and government users of the research
- Increase the number of articles published in industry journals
- Prepare and distribute occasional CRC 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 user organisations
- Secure adequate funding from companies, user agencies and institutions for Centre projects
- Involve personnel from industry and user agencies in the Centre's research.

Strategy for Utilisation and Commercialisation of Research Outputs

Performance indicator	2001/02
Number of short courses	6
Number of items sold (open file reports, manuals, course notes, etc)	120
Number of articles in prospecting magazines	3
Number of reports to sponsors and companies	15
Number of collaborative projects with industry users and user organisations	49
Annual external research income	$782k

Education and Training

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

- Increase the number of postgraduate research scholars conducting and completing their degrees within the Centre or through universities associated with the Centre
- Produce a continuing stream of Bachelor Degree Honours graduates from the core-party 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
- Ensure postgraduate research and Honours students have an opportunity to work in a non core-party university during their studies
- Allocate an advisor for all postgraduate research and Honours students outside their enrolled university and preferably in a non-university core party or other external partner
- Develop a formal Masters by Coursework Degree in Regolith Studies
- Increase the profile of regolith geology in undergraduate courses of core party and other Australian universities via an annual National Undergraduate Regolith Geology School
- Market and provide professional short courses and workshops to research users and increase awareness of the Centre's research in the community at large.

Education and Training

Performance indicator	2001/02
Number of Postgraduate students working on CRC LEME research projects	38
Number of Postgraduate awards each year	1
Number of BSc Honours graduates completing CRC LEME projects	16
Number of BSc Honours graduates commenced/continuing CRC LEME projects	37
Number of class hours taught by CRC LEME personnel	1120
Number of external supervisors of research students	20
Number of student class hours of instruction in Masters by course work degrees related to the regolith	80
Number of students participating in NURGS or similar programs	12

Collaborative Arrangements

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

- Maintain an appropriate mix of staff, in terms of disciplines/sub-disciplines, function etc, within and across the core-parties
- Develop multi-disciplinary, project-based research teams involving staff from several core parties and/or supporting participants
- Establish a culture of collaboration between the core parties, such that the collaboration will continue beyond the life of the Centre
- Ensure that the mineral and environmental industries and other user groups participate in the functioning of the Centre, including the Board, User Advisory Council, in project generation, support and collaboration, education, technology transfer and application of research findings
- Develop collaborative projects where overseas researchers participate in the Centre's research to the benefit of Centre staff and students
- Attract leading scientists from overseas for sabbatical study.

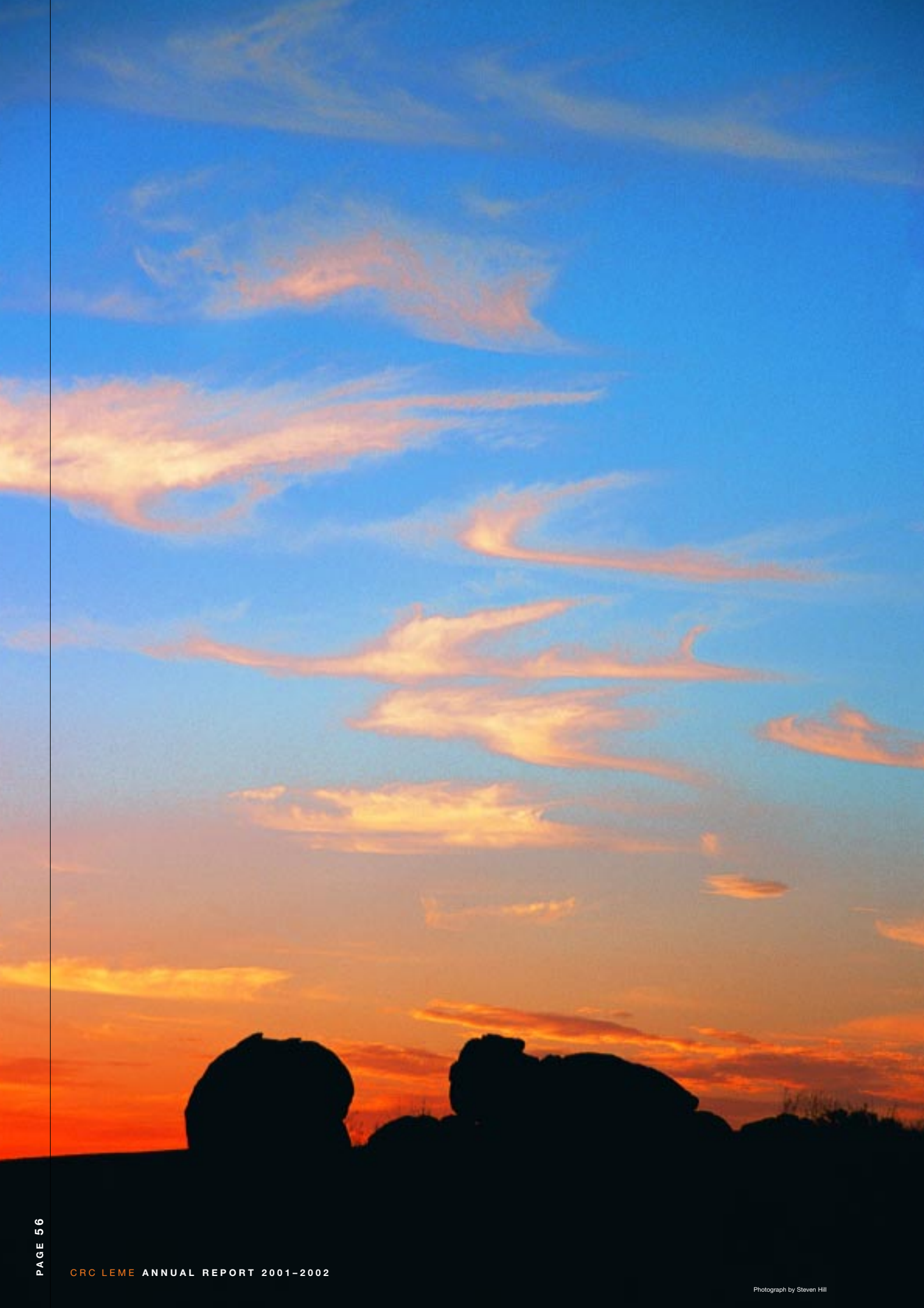
Photograph by Steven Hill

Collaborative Arrangements

Performance indicator	2001/02
Develop a capability profile for CRC LEME researchers	Yes
Number of themes developed within research programs	9
Attract at least one leading overseas scientist per year to a CRC LEME site	Yes
Number of external stakeholders involved in the direction of CRC LEME through the Governing Board and Advisory Councils	14
Number of projects involving international collaborators	6

Resources and Budget

Performance indicator	2001/02
Total income from all sources (cash and in-kind excluding CRC Grant)	$17.65m
FTE research staff (excluding students)	73.3
FTE technical and other support staff	11.1



Photograph by Steven Hill

14. Budget and Finances

As at 30 June 2002, each of the CRC LEME Core Participants met or exceeded its in-kind contribution target defined in the Commonwealth Agreement. The total cash income received for collaborative activities from industry and other users in Year 1 was $0.89m. These substantial achievements were made in the face of a general downturn in the mineral industry and the global economy.

The leverage of actual contributed resources to CRC Program funding from the Commonwealth was 6.4:1.

Actual contributed resources

Item	Value
Total Cash from Industry and other users, and from Core Participants	$3.48m
Total In-Kind resources from Core Participants	$14.17m
Total Actual Contributed Resources	$17.65m
CRC Program funds	$2.754m
Leverage on CRC funding	6.41

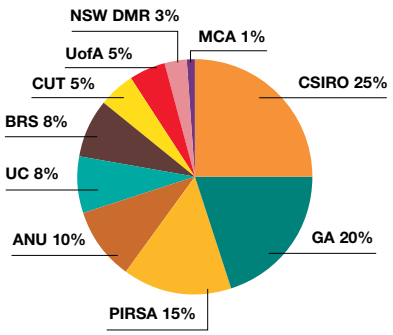
All figures for Year 1 only

Financial Reports for 2001/2002

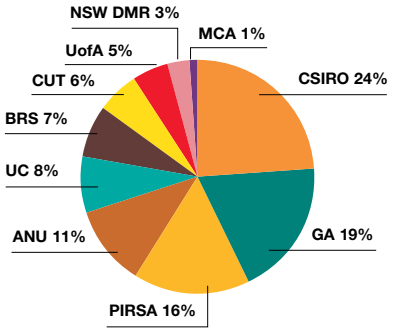
The following statements and accounting policy notes represent the known financial status as at 30 June, 2002.

Core Party equity positions are summarised as follows:

Core participant equity as per Commonwealth Agreement as at 30/06/2002 (Year 1)



Core participant actual cumulative equity as at 30/06/2002 (Year 1)



Total External Income

CRC LEME has exceeded the year 1 external income target set in the Commonwealth Agreement.

Total external income

Item	Year 1 ($'000s)	Cumulative ($'000s)
Budget	765	765
Actual	892	892
Variance	+127	+127

In-Kind Contributions

Cumulative Core Participant in-kind contributions through to 30 June 2002 are summarised below:

Cumulative Core Participant in-kind contributions ($'000s)

Participant	Budget Year 1*	Actual Contributions Year 1	Cumulative Variance Year 1
Commonwealth Scientific and Industrial Research Organisation	3,678	3,892	+214
Australian National University	1,345	1,600	+255
Curtin University of Technology	649	798	+149
The University of Adelaide	629	687	+58
University of Canberra	1,046	1,166	+120
Geoscience Australia	2,917	2,947	+30
Bureau of Rural Sciences	330	332	+2
Primary Industries and Resources South Australia	2,277	2,490	+213
NSW Department of Mineral Resources	246	253	+7
Minerals Council of Australia	N/A	N/A	N/A

*as per Commonwealth Agreement

Table 14.1 In-kind contributions from partners

Participant	Expenditure (dollars in '000s)				Projected expenditure (dollars in '000s)						Grand 7-year total (dollars in '000s)			
	2001-02		Cumulative total to date		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Total	Agreement	Difference	Agreement
	Actual	Agreement	Actual	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement		(revised)		(original)
Commonwealth Scientific and Industrial Research Organisation														
Salaries	1,333	942	1,333	942	989	1,039	1,091	1,145	1,202	1,262	8,061	7,670	391	7670
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	2,559	2,736	2,559	2,736	2,964	3,111	3,267	3,173	2,931	2,844	20,849	21,026	(177)	21026
Total	3,892	3,678	3,892	3,678	3,953	4,150	4,358	4,318	4,133	4,106	28,910	28,696	214	28696
Australian National University														
Salaries	474	384	474	384	403	423	445	467	490	515	3,217	3,127	90	3127
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	1,126	961	1,126	961	1,133	1,190	1,249	1,311	1,233	1,212	8,454	8,289	165	8289
Total	1,600	1,345	1,600	1,345	1,536	1,613	1,694	1,778	1,723	1,727	11,671	11,416	255	11416
Curtin University of Technology														
Salaries	329	307	329	307	351	368	387	406	427	448	2,716	2,694	22	2694
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	469	342	469	342	590	620	651	683	629	611	4,253	4,126	127	4126
Total	798	649	798	649	941	988	1,038	1,089	1,056	1,059	6,969	6,820	149	6820
The University of Adelaide														
Salaries	314	287	314	287	379	398	418	439	462	484	2,894	2,867	27	2868
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	373	342	373	342	649	681	715	751	717	710	4,596	4,565	31	4565
Total	687	629	687	629	1,028	1,079	1,133	1,190	1,179	1,194	7,490	7,432	58	7433
University of Canberra														
Salaries	314	262	314	262	298	313	329	345	362	380	2,341	2,289	52	2289
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	852	784	852	784	645	677	613	559	533	528	4,407	4,339	68	4339
Total	1,166	1,046	1,166	1,046	943	990	942	904	895	908	6,748	6,628	120	6628
Geoscience Australia														
Salaries	974	692	974	692	726	762	800	840	882	926	5,910	5,628	282	5627
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	1,973	2,225	1,973	2,225	2,329	2,445	2,567	1,723	1,738	1,785	14,560	14,812	(252)	14812
Total	2,947	2,917	2,947	2,917	3,055	3,207	3,367	2,563	2,620	2,711	20,470	20,440	30	20439
Bureau of Rural Sciences														
Salaries	193	192	193	192	202	212	222	234	245	257	1,565	1,564	1	1563
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	139	138	139	138	145	152	160	168	177	186	1,127	1,126	1	1126
Total	332	330	332	330	347	364	382	402	422	443	2,692	2,690	2	2689
Primary Industries and Resources South Australia														
Salaries	506	389	506	389	408	428	449	472	495	520	3,278	3,161	117	3161
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	1,984	1,888	1,984	1,888	406	427	448	470	494	518	4,747	4,651	96	4651
Total	2,490	2,277	2,490	2,277	814	855	897	942	989	1,038	8,025	7,812	213	7812
NSW Department of Mineral Resources														
Salaries	224	218	224	218	230	242	254	266	280	294	1,790	1,784	6	1783
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	29	28	29	28	29	31	32	34	36	38	229	228	1	228
Total	253	246	253	246	259	273	286	300	316	332	2,019	2,012	7	2011
Minerals Council of Australia														
Salaries	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Supporting contributions														
Salaries	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total in-kind contributions														
Salaries	4,661	3,673	4,661	3,673	3,986	4,185	4,395	4,614	4,845	5,086	31,772	30,784	988	30782
Capital	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Other	9504	9444	9504	9444	8890	9334	9702	8872	8488	8432	63222	63162	60	63162
Grand Total in-kind (T1)	**14165**	**13117**	**14165**	**13117**	**12876**	**13519**	**14097**	**13486**	**13333**	**13518**	**94994**	**93946**	**1,048**	**93944**

Table 14.2 Cash contributions

Partner	Contribution (Dollars in '000s)				Projected (Dollars in '000s)						Grand 7-year total (dollars in '000s)			
	2001-02		Cumulative total to date		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Total	Agreement	Difference	Agreement
	Actual	Agreement	Actual	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement		(revised)		(original)
CSIRO	150	150	150	150	100	100	100	100	100	100	750	750	-	750
Australian National University	100	100	100	100	100	100	100	100	100	100	700	700	-	700
Curtin University of Technology	100	100	100	100	100	100	100	100	100	100	700	700	-	700
The University of Adelaide	100	100	100	100	100	100	100	100	100	100	700	700	-	700
University of Canberra	100	100	100	100	100	100	100	100	100	100	700	700	-	700
Geoscience Australia	100	100	100	100	100	100	100	100	100	100	700	700	-	700
Bureau of Rural Sciences	810	810	810	810	1,268	858	858	-	-	-	3,794	3,794	-	3,794
Primary Industries and Resources SA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NSW Department of Mineral Resources	250	250	250	250	250	250	250	250	150	-	1,400	1,400	-	1,400
Minerals Council of Australia	100	100	100	100	100	100	-	-	-	-	300	300	-	300
Total cash from participants	1,810	1,810	1,810	1810	2,218	1,808	1,708	850	750	600	9,744	9,744	-	9,744
Supporting Participants	-	-	-	0	150	150	150	-	-	-	450	450	-	450
Other cash	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Non-participants	-	400	-	400	500	600	400	-	-	-	1,500	1,900	(400)	1900
External grants	-	-	-	0	-	-	-	-	-	-	-	-	-	-
Contract research	696	300	696	300	400	600	800	900	1,000	1,100	5,496	5,100	396	5100
Commercialisation	-	30	-	30	120	355	520	640	640	640	2,915	2,945	(30)	2945
Education	86	20	86	20	45	88	120	120	120	120	699	633	66	633
Interest income	110	15	110	15	15	15	15	15	15	15	200	105	95	105
Total	892	765	892	765	1,080	1,658	1,855	1,675	1,775	1,875	10,810	10,683	127	10683
Funding from the CRC grant	2,754	2,754	2,754	2754	3,300	3,300	3,300	3,300	2,700	1,546	20,200	20,200	-	20200
Total CRC cash contribution (T2)	5,456	5,329	5,456	5329	6,748	6,916	7,013	5,825	5,225	4,021	41,204	41,077	127	41077
Cash carried over from previous year*	777	2,406	-	-	4,035	5,377	6,361	6,672	6,774	6,865	-	-	-	-
Less Unspent Balance	2,504	4,035	-	2406	5,377	6,361	6,672	6,774	6,865	6,477	-	-	-	-
Total cash expenditure (T3)	3,729	3,700	3,729	3700	5,406	5,932	6,702	5,723	5,134	4,409	37,035	37,006	29	41077
Allocation of cash expenditure between heads of expenditure														
Salaries	1,916	1,900	1,916	1900	3,333	3,569	3,742	2,946	2,306	1,830	19,642	19,626	16	21351
Capital	-	-	-	0	98	96	116	101	-	-	411	411	0	411
Other	1,813	1,800	1,813	1800	1,975	2,267	2,844	2,676	2,828	2,579	16,982	16,969	13	19315

*Balance brought forward at 1.7.01 relates to funds from CRC LEME 1 brought into CRC LEME 2

Table 14.3 Summary of resources applied to activities of centre

Item	Actual (dollars in '000s)										Grand 7-year total (dollars in '000s)			
	2001-02		Cumulative total		2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	Total	Agreement (revised)	Difference	Agreement (original)
	Actual	Agreement	Actual	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement	Agreement				
Grand total, in-kind (T1)	14,165	13,117	14,165	13,117	12,876	13,519	14,097	13,486	13,333	13,518	94,994	93,946	1,048	93,944
Grand total, cash expenditure (T3)	3,729	3,700	3,729	3,700	5,406	5,932	6,702	5,723	5,134	4,409	37,035	37,006	29	41,077
Total resources applied to activities of Centre	17,894	16,817	17,894	16,817	18,282	19,451	20,799	19,209	18,467	17,927	132,029	130,952	1,077	135,021
Allocation of total resources applied to activities of Centre between Heads of expenditure														
Total salaries, cash & in-kind	6,577	5,573	6,577	5,573	7,319	7,754	8,137	7,560	7,151	6,916	51,414	50,410	1,004	52,133
Total capital, cash & in-kind	-	-	-	-	98	96	116	101	-	-	411	411	-	411
Total other, cash & in-kind	11,317	11,244	11,317	11,244	10,865	11,601	12,546	11,548	11,316	11,011	80,204	80,131	73	82,477

Table 14.4 Allocation of resources between categories of activities

Program	Resource usage (dollars in '000s)						
	Expenditure				Research staff (FTE's)		
	Cash	In-kind	Total	%	In-kind contribution	CRC-funded	Total
Research	1,696	11,156	12,852	72%	16.53	13.92	30.45
Education	676	1,915	2,591	14%	2.53	0.90	3.43
External communications	-	-	-	-	-	-	-
Commercialisation/Tech. transfer	137	221	358	2%	2.30	1.30	3.60
Administration	1,220	873	2,093	12%	1.04	0.30	1.34
Total	3,729	14,165	17,894	100%	22.40	16.42	38.82

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 invoicing. In general, all income is received by CSIRO, the Centre's 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 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 2001, and for which goods had not been receipted at 30 June 2002.

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 Participant. 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. Refer to table 14.5.

The in-kind contribution 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. Refer to table 14.6.

No major items of capital expenditure (individual items exceeding $20K) were purchased in the financial year ending 30 June 2002.

Table 14.5 Costing of salaries and on-costs by the Core Participants

Core Participant	Salary on-costs as a multiple of base salary
CSIRO (CSS Superannuation)	0.3185
CSIRO (PSS Superannuation)	0.2205
Australian National University	0.2889
Curtin University of Technology	0.2806
The University of Adelaide	0.2942
University of Canberra	0.3426
Geoscience Australia	0.2050
Bureau of Rural Sciences	0.2632
Primary Industries and Resources South Australia	0.2590
NSW Department of Mineral Resources	0.3300
Minerals Council of Australia	N/A

Table 14.6 Infrastructure overhead multipliers of core participants

Core Participant	In-kind staff	CRC-funded staff
CSIRO	1.3400	1.3400
Australian National University	2.3656	2.3656
Curtin University of Technology	1.2800	1.2800
The University of Adelaide	1.5400	1.5400
University of Canberra	1.5000	1.5000
Geoscience Australia	2.1500	2.1500
Bureau of Rural Sciences	0.9095	0.9095
Primary Industries and Resources South Australia	1.2550	1.2550
NSW Department of Mineral Resources	0.1700	0.1700
Minerals Council of Australia	N/A	N/A

15. Auditor's Report

PRICEWATERHOUSECOOPERS

PricewaterhouseCoopers
The Quadrant
1 William Street
PERTH WA 6000
GPO Box D198
PERTH WA 6840
Telephone (08) 9238 3000
Facsimile (08) 9238 3999
DX 77 Perth

Independent audit report to the Cooperative Research Centres Program, Department of Education, Science and Training representing the Commonwealth in respect of

Cooperative Research Centre for Landscape Environments and Mineral Exploration

Audit opinion

In our opinion, the financial information as set out in Tables 12.1, 12.2 and 12.3 presents fairly, in accordance with the accounting policies described in the financial statements, the requirements of the Commonwealth Agreement dated 13 August 2001 in terms of Clauses 4 (Contributions), 5(1), 5(2), 5(3) (Application of the Grant and Contribution), 9(1), 9(5) (Intellectual Property) and 12(2) (Financial Provisions), the sources of funding and the application of funding of the Cooperative Research Centre for Landscape Environments and Mineral Exploration for the year ended 30 June 2002.

This opinion must be read in conjunction with the following explanation of the scope and summary of our role as auditor.

Scope and summary of our role

The financial information – responsibility and content

The preparation of the financial information for the year ended 30 June 2002 is the responsibility of the Board of Management of the Cooperative Research Centre for Landscape Environments and Mineral Exploration. It includes the financial information as set out in Tables 12.1, 12.2 and 12.3 for the Cooperative Research Centre for Landscape Environments and Mineral Exploration (the CRC LEME) and has been prepared for distribution to the Cooperative Research Centres Program, Department of Education, Science and Training, representing the Commonwealth of Australia, for the purpose of fulfilling the requirements of the Commonwealth Agreement dated 13 August 2001.

The Board of Management have determined that the accounting policies used and described in the financial statements, including the basis of accounting are appropriate to meet the requirements of the Commonwealth Agreement dated 13 August 2001 and the needs of the Commonwealth.

The auditor's role and work

We conducted an independent audit of the financial information in order to express an opinion on it to the Commonwealth. No opinion is expressed as to whether the accounting policies used, and described in the financial statements are appropriate to the needs of the Commonwealth. 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 it was prepared.

PRICEWATERHOUSECOOPERS

Our role was to conduct the audit in accordance with Australian Auditing Standards. Our audit did not involve an analysis of the prudence of business decisions made by the Board of Management.

In conducting the audit, we carried out a number of procedures to assess whether in all material respects the financial report presents fairly a view, in accordance with the accounting policies described in the financial statements, the requirements of the Commonwealth Agreement dated 13 August 2001 in terms of Clauses 4 (Contributions), 5(1), 5(2), 5(3) (Application of the Grant and Contribution), 9(1), 9(5) (Intellectual Property) and 12(2) (Financial Provisions)), the sources of funding and the application of funding. These policies do not require the application of all Accounting Standards and other mandatory professional reporting requirements in Australia.

The procedures included:

- selecting and examining evidence, on a test basis, to support amounts and disclosures in the financial statements. This included testing, as required by auditing standards, certain internal controls, transactions and individual items. We did not examine every item of available evidence
- evaluating the accounting policies applied and significant accounting estimates made by the Board of Management in its preparation of the financial information
- obtaining written confirmation regarding material representations made to us in connection with the audit
- reviewing the overall presentation of the financial information
- ascertaining whether the multipliers adopted by CRC LEME to value in-kind contributions other than salary costs have a sound and reasonable basis and each partner's component of the Researcher's Contributions for the year under report has been provided at least to the value for that year committed in the Budget as specified in the Agreement, and the total value of all Contributions for the year under report equalled or exceeded the amount of grant paid during the year (not including advances) [Clause 4]
- ascertaining whether the Researcher has used the Grant and the Researcher's Contributions for the Activities of the Centre and that there appear to be no material reporting irregularities [Clause 5(1)]
- ascertaining whether the Researcher's allocations of the budgetary resources between Heads of Expenditure has not been lower or higher than the allocation in the budget by $100,000 or 20% (whichever is the greater amount) without prior approval by the Commonwealth [Clause 5(2)]
- ascertaining whether Capital Items acquired from the Grant and Researcher's Contributions are vested as provided in the Joint Venture Agreement [Clause 5(3)]
- ascertaining whether Intellectual Property in all Contract Material is vested as provided in the Joint Venture Agreement and no Intellectual Property has been assigned or licensed without the prior approval of the Commonwealth [Clause 9(1), 9(5)]

PRICEWATERHOUSECOOPERS

- ascertaining whether proper accounting standards and controls have been exercised in respect of the Grant and Researcher's Contributions and income and expenditure in relation to the Activities of the Centre have been recorded separately from other transactions of the Researcher [Clause 12(2)].

While we have not performed any audit procedures upon the estimates for the next period and do not express any opinion thereon, we ascertained that they have been formally approved by the Board of Management as required under the Centre Agreement to establish CRC for Landscape Environments and Mineral Exploration.

Our audit opinion was formed on the basis of these procedures.

Independence

As auditor, we are required to be independent of CRC LEME and free of interests which could be incompatible with integrity and objectivity. In respect of this engagement, we followed the independence requirements set out by The Institute of Chartered Accountants in Australia and the Auditing and Assurance Standards Board.

PricewaterhouseCoopers

Alan J Good
Partner

Perth
21 August 2002

16. Glossary

4D: four dimensional (3 spatial + time)

acid sulphate soils: soils characterised by low pH (<3.5) deriving their acidity from the presence of oxidised sulphur*

AEM: airborne electromagnetic

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*

AGSO: Australian Geological Survey Organisation (now operating as Geoscience Australia)

AIH: Australian Institute of Health

AIMM: Australasian Institute of Mining and Metallurgy

AIRSAR: Airborne Synthetic Aperture Radar

AMIRA: Australian Mineral Industries Research Association Ltd

ANU: The Australian National University

APA: Australian Postgraduate Award

APAI: Australian Postgraduate Award (Industry)

aquiclude: a layer of rock that prevents water ingress*

aquifer: a permeable layer carrying accessible water*

ARC: Australian Research Council

ARRC: Australian Resources Research Centre

ASEG: Australian Society of Exploration Geophysicists

AusIMM: Australasian Institute of Mining and Metallurgy

base metals: Group term for common metals such as copper, lead, zinc, etc

BRS: Bureau of Rural Sciences

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

CANQUA: Canadian Quaternary Association

CASSP: Coastal Acid Sulphate Soils Program

CDI: Conductivity Depth Image

CDT: Conductivity Depth Transform

clastic: consisting of fragments of rocks that have been moved individually from their places of origin

CLW: CSIRO Land & Water

cover: See Regolith

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

CRC: Cooperative Research Centre

CRC LEME: Cooperative Research Centre for Landscape Environments and Mineral Exploration

CSAMT: Controlled-Source Audio Frequency Magnetotelluric

CSIRO: Commonwealth Scientific and Industrial Research Organisation

CSIRO-AGE: Commonwealth Scientific and Industrial Research Organisation-Australian Geochemical Exercise

CUT: Curtin University of Technology

DC: Direct current

DEM: Digital Elevation Model

DLWC: Department of Land Water Conservation (New South Wales)

DSHMP: Dryland Salinity Hazard Mitigation Program

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

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

EDXRF: Energy Dispersive X-Ray Fluorescence

facies: part of a rock body differentiated from other parts by appearance or composition

ferruginous: pertaining to or containing iron*

G3: Group of three Australian Universities with designated key centres of excellence for teaching geoscience

GA: Geoscience Australia

GILMORE: Geoscience In Land Management and Ore systems Research for Exploration

GIS: Geographical Information System

GPS: Global Positioning System

GSC: Geological Survey of Canada

GSWA: Geological Survey of Western Australia

hydraulic conductivity: ratio of flow velocity to driving force of a specified liquid in a porous medium

hyperspectral: having many narrow spectral bands used in remote sensing

ICP-MS: Inductively Coupled Plasma Mass Spectrometry

IP: Induced Polarisation

IPRS: International Postgraduate Research Scholarship

laterite: regolith produced by weathering, with a hard, more or less prominent, ferruginous surface expression*

lens: a body of rock similar in shape to a biconvex lens

lithofacies: the rock record of any sedimentary environment, including both physical and organic characters

lithology: the description of rocks on the basis of mineralogy, colour and grain size.

Ma: mega anna (million years)

MCA: Minerals Council of Australia

MDBC: Murray-Darling Basin Commission

MIM: Mount Isa Mines

morphology: the shape of the earth's surface

MTEC: Minerals Tertiary Education Council

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

NGTN: National Geoscience Teaching Network

NSW DMR: New South Wales Department of Mineral Resources

NTGS: Northern Territory Geological Survey (Australia)

NURGS: National Undergraduate Regolith School

palaeo: a prefix used to relate subjects to earlier periods of time, eg palaeoclimatology, palaeodrainage

pathfinder elements: 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

PIRSA: Primary Industries and Resources South Australia

pisolith: a spherical or ellipsoidal body resembling a pea with a diameter between 2–64 mm*

placer: a mineral deposit formed by the accumulation of weathering resistant minerals, usually in alluvium or on a shore*

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

QDME: Queensland Department of Minerals and Energy

racemization: the process of conversion of optically active compounds (usually of biological origin) to non-optically active 50: 50 isomeric mixtures

RC percussion: reverse circulation percussion (drilling)

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*

relict: remnant

saprolite: weathered rock in which the fabric of the parent rock is retained*

SASW: Spectral Analysis of Surface Waves

SEG: Society of Exploration Geophysicists

sequestration: the removal of a substance as an active component in a system

surficial: at the surface, especially the surface of the earth*

tectonic: pertaining to the rock structure and external forms resulting from deformation of the earth's crust

TEISA: Targeted Exploration Initiative South Australia

traverse: a line surveyed across a plot of ground

UB: University of Ballarat, Australia

UC: University of Canberra, Australia

UNSW: The University of New South Wales, Australia

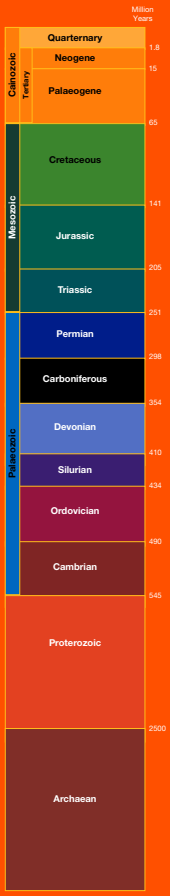
UofA: The University of Adelaide, Australia

UWA: The University of Western Australia

VIEPS: Victorian Institute of Earth and Planetary Sciences

VUESC: Victorian Universities Earth Sciences Conference

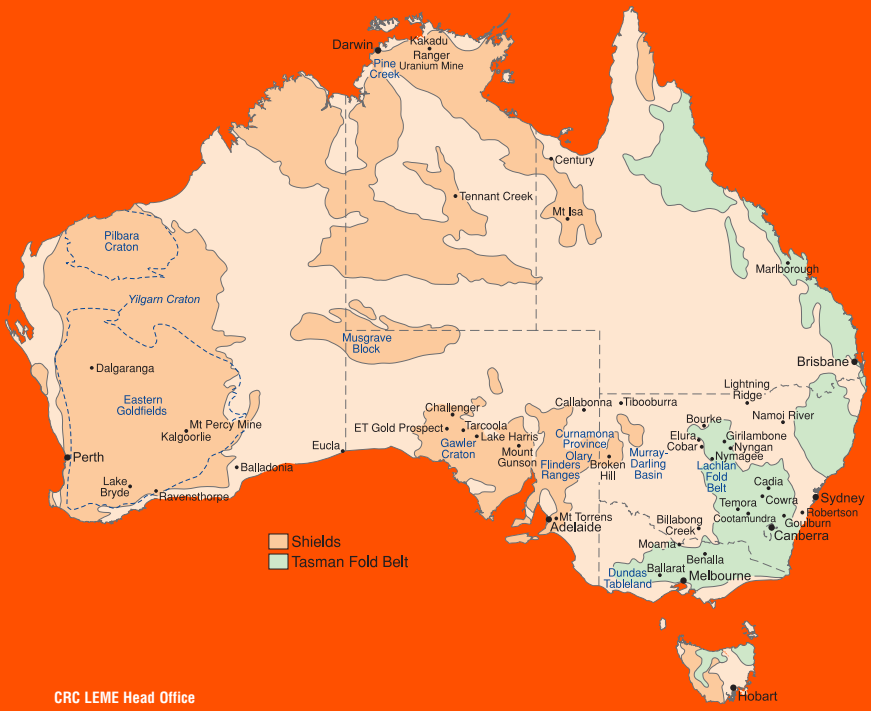
WMC: Western Mining Corporation



(Ages not to scale)

*The principal source for this glossary is *The Regolith Glossary—surficial geology, soils and landscapes* edited by Richard A. Eggleton, published in 2001 by the CRC for Landscape Evolution and Mineral Exploration and available from CRC LEME.

CRC LEME Research Locations



CRC LEME Head Office

Office location
Australian Resources Research Centre
26 Dick Perry Avenue
Kensington
Western Australia 6151

Postal address
CRC LEME
PO Box 1130
Bentley
Western Australia 6102

t: +61 8 6436 8695
f: +81 8 6436 8560
e: crcleme-hq@csiro.au
w: http://crcleme.org.au

Photographs by Steven Hill

Centre Objectives

Page

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 multidisciplinary 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, geoscience-based 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.**

October 2002

ISSN 1447-4395

Cover photography by Steven Hill, Ian W. Roberts, Ravi Anand and Mark Paine

16. Glossary

4D: four dimensional (3 spatial + time)

acid sulphate soils: soils characterised by low pH (<3.5) deriving their acidity from the presence of oxidised sulphur*

AEM: airborne electromagnetic

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*

AGSO: Australian Geological Survey Organisation (now operating as Geoscience Australia)

AIH: Australian Institute of Health

AIMM: Australasian Institute of Mining and Metallurgy

AIRSAR: Airborne Synthetic Aperture Radar

AMIRA: Australian Mineral Industries Research Association Ltd

ANU: The Australian National University

APA: Australian Postgraduate Award

APAI: Australian Postgraduate Award (Industry)

aquiclude: a layer of rock that prevents water ingress*

aquifer: a permeable layer carrying accessible water*

ARC: Australian Research Council

ARRC: Australian Resources Research Centre

ASEG: Australian Society of Exploration Geophysicists

AusIMM: Australasian Institute of Mining and Metallurgy

base metals: Group term for common metals such as copper, lead, zinc, etc

BRS: Bureau of Rural Sciences

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

CANQUA: Canadian Quaternary Association

CASSP: Coastal Acid Sulphate Soils Program

CDI: Conductivity Depth Image

CDT: Conductivity Depth Transform

clastic: consisting of fragments of rocks that have been moved individually from their places of origin

CLW: CSIRO Land & Water

cover: See Regolith

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

CRC: Cooperative Research Centre

CRC LEME: Cooperative Research Centre for Landscape Environments and Mineral Exploration

CSAMT: Controlled-Source Audio Frequency Magnetotelluric

CSIRO: Commonwealth Scientific and Industrial Research Organisation

CSIRO-AGE: Commonwealth Scientific and Industrial Research Organisation-Australian Geochemical Exercise

CUT: Curtin University of Technology

DC: Direct current

DEM: Digital Elevation Model

DLWC: Department of Land Water Conservation (New South Wales)

DSHMP: Dryland Salinity Hazard Mitigation Program

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

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

EDXRF: Energy Dispersive X-Ray Fluorescence

facies: part of a rock body differentiated from other parts by appearance or composition

ferruginous: pertaining to or containing iron*

G3: Group of three Australian Universities with designated key centres of excellence for teaching geoscience

GA: Geoscience Australia

GILMORE: Geoscience In Land Management and Ore systems Research for Exploration

GIS: Geographical Information System

GPS: Global Positioning System

GSC: Geological Survey of Canada

GSWA: Geological Survey of Western Australia

hydraulic conductivity: ratio of flow velocity to driving force of a specified liquid in a porous medium

hyperspectral: having many narrow spectral bands used in remote sensing

ICP-MS: Inductively Coupled Plasma Mass Spectrometry

IP: Induced Polarisation

IPRS: International Postgraduate Research Scholarship

laterite: regolith produced by weathering, with a hard, more or less prominent, ferruginous surface expression*

lens: a body of rock similar in shape to a biconvex lens

lithofacies: the rock record of any sedimentary environment, including both physical and organic characters

lithology: the description of rocks on the basis of mineralogy, colour and grain size.

Ma: mega anna (million years)

MCA: Minerals Council of Australia

MDBC: Murray-Darling Basin Commission

MIM: Mount Isa Mines

morphology: the shape of the earth's surface

MTEC: Minerals Tertiary Education Council

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

NGTN: National Geoscience Teaching Network

NSW DMR: New South Wales Department of Mineral Resources

NTGS: Northern Territory Geological Survey (Australia)

NURGS: National Undergraduate Regolith School

palaeo: a prefix used to relate subjects to earlier periods of time, eg palaeoclimatology, palaeodrainage

pathfinder elements: 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

PIRSA: Primary Industries and Resources South Australia

pisolith: a spherical or ellipsoidal body resembling a pea with a diameter between 2–64 mm*

placer: a mineral deposit formed by the accumulation of weathering resistant minerals, usually in alluvium or on a shore*

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

QDME: Queensland Department of Minerals and Energy

racemization: the process of conversion of optically active compounds (usually of biological origin) to non-optically active 50: 50 isomeric mixtures

RC percussion: reverse circulation percussion (drilling)

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*

relict: remnant

saprolite: weathered rock in which the fabric of the parent rock is retained*

SASW: Spectral Analysis of Surface Waves

SEG: Society of Exploration Geophysicists

sequestration: the removal of a substance as an active component in a system

surficial: at the surface, especially the surface of the earth*

tectonic: pertaining to the rock structure and external forms resulting from deformation of the earth's crust

TEISA: Targeted Exploration Initiative South Australia

traverse: a line surveyed across a plot of ground

UB: University of Ballarat, Australia

UC: University of Canberra, Australia

UNSW: The University of New South Wales, Australia

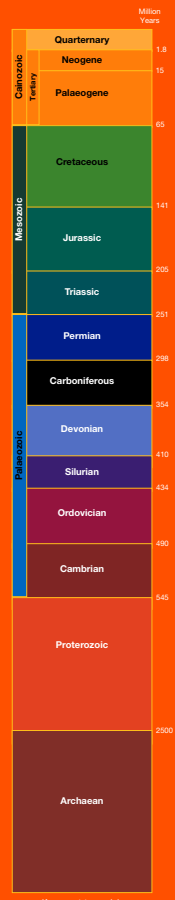
UofA: The University of Adelaide, Australia

UWA: The University of Western Australia

VIEPS: Victorian Institute of Earth and Planetary Sciences

VUESC: Victorian Universities Earth Sciences Conference

WMC: Western Mining Corporation



*The principal source for this glossary is *The Regolith Glossary—surficial geology, soils and landscapes* edited by Richard A. Eggleton, published in 2001 by the CRC for Landscape Evolution and Mineral Exploration and available from CRC LEME.