PROGRAM THREE: ENVIRONMENTAL APPLICATIONS OF REGOLITH GEOSCIENCE PROJECT SUMMARIES - 2006- 2007

Project name:
ENVIRONMENTAL HAZARD OF NATURAL ASBESTOS

Abbreviated title: Asbestos Hazard

Type of project Centre
Themes: **Regolith geoscience and urban Australia.**
Environmental geochemistry and the regolith

Project Leader: John Keeling
Start date and duration: June 2006 - 1 Year

Participants: John Keeling (PIRSA), Tony Eggleton (ANU), Rob Fitzpatrick (CSIRO L&W). External collaborators: Mark Raven (CSIRO L&W), Peter Self (AU - Adelaide Microscopy), John FitzGerald (ANU – RSES), Edward Wiecek (formerly Nofer Institute, Poland)

Brief project description:
Australia is presently experiencing a mesothelioma epidemic, with almost 500 new cases annually; the highest reported incidence of mesothelioma per capita in the world. While this is due primarily to the widespread use of asbestos products in post war construction during the 1950s to 1970s, the situation has raised concerns nationally about the risks associated with natural asbestos in the environment. Governments in NSW, WA and SA are actively gathering data on the potential risks and liabilities associated with natural asbestos. This project is developed from a preliminary study of asbestos at a former mining operation near Rowland Flat in the Barossa Valley, South Australia.

The study by Keeling et al. (2006) indicates that there is significant new scientific information that can be contributed on asbestos mineralogy that has direct health and legislation implications. This is of both local and international interest. The investigation will include identification and characterisation of the asbestos mineralogy and also trace the fate of asbestos through the weathered profile into the soil. Mineralogy will be confirmed by XRD, FTIR, SEM, and electron diffraction, supported by chemical analysis and comparison with other asbestos mineral polymorphs. The structural controls on development of asbestiform fibres will be investigated by high resolution TEM. The soil profile will be described and the impacts of weathering and soil processes on asbestos fibres will be reported.

Deliverables (outputs) and expected impacts of research (outcomes):

- Paper submitted to "Geology" documenting the occurrence, identification and the issues and implications that arise from this form of asbestos with regard to health effects and legislative controls.
- Paper submitted to "American Mineralogist" providing additional detail on the mineralogy of this form of asbestos and interpretation of the structural arrangement that produces an asbestiform habit in this mineral.
- Subject to the outcome of investigations, a LEME report or further paper describing the soil profile and the physical and chemical changes that take place during weathering and incorporation of asbestos fibres into the soil.

If the results of investigation are as anticipated, this work will provide significant new information on the potential for different asbestiform mineral polymorphs to affect human health and their relative hazard in the natural environment. This could impact current legislation on asbestos minerals internationally. The one-year project is an opportunity to showcase LEME's ability to effectively integrate research expertise in geology, mineralogy and soil science to investigate a potential natural hazard in the regolith environment. The link to human health impacts will be provided from studies done by the Nofer Institute of Occupational Medicine in Poland.

Results will be communicated to groups tasked with legislation and environmental control of asbestos minerals. This may lead to further client-funded research in 2007-08, or post LEME.

Milestones: *(dates of significant events marking scientific progress)*

- December 2006 – Mineral identification completed. Paper submitted to "Geology"
- June 2007 – Final report and paper submitted to "American Mineralogist"

Confidentiality requirements - Nil

Project name:
WA WHEAT BELT DRAINAGE - ACIDIC GROUNDWATER – GEOCHEMICAL RISK ASSESSMENT AND EVALUATION OF MANAGEMENT OPTIONS

Abbreviated title: Acid Drainage WA - AG1

Type of project Co-Investment *(Centre or Industry/Commercial):*
Themes: Acid Sulfate Soils

Project Leader: Paul Shand
Start date and duration: 1.7.04 to 30.6.06

Participants: CSIRO L&W & CEM (CSIRO Healthy Country), Dept of Agriculture WA, Dept of Environment WA

Brief project description:
SUMMARY
This project aims to address the following issues with regard to acid drainage and trace element transport occurring as a result of salinity mitigation engineering drainage schemes in the WA wheat belt:

1. Understanding the processes of acidic groundwater in the natural or pre-disturbance regolith, and later, beneath the cleared landscape,
2. Forecasting the impacts of engineering drainage on the transport and transformation of trace elements in undrained and drained environments (Geochemical risk assessment).
3. Assessment of feasible management options (opportunities and constraints).
4. Demonstration/evaluation of appropriate management options including potential productive recovery of minerals, salt and trace elements in drainage waters at relevant scales.

The geochemical risk assessment will involve a consortium of end-users (WA DoE, EEI and WA Agriculture) and research providers (CRC LEME and CSIRO Healthy Country) and will be integrated into the current Avon Regional Drainage Evaluation project undertaken by the WA government - CSIRO Healthy Country consortium.

1. BACKGROUND

Acidic, saline and metal rich groundwater is common is the natural environment of parts of the wheatbelt and southeastern parts of Western Australia. In addition clearing has resulted in further acidification of groundwater and the mobilization of salt, ions, metal and other geochemical elements.

Field observations suggest that the development of acidic seepages in parts of the higher rainfall areas of the wheatbelt is a consequence of groundwater rise. In the northern and eastern areas, acid and saline groundwater enters surface systems as a consequence of engineering drainage. The growing demand to install deep drains and other forms of drainage (eg pumping to protect built and natural assets) highlights the need to better understand and manage acidification, and the potential mobilisation of trace elements, associated with drainage.

The cause of acid groundwater and its further acidification (by either ferrolysis or, sulphide and/or pyrite reactions as a result of acid sulphate soils (ASS) are confusing concepts to the farmer and environmental manager. Research into processes of acidification on the Yilgarn block has identified the cause to be ferrolysis (Mann 1983, McArthur et al, 1991), while on the coastal margins both ferrolysis and ASS are believed to be responsible.

In other words, we have confusion about processes, extent and severity of the issue.

In response to developing salinity and a lack of viable plant based options for salinity management, over 12,000 km of deep open drains have been installed in the wheatbelt. Some of these drains have been found to export waters with a pH of 2-3, a flow of 50 kL/km/day and a salinity of 30,000-50,000 mg/L. Drainage waters in some areas have also been shown to have increased concentrations of aluminium, lead, copper, cadmium, manganese, radionuclides, (eg radium, Dickson 1985) and other trace elements.

Drainage is expanding as a management option of choice and regional drainage proposals has been advanced by several groups (Avon, Yarra Yarra, Blackwood). One such group, the WA Channel Management Group (representing 400 farmers) wishes to construct a 900 km channel after approval of a 28 km pilot (Farm Weekly 20 April 2004). An evaluation of hydraulic-based elements of this proposal has commenced (NAP-EEI and CSIRO- Healthy Country).

2. GEOCHEMICAL RISK ASSESSMENT

Given the current level of confusion and concern within certain stakeholder groups regarding the potential environmental issues arising from installation of drains in areas of acidic groundwater, it is critical that future NRM decision making is based on sound defendable scientific data and a robust assessment of the potential risks and impacts of a range of drainage scenarios in the wheat belt, with regard to trace element transport and acidity. It is also important that appropriate management strategies are devised for any risks identified.

The specific issues that need to be addressed in the wheatbelt of Western Australia associated with acidic groundwaters are:

1. Understanding the processes of acidic groundwater in the natural or pre-disturbance regolith, and later, beneath the a cleared landscape,
2. Forecasting the impacts of engineering drainage on the transport and transformation of trace elements in undrained and drained environments, and
3. Assessment of feasible management options (opportunities and constraints).
4. Demonstration/evaluation of appropriate management options at relevant scales

3. EVALUATION STRATEGY

The proposed acid drainage geochemical risk assessment will be integrated into the current wheatbelt Engineering Evaluation Initiative (EEI), specifically the Avon Regional Drainage Model being developed by the WA government - CSIRO Healthy Country consortium. The current regional drainage model aims to assess the surface and groundwater hydraulics (flows and volumes, salt loads and nutrient loads) resulting from eight different scenarios. This project proposes to undertake a geochemical risk assessment that will provide a forecast and prediction of trace element transportation, transformation and loadings associated with the eight drainage

scenario's, identifying if significant risk of trace element transport will occur under any of the planned scenarios. The project will also evalue and demonstrate appropriate management options aimed at minimising environmental risks identified.

4. PROJECT PLAN

The project will comprise four stages.

Stage 1: Data Review

Review of existing data on acid groundwater trace element geochemistry, soil types, regolith architecture, trace element analysis in existing drains, flow regimes and, remote sensing data. This largely desktop study will collate existing monitoring data and results of previous research studies that currently reside with state agencies and various research organisations, and place that data within a GIS framework.
Outputs: Database and preliminary interpretation. Identification of knowledge gaps and additional data requirements needed to complete regional-scaled risk assessment.

Stage 2: Additional Data Collection

Data required to fill knowledge gaps identified in Stage 1 will be collected in the field in cooperation with EEI and other research activities being undertaken. It is envisaged that this will involve sampling and detailed geochemical analysis of drainage waters, a focussed soil survey (eg of proposed drainage areas), mineralogical analysis of drainage material (Fe precipitates), determination of the presence of secondary sulphide minerals, regolith/landscape models etc. Identification of the detailed data required will only be possible once stage 1 is completed.

Output: Interim report outlining the geochemical processes, causes and nature of groundwater acidification in the wheatbelt. Complete data set required to calculate trace element transportation, transformation and loadings associated with drainage scenarios.

Stage 3: Integration of geochemical data into Avon Regional Drainage Evaluation scenarios

Calculation of trace element loadings and transport under different Avon regional drainage model scenarios. Integration of geochemistry data into hydraulic scenarios. Identification of potential geochemical risks.

Outputs: Identification of geochemical risks resulting from wheatbelt drainage scenarios. Application of geochemical risk assessment to inform ecological impact (ecotoxicological) risk assessment. Identification of geochemical risk management options. Reporting consistent with outputs of Avon modelling.

Stage 4: Evaluation and demonstration of options to mitigate or productively utilise acid groundwater, minerals, metals and other constituents.

Examples of potential evaluation/demonstration of options will include:

- Identification of potential environmental impacts resulting from long term storage of trace element rich drainage waters in disposal basins, demonstration of appropriate technologies that minimise any future risks of exposure, transport etc.

- Options for reduction of drainage water pH through mixing with surface run off, demonstration of appropriate mixing ratios and buffering of pH.
- Identification of appropriate technologies for potential, productive recovery of minerals, salt and trace elements in drainage waters

The main aim of Stage 4 will be to demonstrate cost effective appropriate technologies to potential end users in the field with suitable pilot projects.

Outputs: Recommendation of acid drainage water management options with a focus on technologies appropriate to regional land managers, and community based schemes at appropriate scales

Deliverables (outputs) and expected impacts of research (outcomes):
See above

Milestones: *(dates of significant events marking scientific progress)*

Milestone	Description	Date
1	Project sign-off, contractual arrangements completed	30.06.04
2	Stage 1 data review commenced	01.07.04
3	Stage 1 completed. Knowledge gaps identified.	20.08.04
4	Network meeting Perth to discuss existing data and additional data needs	30.08.04
5	Stage 2 Additional data collection and analysis completed	01.01.05
6	Network meeting Perth to review data and commence risk assessment	01.05
7	Stage 3 Geochemical risk assessment incorporated into Avon regional drainage model.	30.06.05
8	Initial identification of Geochemical risk management options available	30.06.05
9	End-user workshop to present outcome of geochemical risk assessment and seek input from end-users on Stage 4 management option demonstrations	30.07.05
10	Evaluation and demonstration of geochemical risk management options at appropriate scales.	31.05.06
11	Final report, recommendation of management options	30.06.06

Stages 1-3 of this project will parallel EEI projects, working towards an evaluation of the risk and mitigation options for the management of acid saline drainage waters in the wheatbelt of WA by June 30, 2005. Initial management options will be identified by this date. Management option demonstration and evaluation outputs will be delivered throughout the 2005-2006 financial year.

NOTE: Delivery of the LASCAM Avon Regional Drainage model by the water for a healthy Country Group was delayed by over 12 months. Stage 3 therefore only commenced in May 06. Delivery of final report MILESTONE 11 will be delayed by 3-4 months.

Confidentiality requirements Data on Drain geochemistry not to be communicated to third parties without EEI permission

Project name:
ENGINEERING EVALUATION INITIATIVE PHASE II-WHEAT BELT GEOCHEMISTRY RISK ASSESSMENT

Abbreviated title: Acid Drainage WAPHIL AG2

Type of project Centre-Industry (WA EEI, CALM, Avon Catchment Council) co-investment
Themes: Acid Sulfate Soils

Project Leader: Paul Shand
Start date and duration: 01.01.06-30.12.08

Participants: CRC LEME, CSIRO L&W, Agriculture WA, DoE WA, CALM, WA EEI, Avon CC, Yarra Yarra CC, WA Channel Management Group

Brief project description:
This project will be a new initiative based on the current CRC LEME Project 3.15. Drainage geochemical risk assessments will be expanded beyond their current focus in the Avon Catchment. The Engineering Evaluation Initiative is a program founded, supported and largely funded by WA government agencies (principally WA Ag Dept, CALM) and relevant Catchment Authorities) to evaluate engineering options for environmental rehabilitations in agricultural areas subject to salinity risk.

New initiatives for drainage geochemistry risk assessment will comprise four main foci (duration of three years FY 2005-2008):

1. Pilot geochemical evaluation of specific engineering projects
2. Assessment of potential trace-element risk risks
3. Geochemical risks to receiving environments
4. Active management of acid-trace element rich drainage waters
5. Project coordination

Details of focus and outputs

1. **<u>Pilot Geochemical Evaluation</u>**

Pilot drainage studies will focus on selected sites of the Engineering Evaluation Initiative Stage 2 (EEI-2):

a. Yenyenning
b. Yarra Yarra (specific site to be determined)
c. Two others - to be determined

Outputs

i. Database of analyses of surface waters, drain waters and groundwaters
ii. Prediction of drainage water characteristics (geochemistry, pH) prior to drain installation based on groundwater hydrogeochemistry, soil pit geochemistry, regolith and basement geology, and geochemistry of proposed receiving environments.
iii. Prediction of geochemical risk to receiving environments and recommend management options based on ii above.

iv. Observation of pilot drain geochemistry if drain installed (validation of predictions)

2. Regional Geochemical Risk Assessment

Regional geochemical surveys at a scale commensurate to that undertaken in Phase 1, Avon River Geochemical Risk Assessment (2005). New catchments to include:

a. Yarra Yarra
b. Moore River (to be defined by consultation)
c. Upper Blackwood (to be defined by consultation)
d. South Coast (to be defined by consultation)

Outputs

i. Review of existing data on acid groundwater trace element geochemistry, soil types, regolith architecture, trace element analysis, flow regimes and, remote sensing data.
ii. Geochemical reconnaissance (similar to current Avon study) of existing drains, ground and surface waters
iii. Modelling in support of regional water balance assessments (part of EEI 2) using methods established for the CSIRO-EEI *Avon Drainage Modelling* project.
iv. Identification of knowledge gaps and additional data requirements needed to complete regional-scale geochemical risk assessment.
v. Additional data collection: data required to fill knowledge gaps identified in Output iv, sampling and detailed geochemical analysis of ground waters and drainage waters, and mineralogical analysis of drainage material (especially Fe precipitates).
vi. Identification of potential geochemical hazards and risks.

3. Geochemical risks of receiving environments

This project will complement assessments in receiving environments being undertaken in the Avon Drainage, as part of Stage two of the current Avon EEI/CRC LEME project. The aspect will focus on:

a. playas and other natural wetlands,
b. surface waters (rivers, creeks)
c. engineered wetlands and disposal basins (Morowa, Bodallin)

Our project will provide assistance with site selection, and forge research partnerships with CALM and other partners, focussing on key receiving environments. Priory will be given to existing or proposed community drainage projects.

Outputs

i. Determination of trace-element and heavy-metal loadings to receiving environments from drains
ii. Prediction of trace-element and heavy-metal behaviour in receiving environments (proportion of material that remains in solution, as distinct from precipitation and incorporation into sediments).
iii. Geochemical speciation of trace-element and heavy-metals in receiving environment sediments.
iv. Determination of scenarios where sediment-bound trace elements and heavy metals may be re-solubilised and re-enter the aqueous phase

v. Determination of long-term acid buffering capacity of alkaline receiving environments, and estimation of useful life for acid drainage disposal
vi. Management options for minimising risks of trace elements in receiving environments

4. Active management

This project will be developed after year two of the current EEI project and is planned for year 2 of the EEI-2 Project. Effective management can only be developed after the water geochemistry and risks have been assessed.

Outputs
Demonstration of active and passive management options for acid drainage with partners

5. Project coordination

A project of this magnitude requires a WA-based project manager, to coordinate day-to-day activities of scientific and community partners, including fieldwork, sampling, community liaison, data management. The project will be managed by Dr Brad Degens WA Department of Water
Outputs
EEI-2 Reporting
Research Management
Project Communication

Deliverables (outputs) and expected impacts of research (outcomes):
See outputs above

Outcomes
- Evaluation of drainage through careful assessment of risk, opportunities and the determination of effective management systems.
- Enable NRM regions and stakeholder groups to develop a consistent approach to catchment and regional drainage, with minimal off site environmental impact.

Publications and Reports
1. Refereed Journals
- Project in early Stages to be defined
2. Reports
- Analysis and interpretation of geochemical risk Yarra Yarra catchment (LEME Open File Report)
- Analysis and interpretation of geochemical risk Yenyenning catchment (LEME Open File Report)
- Blackwood and South Coast and Receiving Environment geochemical Risk assessment (LEME Open File Report)

Regional Evaluation of Geochemical Risks for the Blackwood Catchment and a Coast Catchment and management implications based on geochemical modelling outcomes
- Final Report (LEME Open File Report)

3. Conferences-Seminars

- Rogers et al (2006) Australian Earth Science Congress 'Acid drainage geochemistry Risk Assessment' (invited paper)
- Rogers (2006) WA acid drainage geochemistry UWA seminar
- ISF 2008 Adelaide. Provcisional paper title: Acid saline drainage risk assessment and management
- Case studies to be included in the planned Thematic Volume 'Inland Acid Sulfate Soil Systems' Fitzpatrick, R. (Ed)

Milestones: *(dates of significant events marking scientific progress)*

Milestone	Description	Date
1	Project sign-off, contractual arrangements completed	31 Jan 2006
2	**YY Contract** – Analysis and interpretation of geochemical risk completed (delivery as component of consultant contract report)	30 April 2006
3	**YaYa Contract –** initial team meeting with consultant. Outline subproject requirements	1 March 2006
4	**Yarra Yarra -** Existing geochemical data collated and reviewed. Interim report submitted.	30 June 2006
5	**Catchment 3 and 4 Contract –** initial team meetings with consultants. Outline subproject requirements	1 July 2006
6	**REVIEW MEETING -**review existing data and identify additional information needs for Yarra Yarra	30 July 2006
7	**YaYa Contract** - Analysis and interpretation of geochemical risk completed (delivery as component of consultant contract report)	30 Sept 2006
8	**Catchment 3 contract** - Analysis and interpretation of geochemical risk completed (delivery as component of consultant contract report)	31 Dec 2006
9	**Catchment 4 contract** - Analysis and interpretation of geochemical risk completed (delivery as component of consultant contract report)	31 Dec 2006
10	**Yarra Yarra -** Additional in-fill water geochemistry data collected and analysed. Interim report submitted.	31 Jan 2007
11	**REVIEW MEETING -** team meeting to review data, identify remaining information gaps and commence risk assessment for Yarra Yarra; review existing data and identify additional information needs for Blackwood and South Coast; review receiving environment geochemical data.	30 May 2007
12	**Blackwood and South Coast + Receiving Environment (RE) Geochem Risk Evaluation -** Existing geochemical data collated and reviewed. RE geochemical sampling and analysis completed for Yarra Yarra, Avon Combined interim report submitted.	30 June 2007
13	**Yarra Yarra -** Regional evaluation of geochemical risks for the Yarra Yarra catchment and management implications for drainage based on geochemical modelling outcomes - Final Report submitted	31 Dec 2007
14	**Blackwood and South Coast -** Additional in-fill data collected and analysed. Interim report submitted	30 May 2008
15	**Receiving Environment (RE) Geochem Risk Evaluation** : Geochemical risk assessment of acid waters in receiving environments and management implications based on geochemical modelling outcomes - Final Report submitted	30 Sept 2008
16	**Blackwood and South Coast :** Regional Evaluation of Geochemical Risks for the Blackwood Catchment and a Coast Catchment and management implications based on geochemical modelling outcomes - Final Report submitted	30 Dec 2008

Confidentiality requirements
Permission to be sought from WA DoE EEI (John Ruprecht) prior to media contact

Project Name:
AVON CATCHMENT COUNCIL - FEASIBILITY STUDY OF OPTIONS FOR TREATMENT OF ACID GROUNDWATER

Abbreviated title: **Avon CC Acid Groundwater - AG3**

Type of project: **Industry**:
Themes: **Acid Sulfate Soils**

Project Leader: Paul Shand
Start date and duration: **01.07.06-30.06.09**

Participants: Consortium of LEME, DoE WA, DOW WA, Agriculture WA – WA EEI and Avon Catchment Council

Brief project description:
This new project forms part of the Avon catchment Council (ACC) investment in Salinity Management. The project will be managed by the WA Department of Water. The project will build on the outcomes of the two current P3 acid drainage geochemistry risk assessment projects (3.15 and 3.23). Both these projects have established that acid drainage waters in the WA wheatbelt are widespread and contain highly elevated levels of heavy metals and trace elements. The two projects have also established appropriate sampling protocols, water and sediment analytical procedures (in the presence of highly elevated salt concentrations) and made some initial management recommendations. However, if drainage is to be widely adopted as a salinity mitigation management tool in areas of acid groundwater then appropriate technical options for the treatment of acidity and mitigation of trace elements need to be developed.

Treatment technologies for acidity and trace element mitigation will be trialled and demonstrated in three ways:

1. Through the construction and study of pilot scale engineered treatment/evaporation basins where a range of treatment options will be trialled;
2. Investigating the feasibility of 'in-drain' treatments that do not require significant engineering works; and
3. Amelioration of acidity and associated trace element precipitation through mixing acid drainage waters with alkaline surface waters

Deliverables (outputs) and expected impacts of research (outcomes):
Outputs

1. Acidity and geochemical changes- the proportion of metals in solution compared to the proportion of metals precipitating out into sediment material will be monitored throughout the study using advanced analytical techniques (Inductively Coupled Plasma-Mass Spectroscopy, X-ray diffraction, isotope analysis
2. Geochemical models will be developed to predict the behaviour of trace elements and heavy metals during treatment feasibility studies

3. Information on the feasibility of treatment and disposal options will be communicated to end-users through; pilot scale demonstration trial field days.
4. Incorporation of management recommendations into EEI, NAP drainage management guidelines, information meetings with community groups, WA Channel Management Group (WACMG), CMA's. Technical reports and progress reports as part of EEI program to ACC.
5. Information relating to the potential costs of treatment/disposal options will also be communicated to end users

Outcomes and Impact

1. Development of cost effective treatment options for disposal of acid groundwater in the WA wheatbelt
2. Enable NRM regions and stakeholder groups to develop a consistent approach to acid drainage disposal, with minimal off site environmental impact.

Milestones: *(dates of significant events marking scientific progress)*
To be negotiated with Client (ACC) and project partners

Confidentiality requirements
None

Project name:
INVESTIGATING THE ROLE OF MICROBIAL PROCESSES IN CYCLING OF FE, S, AND METALS IN ACID SULFATE SOIL SITES

Abbreviated title: **Geomicrobiology of ASS**
(Part of *Loveday Wetland Rehabilitation* with *Loveday Drawdown* Geochemistry Project)

Type of project Centre
Themes: **Acid sulfate soils**

Project Leader: Sue Welch
Start date and duration: July 2004, 3 years total, project for year 3

Participants: ANU - Sue Welch, Sara Beavis, Dirk Kirste, Bear McPhail, PhD Student: Luke Wallace, Sarah Tynan, Honours student Andrew Higgins

Brief project description:
Acid sulfate soils are a major environmental problem in both coastal and inland areas of Australia. The increase in acidity associated with pyrite oxidation can lead to adverse environmental impacts such as increased mobility of toxic metals, loss of habitat, and fish kills. The acidity can also have large economic costs due to degradation of land and structures and contamination of ground water.

We propose to determine the factors affecting biotic and abiotic iron and sulfur oxidation and reduction from sediment and water samples collected from acid sulfate soils in collaboration with other LEME researchers and to investigate the link between these cycles and trace metal geochemistry. In partnership with the CRC LEME Project 3.18, the primary field site is the Loveday Wetland, a saline water disposal basin undergoing rehabilitation. Sulfidic materials (including some potential acid sulfate soils) are a key issue for management at this site because of the risk of acidification during drying operations. Loveday Wetland has been designated as the "test case" by the Murray-Darling Basin Commission for the remediation of saline disposal basin in the Lower Murray. Thus, the findings of this study could eventually be widely used elsewhere.

The key goals of the project are to:
- Characterise the storage of sulfur (and its mineralogy), the potential acidity and the potential alkalinity at Loveday Wetland;
- Describe the biogeochemistry of S in Loveday during wetting-drying operations, with an emphasis on microbially-mediated processes.
- Determine the potential acid and sulfur flux between sediments and water as the basin undergoes rehabilitation

This will be done through field studies and sampling to characterise the site, laboratory experiments and some geochemical modelling. Detailed activities will include:

Mineralogy
- Determine the storage and mineralogy of S in the wetland through an extensive coring program (Welch, Kirste, Beavis, Wallace);

- Determine the gross acidification and acid neutralisation capacity of the wetland (Welch, Kirste, Beavis, Wallace);
- Characterize physical and chemical properties of surface sediments focusing specifically on areas with variable redox chemistry or obvious biological activity (Welch, Beavis, Higgins);
- Determine physical and chemical response of sediments to wetting and drying (Welch; Beavis, Higgins)
- Determine the relationship between S and trace metal geochemistry during wetting-drying (Welch, Beavis, Kirste, Wallace);

Organic Geochemistry

- Characterize organic carbon content and nutrient (N, P) content of sediments and water samples (Wallace, Welch, Beavis, Kirste, student).

Aqueous Geochemistry

- Characterise groundwater and pore water chemistry at the site (Kirste);
- Used porewater profile and hydraulic head data (supplied by DWLBC) to estimate the discharge of groundwater-borne S to the wetland;
- Model the precipitation/dissolution of gypsum and other sulfate-bearing minerals as sources or sinks of S to surface water under different regimes.

Biological components

- Determine the abiotic and biotic components of sulfur oxidation and reduction (Wallace, Welch)
- Determine the ability of *in situ* microbial populations to use available Fe and S substrates as electron donors and acceptors by enrichment culturing (Welch, honours student)
- Investigate microbial populations with molecular techniques (Welch, student, Rogers)

Linkages

This project is linked with CRC LEME project 3.18 (Draw Down Geochemistry), the SA Department of Water, Land and Biodiversity Conservation "Loveday Rehabilitation" program and the ANU, with additional collaboration with the CRC LEME project 3.20 (Inland ASS) and Steve Rogers' molecular lab (CSIRO Adelaide).

Deliverables (outputs) and expected impacts of research (outcomes):

Outputs

- report on the storage of S in Loveday Wetland and the acidification risk during water level drawdown operations;
- map of actual and potential acid sulfate soils in Loveday Wetland;
- estimate groundwater-borne S discharge to the wetland using porewater profiles;
- report describing the biogeochemistry of S during water level draw downs at Loveday;
- several papers, presentations at major geochemical conferences (see below)
- one PhD thesis based largely on the site (Wallace)
- one PhD thesis based partially on the site (Tynan)
- one honours thesis (Higgins)

Outcomes

- Provide information and advice on how to manage sulfidic materials during the rehabilitation of wetlands such as Loveday.

- Understand the physical, biological and geochemical controls on the distribution of sulfidic materials and potential acidity in inland systems;
- Develop knowledge and tools for rehabilitation efforts in other saline wetlands in the Murray-Darling Basin.

Milestones: *(dates of significant events marking scientific progress)*

Milestone date	Description	Status April 2006
1 April 2006	Biotic –abiotic experiments to estimate S flux	In progress
2. April 2006	Third visit to the field site under 'dry conditions'. Collect sediment and water samples and meet with colleagues from Adelaide	pending
May 2006-Dec 2006	characterization of chemical, physical and pore water properties of sediments	On track
Jan 2006- Dec 2006	Process samples for S isotope analysis	In progress
May 2006	Visit to Adelaide (Welch) to study microbial processes using molecular techniques	Pending
~ Sept 2006	Visit field site under flooded conditions	
Dec 2006	Final estimates of the storage of S and of the gross acidification and acid neutralisation potential in Loveday Wetland	On track
Dec 2006	Preliminary model of gypsum dissolution/precipitation	Incomplete, lots of data
Mar 2007	End of laboratory experiments	Incomplete
Jun 2007	Final Report	Incomplete
Jun 2007	Report on S oxidation rates based on laboratory experiments	Incomplete, some preliminary data
April 2006-Dec 2007	Write papers for publication	In progress

Confidentiality requirements - nil

Project name:
INLAND ACID SULFATE SOILS: DISTRIBUTION AND REGOLITH PROCESSES

Abbreviated title: Inland ASS

Type of project Centre / Industry
Themes: Acid Sulfate and Alkali Soils

Project Leader: Rob Fitzpatrick
Start date and duration: July 2004, 3 years (to 2007)

Participants: CSIRO Land and Water, AU, ANU

Brief project description:
Objectives

- To develop innovative approaches and methodologies for constructing mechanistic models of soil-landscape evolution for inland sulfidic environments, including inland acid sulfate soil (ASS) and groundwater systems across Australia.
- To apply this information to derive pedo-regolith transfer functions to help spatially model and predict soil-water landscape properties at 30 pilot regions/ catchments across Australia (3-8 pilot studies per State) with implications for infrastructure and NRM planning, water quality management and mineral exploration.
- To apply this information to publish an Atlas of inland ASS in Australia, which includes: (i) a national map of inland ASS with common legend that incorporates risk assessment criteria and correlations between Australian and International Soil Classification Systems, (ii) database of representative soil-regolith case studies from pilot regions around Australia and (iii) web-based product geo-referenced with other ASRIS products.

Scope of Work

- Create a project framework under which integrated outcomes will be delivered to develop a national understanding of the spatial distribution and process of Inland ASS and related hydrology in Australian regolith by undertaking the following three sub-projects:
  (i) Spatial distribution and processes of Inland ASS and acidic groundwaters,
  (ii) Geochemistry, isotope geochemistry and mineralogy,
  (iii) Biomineralisation and microbial biochemistry.

Knowledge to Date

This new project builds on knowledge of existing staff in CRC LEME with skills in pedology, mineralogy, geochemistry, hydro-geochemistry, geophysics and microbiology. Current staff and students in CRC LEME have developed and are continuing to develop special-purpose mechanistic process models and GIS up-scaling approaches for the broad-scale mapping to characterise, map and remediate inland ASS. They have also demonstrated that Inland ASS can contain anomalous concentrations of elements such as Cu, Pb, and Zn and introduced a new geochemical sampling medium for mineral exploration (ore bodies). However, most of this research was conducted in SA and thus far these projects have not been combined into a unified national approach to optimise the use of resources and these approaches.

The distribution and mechanisms of ASS, especially for Inland ASS, have not been adequately assessed nationally despite their known significance in relation to land degradation, water quality and mineral exploration. It is now critical to define the national spatial distribution, impact on water resources, land degradation and significance to mineral

exploration in order to provide the scientific underpinning for policy development, management, amelioration and to identify regions where ASS sampling can be used in mineral exploration.

What is New?

This project integrates new and previous Inland ASS and related hydrogeochemistry projects carried out in Australia for mineral exploration, NRM planning, acidity assessment and management into a National strategic initiative.

Interactions with other projects

This project is linked with CRC LEME projects: (i) 3.18: Impact of water level draw downs on the geochemistry of saline River Murray wetlands (Draw Down Geochemistry), the SA Department of Water, Land and Biodiversity Conservation "Loveday Rehabilitation" program and the ANU, (ii) 3.19: Investigating the role of microbial processes in cycling of Fe, S, and metals in acid sulfate soil sites). Close linkages with WA Drainage project (Steve Rogers/ Richard George). Focus and align Inland ASS research in Australia through NatCASS (steering committee for map component) and other State and Federal NRM committees.

Deliverables (outputs) and expected impacts of research (outcomes):

Outputs

- Develop improved geophysical and geochemical field methods to characterise and map various sulfidic environments across Australia. (RWF, MT, GH).
- Develop quantitative mineralogical (XRD) and geochemical (XRF) techniques to improve reliability, accuracy and speed of analysis of ASS. (RWF, MF).
- Develop new and or more accurate soil-landscape process models of Inland ASS. (RWF).
- Provision of new information on the distribution and properties of Inland ASS in 30 pilot regions/ catchments across Australia (series of web-delivered ASS maps). (RWF).
- Develop and promote improved risk assessment and land management systems for Inland ASS. (RWF, WH).
- Develop new geochemical applications for identifying, and sampling ore bodies from inland ASS and related seepage areas (RWF, WH).
- Provide leadership on the development of national (through NatCASS) and international (through International Union of Soil Sciences) interpretation guidelines for describing, characterising, classifying and managing inland sulfidic environments. (RWF)
- Scientific reports and papers (at least one for Science or Geoderma).
- An Atlas of Australian inland ASS (Stage 3), incorporating:

A database of representative soil-regolith case studies from 30 pilot regions/ catchments across Australia,

- A better understanding of inland ASS geochemical processes in different geomorphic, geologic, mineralised zone and land use settings across Australia and publishing this information in a special LEME Monograph/ web site on Inland ASS in Australia.
- A national map of inland ASS with common legend (web-based product geo-referenced with other ASRIS products) that incorporates: (i) risk assessment criteria, (ii) correlations between Australian and International Soil Classification Systems, (iii) policy, (iv) land-use planning and (v) signatures of economic mineralization.
- Presentations at a National Inland ASS workshop and five International Conferences.

Outcomes

- Develop a national understanding of the spatial distribution and biogeochemical process leading to Inland ASS formation and related hydrology in Australian regolith
- Provide scientific basis upon which ASS risk assessment and management strategies can be developed

Milestone Achievements (Progress against milestones, outputs and outcomes)

Milestones, outputs and outcomes	**Mile-stone Date**	**Progress status at April 2006** (achievements and breakthroughs/ problems experienced)
Develop improved geophysical and geochemical field methods to characterise and map various sulfidic environments across Australia.		Significant overall progress has been made to link pedological, geophysical (gamma ray radiometrics, electromagnetics, magnetics and ground penetrating radar) and clay minerals (layer silicates, oxyhydroxides, sulfides, etc) and remote sensing data to deduce sub-surface geochemical processes and understand how specific properties impact on ASS.
	Sept 04	Organised/ran ClayGEMME 2004 workshop: published 5 papers
	July 06	Progress in organising/presenting three talks at the special symposium at the 18th World Congress of Soil Science (July 9-15, 2006 in Philadelphia, USA) on "Soil Mineralogy and Geophysics for Environmental Management and Mineral Exploration (ideas gained from ClayGEMME 2004 workshop). Present invited keynote paper on "Mineralogy of inland ASS" at symposium on ASS
	Sept 06	Mt Lofty Ranges (SA) – Final write-up stages of two PhD theses by Andrew Baker (Herrmanns and Rodwell catchments) and Mark Thomas (Herrmanns and Spalding catchments), which includes Inland ASS in a Pb-Zn mineralised zone, degraded wetlands and polluted streams. Ground penetrating radar and magnetics illustrated occurrence of paleo-channels and soil morphological features.
Develop quantitative mineralogical and geochemical techniques to improve reliability, accuracy and speed of analysis of ASS		Near final development of standard XRF laboratory methods for determining major elements (fusion method) and trace elements is nearing completion. The latter method has been refined to determine high concentrations of Se (>1ppm), Br, I, Cl and U.
	July 06	Progress in development of an XRF standard fusion and pressed pellet methods by Mark Fritz – MSc student. Also new progress has been made in testing the speciation potential of XRF for the characterisation of pyrite minerals in ASS. Obtained good correlation with chromium reducible method for pyrite determination.
	July 07	Final report: MSc thesis and paper with new XRF methods.
	July 07	Progress in analysing selected Inland ASS samples containing As, Se, Zn, Cu, Cr using synchrotron techniques via CSIRO Emerging Science – synchrotron: Environmental and extreme chemistry – project.
	Aug 07	Progress in development of new national and international soil classification definitions with Prof Leigh Sullivan (CRC CARE).
Develop new and or more accurate soil-landscape process models of Inland ASS Provision of new information on the distribution and properties of Inland ASS in 30 pilot regions/		Good progress in the development of several new mechanistic models for regions/catchments using the toposequence approach, which integrates pedological, mineralogical, hydrological, biogeochemical, geological, climatic and land-use information for the following new/in progress case studies in:
	July 05	South east (SA) – Completed CRC LEME report: "An evaluation of the soils of Tilley Swamp and Morella Basin, South Australia by Richard Merry and Robert Fitzpatrick for South Australian

catchments across Australia (series of web-delivered ASS maps).	Sept 05 Feb 06 May 06 April 06 April 06 May 06 Aug 06 Nov 06 Feb 06 April 07	Department of Water, Land and Biodiversity Conservation. WA Wheat belt drainage project– Completed paper for CRC LEME Regolith Symposium on "Geochemistry and Mineralogy of soils, salts, gels, precipitates and sulfidic materials in drains, including publication of models. Stage 2: Sampling and analyses of Receiving Environments (Acid/alkaline lakes) in WA Wheat belt Write-up of stage 2: model development Riverland – Loxton: Completed CRC LEME report: "Evaluation of Floodplain Soils along the Loxton Salt Interception Scheme Pipeline Corridor near Loxton, South Australia by Robert W Fitzpatrick, Warren S Hicks, Andrew Baker and Julianne James–Smith for South Australian Water Corporation Dundas Tableland (Victoria) – completion of PhD by Jon Fawcett – on development of a mechanistic model to predict ASS soil-water landscape properties with implications for infrastructure and NRM planning, water quality management. Mid North - Port Pirie: Completed CRC LEME report: Evaluation of Acid Sulfate Soil Conditions at the Solomontown Island Marina Development Site, South Australia: Brett Thomas and Rob Fitzpatrick. Mt Lofty Ranges (SA) – In progress (write-up stage) Two PhD theses by Andrew Baker (Herrmanns and Rodwell catchments); Mark Thomas Case study in Victoria - Dowds Morass in Gippsland – some additional funding is being negotiated via several agencies in Victoria. Case studies in NSW – mostly case studies in Dicks creek catchment / others. Some additional funding is being negotiated via several agencies in NSW (Warren Hicks to lead on this). Case studies in Tasmania – mostly case studies in North East and North western regions/ perhaps Flinders Island. Some additional funding is being negotiated via several agencies in Tasmania.
Develop and promote improved risk assessment and land management systems for Inland ASS Develop new geochemical applications for identifying, and sampling ore bodies from inland ASS and related seepage areas	Jul 07 Sept 05	Development and promotion of improved risk assessment and land management systems for ASS - See case study reports above. Presented oral paper at the 22nd International Geochemical Exploration Symposium, Perth on "Inland Acid Sulfate Soils – a new geochemical sampling medium: A regional orientation study from the Mount Lofty Ranges, South Australia" by Marian Skwarnecki and Rob Fitzpatrick.
Provide leadership on the development of national and international interpretation guidelines for describing,		Provided on-going technical and policy advice on Inland ASS by presenting/writing: (i) several invited papers/keynote addresses at workshops/conferences in Australia (Adelaide, Perth, Melbourne, Brisbane and Cairns) and overseas (USA, Europe); (ii) information at national (NatCASS/ NRM Standing/Ministerial Committees) and

characterising, classifying and managing inland ASS		international (IUSS) committees; (iii) information to mineral exploration companies and at both public and government arenas, (iv) lecturing at international / Australian Universities agencies/conferences to successfully insure that Inland ASS is recognised as a "Geohazard to environments of the world".
	July 05	Visiting Professor at the "Summer University of the University of Lleida" Spain, Rob Fitzpatrick gave lectures on "Inland ASS and granite weathering processes" and assist students field studies of soils in the La Cerdanya (Pyrenees, Catalonia, northeast Spain) 11th course; 18th to 21st July, 05.
	Aug 05	Visiting scientist at Institut de Recherche pour le Developpement (IRD) and Institut de Mineralogie et de Physique des Milieux Condenses (IMPMC) in Paris where Rob Fitzpatrick gave a seminar on ASS and developed linkages with researches to undertake future collaborative research on metals and metalloides in sulfides and iron oxides in Australian ASS via Synchrotron experiments in France with Drs Emmanuel Fritsch, Etienne Balan, Guillaume Morin and Farid Juillot.
	Aug 05	Visiting scientist to International Soil Reference and Information Centre (ISRIC) and ICSU World Data Centre for Soils, where Rob Fitzpatrick gave a seminar on ASS and develop linkages with Dr David Dent (Director) to progress proposed publication: "Inland ASS: a global overview"
	Feb 06 Feb 06 March 6 April 06 Aug 06	Provided information (agenda papers)/presentations to several national committees such NatCASS, Marine And Coastal Committee (MACC), NRM Standing Committee (NRMSC), NRM Ministerial Committee (NRMMC) and LGPMC on the recent outcomes/future work of the "Atlas of Australian Acid Sulfate Soils (ASS) Project (Stage 1 to 3): NatCASS – Melbourne and Gippsland MACC – Adelaide NRMSC – Adelaide NRMMC – Sydney Local Government and Planning Ministers Council - Adelaide
	Sept 05	Gave lecture and field trip: "ASS origin, distribution, development and management" and ran one day Field trip for the "Surficial Geology III at the University of Adelaide (Rob Fitzpatrick)
	Sept 06 Aug 07	Provide lectures in 06 and 07 as for Sept 05: Uncompleted
	April 06	Initiate/organise/present three papers at the International Workshop on Criminal and Environmental Soil Forensics (part sponsored by LEME) 8th and 9th April 2006, Perth (WA Chemistry Centre) A Post Symposium Workshop following the 18th International Symposium on the Forensic Sciences
Publish scientific papers	May 06	Present keynote address and publish paper on "Coastal Acid Sulfate Soils: National Atlas and Future Scenarios" at the Coast to Coast Conference in Melbourne in May, 2006.
	June 06	Publish journal paper on: "Inland Acid Sulfate Soils – a new geochemical sampling medium: A regional orientation study from the Mount Lofty Ranges, South Australia" by Marian Skwarnecki and Rob Fitzpatrick.

	July 07	Publish two journal overview papers on: New minerals and models in inland ASS (possibly Science / Geoderma). Have draft outline of papers.
Develop an Atlas of Australian inland ASS, (Stage 2 and 3) incorporating a database of representative soil-regolith case studies from 30 pilot regions/ catchments across Australia	Feb 05 March 06 Feb 06 Aug 07 Sept 07	Progress in the development of a framework for national database for 30 sites, including incorporation of process models, with Andrew Baker using FrontPage web based software. Completed paper for CRC LEME Regolith Symposium on the development of online database using toposequence approaches incorporating, pedological, geochemical and mineralogical data with Andrew Baker (PhD student). Publication of article in Focus on Salt in Issue 36, March 06) Developed draft legend for the National Inland ASS map (Stage 3) to reside on ASRIS web site via NatCASS. Final National Atlas of Inland ASS (Stage 3) – Incomplete Final Report on Inland ASS, including publication of key models and Case Studies in CRC LEME Monograph on Inland ASS– Incomplete

Confidentiality requirements Nil

Project Name:
LOW-DENSITY GEOCHEMICAL SURVEYS

Abbreviated: LDGS

Leader: Patrice de Caritat
Start - finish - duration: 1 July 2006-30 June 2007-12 months

Brief project description:

1. Document element concentrations and geochemical patterns in near-surface materials (sediments, plants, groundwater) in the Riverina and Gawler pilot project areas
2. Help understand processes affecting element sources, residence and mobility in near-surface environment in these areas
3. An Honours project will be integrated within LDGS this year (2006)

Scientific Deliverables (new scientific advances)

6. What are the natural concentrations of chemical elements in these areas?
7. What are the sources of these elements and what control their mobility?
8. What are the implications of this for land-use management (crops, stock, natural reserves, mineral exploration, etc.)?

Deliverables to Client (Adoption mechanisms)

1. Final report Riverina pilot project
2. Final report Gawler pilot project
3. Synthesis report based on Riverina and Gawler pilot projects
4. Honours thesis on aspects of the Riverina survey

Impacts

3. Decisions about land-use can be taken on the basis of an internally consistent and scientifically rigorous layer of data based on facts
4. Next phase of funding to NSW DPI will be partly based on geochemical survey results
5. Establish guidelines for geochemical mapping at the national scale

Project name:
IMPACT OF WATER LEVEL DRAW DOWNS ON THE GEOCHEMISTRY OF SALINE RIVER MURRAY WETLANDS

Abbreviated title: **Loveday Drawdown**
(Part of Loveday Wetland Rehabilitation with Geomicrobiology ASS-Loveday 3.19)

Type of project Centre
Themes: **Acid sulfate soils**

Project Leader: S Lamontagne
Start date and duration: 1 July 2004 - 1 July 2007

Participants: CSIRO Land and Water - Lamontagne, Hicks

Brief project description:
During the last century, many floodplain wetlands in the Murray Basin were converted into disposal basins to store excess irrigation water. From an ephemeral freshwater environment, these wetlands became permanently flooded and saline. These modifications to the hydrology of the wetlands had a profound impact on their biodiversity values, including the loss of riparian red gum and native fish species.

Loveday Wetland (Barmera, SA) was used extensively as a disposal basin from the 1970s to the early 2000s, during which time it became severely degraded. The wetland has been recently selected as the case study for the rehabilitation of disposal basins in River Murray floodplains. One of the challenges facing managers to rehabilitate disposal basins is how to deal with sulfidic materials present in the sediments. Sulfidic materials were identified at Loveday Wetland during a previous CRC LEME study (Lamontagne et al 2004). Sulfidic materials are known to have potential environmental risks when disturbed (that is, exposed to oxygen), including the generation of noxious smells and acidification. Because rehabilitation of Loveday Wetland will involve changes water level, and possible exposure of sediments to the atmosphere, the risks associated with sulfidic materials are significant.

The aim of the Loveday Drawdown project is to develop knowledge and tools that will enable a safer management of the water level regime in Loveday Basin. This will be done through:

- reconstruction of historical water, salt and sulfur balances for the wetland between 1970 and 2000 (when the wetland was used as a disposal basin);
- monitoring of surface water quality to follow impacts of water level variations over two years (May 2005 – May 2007);
- literature review on mechanisms causing noxious smells in sulfide-rich wetlands;
- estimation of gaseous S losses from the wetland in partnership with the DWLBC *Odour control program.*

The current storage of S in the wetland and the assessment of biogeochemical processes in sediments during wetting-drying operations will be done through the CRC LEME Project 3.19.

Deliverables (outputs) and expected impacts of research (outcomes):

Outputs

1) Report on historical water, salt and S budgets for the wetland;
2) Report on water quality changes and sulfur mass-balance during wetting-drying operations between 2005 and 2007;
3) Literature review on sulfur gas emissions from wetlands;
4) Report on gaseous S losses from the wetland between 2005 and 20007;
5) Produce a simple hydrological-biogeochemical model to predict how changes in wetland water regime result in gain or loss of sulfidic materials over time.
6) Present national and international scientific conferences; write several scientific journal papers.

Outcomes

1) Participation to the design of the rehabilitation program for Loveday Wetland with SA DWLBC;
2) Knowledge to help manager assess and mitigate the risks associated with sulfidic materials during wetland rehabilitation efforts across the Murray-Darling Basin;

Milestones: *(dates of significant events marking scientific progress)*

Milestone date	Description	Status at May 2005
1. Dec 2004	Selection of field site	Completed
2. Apr 2005	Preliminary compilation of historical water, salt and sulfur budgets for Loveday	Completed
3. May 2005	Contract with DWLBC for 2005/06 monitoring program	Completed
4. May 2005	Start of water quality monitoring program	Completed
5. Dec 2005	Literature review on the significance of S gas emissions from wetlands	Drafted
6. May 2006	Contract with DWLBC for 2006/07 monitoring program	Incomplete
7. Jun 2006	Report on first year of monitoring program	Completed
8. Jun 2006	Final Report on historical water, salt and sulfur budgets for the wetland	Incomplete
9. Mar 2007	End of monitoring program	Incomplete
10. Jun 2007	Final report	Incomplete

Confidentiality requirements - NIL

Project name:
PROGRAM 3 COMMUNICATIONS

Type of project Centre
Themes: **Acid Sulfate Soils**
Environmental geochemistry and the Regolith

Project Leader: Program 3 Leader TBA - Interim Steve Rogers
Start date and duration: 01.07.06-30.06.07

Participants: PIRSA, ANU, GA, CSIRO Land And Water

Brief project description:
Communications and Conference Attendance for LEME P3 staff

Deliverables (outputs) and expected impacts of research (outcomes):
Communication of LEME scientific outputs to national and international audience

Milestones: *(dates of significant events marking scientific progress)*

Conference	**Staff member**	**Title**
ASSSI - ASPAC National Soils Conference, Adelaide University: *Soil Science Solving Problems* 3 to 7 December 2006. Australian Clay Minerals Society session	J. Keeling	Asbestos in soils – mineralogy and hazard assessment"
Australian Earth Sciences Convention 2006	Sara Beavis	Physical, geochemical and biological controls of S redox chemistry in an inland salt disposal basin.
American Geophysical Union (San Francisco) or GSA (Philadelphia)	Sue Welch	Geomicrobiology of an inland hypersaline acid sulfate soil site
AESC	Patrice de Caritat	Regional geochemical mapping (talk & poster) +
Goldschmidt Workshop	Patrice de Caritat	Pre-conference workshop (GWB)
18th World Congress of Soil Science - July 9-15, 2006 in Philadelphia, USA.	Rob Fitzpatrick	(i) Recent advances in formation mechanisms of minerals in precipitates, salt efflorescences and sulfidic materials in acid sulfate weathering environments by Rob Fitzpatrick (invited keynote paper) (ii) Australian coastal acid sulfate soils - a national atlas by Robert Fitzpatrick, Bernard Powell and Steven Marvanek (iii) Predicting regional complex saline-sodic

		soil patterns using geophysical, hydropedological and mineralogical approaches that translate across scales by Mark Thomas, Robert Fitzpatrick, and Graham S. Heinson. (iv) Using gamma-ray spectroscopy in mineralogical and geochemical soil-regolith investigations: Australian case studies from depositional and erosional landscapes by John R. Wilford, Mark Thomas, and Robert Fitzpatrick.