CRCLEME
Cooperative Research Centre for
Landscape Environments
and Mineral Exploration

PROGRAM TWO: MINERAL EXPLORATION IN AREAS OF COVER
PROJECT SUMMARIES 2006-2007

Project name: **Hydrogeochemistry for Mineral Exploration Under Cover**

Abbreviated title: **HydroMinEx**

Type of project Industry/Commercial
Themes: Theme 1. Understanding regolith processes
Theme 4. Regional mineral exploration studies
Theme 5. Making geochemistry more effective

Project Leader: Patrice de Caritat
Start date and duration: July 2004 –June 2007

Participants: GA, CSIRO EM, ANU, CSIRO L&W - Patrice de Caritat, Dirk Kirste, David Gray, Bear McPhail, Grant Douglas

Brief project description:
We propose to carry out an umbrella project with the general aim of promoting groundwater geochemistry for mineral exploration. This umbrella project will host a series of activities, ranging from self-contained sub-projects (with separate budgets), to one-on-one projects with industry partners, teaching, presentations at meetings and publications.

Thus, the umbrella project's aims are twofold:

1. To *further develop* hydrogeochemistry as a tool for mineral exploration under cover (new areas/commodities)
2. To *promote* hydrogeochemistry as a tool for mineral exploration under cover through talks, lectures and publications.

Sub-projects include:

- Cobar Cu-Au (PL Bear)
    - The aims of this sub-project are to understand the potential for using hydrogeochemistry in mineral exploration for gold, copper and related elements in the Lachlan Fold Belt, and to understand the potential for those elements to be dispersed and/or concentrated under present day groundwater conditions. In addition, we aim to develop a hydrogeological model to understand the groundwater flow paths and rates on deposit to regional scales.
- Moolart Well Au (PL Bear)
    - The aims of this project are similar to the Cobar sub-project, but to apply them to gold deposits in the northern Yilgarn. There are likely to be useful comparisons between hydrogeochemistry and its effectiveness in mineral exploration for gold deposits in two different terrains on the eastern and western sides of Australia.
- S Yilgarn Ni (PL Dave)
    - Research into the hydrogeochemistry of Ni Sulfide in northern parts of the Yilgarn Craton has yielded very useful parameters associated with normal ultramafic rocks, barren sulfides and mineralized sulfides. It is proposed to extend this to the acid/saline groundwaters of the Yilgarn Craton and of the Gawler Craton. This will be relevant to the many prospective zones in these areas. Investigations in these environments

will be complicated by the variable acidity, redox and salinity, depth variability and the high dissolved background for many metals. New pathfinders and modeling techniques will be tested as well as fundamental research into groundwater evolution.

- Wheat Belt U (PL Dave/Grant)
    - See separate form

Additional activities include:

- Consultancy for industry on groundwater interpretation
- Interact with other LEME projects interested in hydrogeochemistry (at these projects' cost)
- Meeting with industry stakeholders
- Promote hydrogeochemistry applications at various meetings
- Publication of our work in reports, general and scientific articles

There is a strong component of collaboration and consultancy with industry in this project, which will bring in cash and in-kind support. For instance, existing activities with industry support include the southern Yilgarn Ni project and consultancy projects with Anglo-American plc interpreting groundwater geochemistry.

This project contributes to the overall outcomes of hydrogeochemistry applied to mineral exploration, which are:

1. Lower the cost of exploration by selecting smaller areas for drilling (area selection)
2. Rank geophysical or other anomalies (ranking)
3. Discover point-sources for hydromorphic dispersion (targeting)

Scientific Deliverables (new scientific advances)

1. Broaden spectrum of commodities for which hydrogeochemical exploration has been trialled
2. Apply hydrogeochemical exploration expertise to new areas in different geology, regolith and landscape settings
3. Apply geochemical and hydrogeological modelling to gain better understanding of processes affecting dispersion, footprint size, and the development of geochemical and isotopic vectors

Deliverables to Client (Adoption mechanisms)

1. Case studies to clients (externally funded)
2. LEME case studies, e.g., copper and gold in Cobar, gold at Moolart Well, nickel and base metal sulfides in the southern Yilgarn
3. Provide a HydroMinEx component to other LEME projects, e.g., Ravi's biogeochemistry, Curnamona MinEx (budgeted separately in these projects)

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

1 July 2006	Project and sub-projects start
September 2006	Paper(s) presented at AESC and/or Goldschmidt conference
November 2006	Paper(s) presented at LEME conference
30 June 2007	Activities in sub-projects conclude, report(s) submitted

Project name: **The Development of a Laterite Geochemical Map of the Western Yilgarn Craton**

Abbreviated title: **Laterite Atlas**

Type of project Centre
Themes: **Themes 4 & 5**

Project Leader: Matthias Cornelius (and Paul Morris, GSWA)
Start date and duration: July 2003; 4 years

Participants: Matthias Cornelius, Ian Robertson, Charles Butt, Amanda Cornelius, Andrew Hacket

Brief project description:
The project is aimed at establishing a geochemical atlas for the Western Yilgarn Craton, using lateritic residuum, lag derived from lateritic residuum and lateritic detritus from colluvium. The overall objective of a geochemical atlas is to identify major new geochemical trends and provinces, both in residual and in depositional terrains, that could assist exploration and lead to the discovery of new mineral deposits. The project is in collaboration with the Geological Survey of Western Australia and MERIWA.
To date, approximately 2000 samples from the southwest quadrant of the Yilgarn Craton have been analysed and results have been published as CRC LEME OFR201 in March 2006.
In 2006, sampling will continue in the NW quadrant and a number of laterite samples from previous CSIRO and CRC LEME studies, representing different styles of mineralization and different commodities, and different bedrock types, e.g., from Golden Grove, Boddington, Mt Gibson, Lawlers, Ora Banda, Beasley Creek, will also be included for analysis to provide target data sets for statistical evaluation using multivariate analysis. Representative samples from various parts of the western Yilgarn and samples both with an unusual and a typical geochemical composition will undergo mineralogical investigation.

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

- Collect approximately 700 samples in the northwestern Yilgarn and analyse using ICP-MS and XRF.
- Produce imaged concentration maps for 53 elements.
- Correlate geochemistry with major lithological bedrock units and structural features.
- Identify major new geochemical trends and provinces.
- Calculate exploration indices, e.g., CHI and PEG (after Smith and Perdrix).
- Calculate summary statistics.
- Provide quality control.
- Characterize the mineralogy and fabric of representative samples.
- Link data to company data sets (e.g., Dominion Mining) and establish projects with industry partners to follow-up specific trends or anomalies

Milestones: *(dates of significant events marking scientific progress)*
October 2006 – Complete all sampling including helicopter work (subject to sufficient field support staff)
April/May 2007 – Final project report (GSWA Record/MERIWA Final Report) and release of all data into the public domain
September 2007 – Present results at the IGES in Spain
December 2007 – Submit draft paper to an international journal (GEEA?)

Confidentiality requirements
There is no confidentiality requirement post release of the final report.

Project name: **Gold and metal geochemistry and mobility in the regolith**

Abbreviated title: **Metal mobility**

Type of project Centre
Themes: 1. Understanding regolith processes
4. Regional exploration studies
5. how geochemical anomalies form in complex landscapes
9. Regolith geoscience and urban Australia

Project Leader: D.C. "Bear" McPhail
Start date and duration: July 2003-June 2008

Participants: ANU, CSIRO E&M, University of Adelaide

Brief project description:
This is the continuation and extension of Project 2.37 Gold Geochemistry and mobility, which started in July 2003 and was originally intended to last for three years. In consultation with Program 2 leader, Ravi Anand, the original project has been extended to the end of LEME in June 2008. I list the original objectives, give a brief background and summaries of work to date and follow with a list of specific studies and outputs for financial year 2006-07.

The objectives are to understand:

i) the geochemistry and mobility of gold in waters and brines;
ii) the impact of microbiota (bacteria and fungi) on the mobility of gold in regolith;
iii) sorption of metals, e.g., Cu and Zn, to iron oxyhydroxide minerals, in particular as a function of salinity;
iv) the solubilities of zinc alteration minerals and the dispersion and mobility of zinc in the regolith;
v) the aqueous transport of base and precious metals through the regolith; and
vi) the leaching from and uptake of metals in ferruginous and carbonate regolith materials.

The scope of the work includes:

i) experimental studies (UV-Vis spectrophotometry, mineral solubility) to identify aqueous gold complexes (chloride, iodide, thiosulphate) and measure their thermodynamic properties;
ii) field, experimental and molecular microbiology studies to identify correlations between microbiota and gold distribution in the regolith;
iii) column experiments to study the mobility of copper, zinc and possibly gold and other metals through synthetic and natural regolith under different salinity, pH and redox conditions;
iv) field studies of gold distribution and dispersion in regolith and groundwater;
v) experimental studies of copper and zinc sorption onto goethite as a function of pH and NaCl concentration;
vi) experimental studies of zinc mineral (hemimorphite) solubility and field studies of zinc dispersion, and;

vii) experimental and field studies to determine the conditions, e.g., pH, salinity, redox, dissolved organics, under which metals are incorporated into ferruginous minerals and materials during growth and/or released during mineral changes and/or dissolution.

Gold geochemistry and mobility

Although many aqueous complexes of gold have been identified, their thermodynamic properties are not well known. Part of the work in this project is to measure experimentally new thermodynamic properties for gold complexes, especially halide ones, which will include new estimates of activity coefficients for hypersaline conditions. The specific gold complexes we are targeting are chloride, bromide, iodide and thiosulphate, as a result of field and theoretical studies by Michelle Carey and D.C. McPhail in the St. Ives gold field of WA, and previous studies by David Gray of CSIRO Exploration of Mining. The experimental methods we are using are UV-VIS spectrophotometry (Au(III) chloride, bromide and hydroxide complexes; 25-80°C) and solubility of native gold in brines at 50°C. In addition, we are studying the effectiveness of analysing low-level gold concentrations in brines using carbon sachets and INAA.

In related studies as part of the HydroMinEx project, we will also do field studies (i.e., gold deposits at Cobar, NSW and Moolart Well, WA) to focus experiments and subsequently apply the results of our experimental studies. In particular, the field studies are aimed at understanding the potential to use hydrogeochemistry effectively for mineral exploration, especially in areas of transported cover, and the potential for the dispersion and/or concentration of gold and related elements given current groundwater conditions (e.g., temperature, pH, Eh, salinity).

The microbiology component of the original project is now finished with the completion of Frank Reith's Ph.D. thesis; however, I anticipate ongoing collaboration with Frank in his new position as a post-doctoral fellow in CSIRO Exploration and Mining.

The results from the several aspects of this work can used to develop more rigorous and effective predictive models of gold transport in natural regolith environments. This will lead to improved exploration strategies for new gold deposits.

Copper and zinc adsorption

The adsorption of metals onto mineral surfaces has been studied extensively, but despite this, the effect of salinity is not clearly understood. Ph.D. student, Chris Gunton has measured the effect of pH, and concentrations of NaCl and Na_2SO_4 on the adsorption of copper and zinc to synthetic goethite. The results show that Cu adsorption is enhanced with increasing NaCl at pH < approximately 4.5, but unchanged at higher pH. Zn adsorption is suppressed with increasing NaCl. Sulphate has little effect on Cu adsorption, but suppresses Zn adsorption. The experimental work and much of the interpretation is complete and writing of thesis and manuscripts is well under way.

Zinc solubility and dispersion

We will continue to measure the solubility of a zinc mineral, hemimorphite (hydrated zinc silicate), and study the dispersion of zinc around the Reliance deposit in South Australia (Honours project by Nathan Emselle), building on our recent experimental and numerical modelling studies (zinc adsorption, zinc transport, willemite (anhydrous zinc silicate) formation). We are in the process of completing experiments to measure the solubility of hemimorphite, with the aim of having a publishable dataset during the coming year. Preliminary sampling and anaysis of ore and regolith samples from the Reliance deposit indicate colluvial/alluvial transport as the main process of zinc dispersion in surface regolith samples; however, there are indications of elevated zinc concentrations in transported regolith that indicate other dispersion mechanisms (e.g., hydromorphic).

Copper and zinc transport

We (Dirk Kirste, Sue Welch and I) have established an experimental facility to study the transport of copper, zinc, salt and perhaps other metals in regolith. We are using column experiments, in which the columns are packed with regolith material (e.g., natural and synthetic goethite-coated sand, hematite-coated sand) and copper-bearing solutions of different pH are pumped through the regolith material (completed Honours project by Jennifer de Livera). The results show that the effect of pH (4-5) is small, in contrast to the adsorption experiments of Chris Gunton, because of the presence of kaolinite in the natural sand and consequent adsorption of copper to kaolinite at lower pH than goethite. Quantitative interpretation of the experimental data is complex as it requires an understanding of the hydraulic properties of the material (i.e., porosity, hydraulic conductivity, dispersion) as well as the geochemical interaction between dissolved metals and the regolith (mainly adsorption). The combination of the results from adsorption experiments and transport experiments will lead to a much more comprehensive understanding of how dissolved metals will transport in groundwater through regolith.

Metal fractionation between water and ferruginous regolith material

The original project is being extended to add a new component of studies, the fractionation of metals between water and ferruginous material. There is a growing body of studies in LEME and elsewhere showing trace metal (e.g., Cu, Zn, Pb, As, Au, Ni, U, Th) concentrations in ferruginous material, e.g., goethite- and/or hematite-rich regolith, lag material, but the conditions and mechanisms by which the metals are incorporated into, and/or leached out of, the material are poorly understood. This makes it difficult, if not impossible, to interpret the microanalytical results and decipher whether they mean there is an associated ore body. We propose to study the entrapment and release of metals in or out of natural ferruginous regolith, as a function of time (weeks to months), pH (3-6) and NaCl (0-3 molal). Time and resources permitting we will also study similar/analogous phenomena with carbonate-rich regolith (e.g., calcrete).

There is potential for close interaction with many LEME projects, in particular Metal Transfer Mechanisms and Hydrogeochemistry for Mineral Exploration.

This project clearly contributes to the strategic intent of LEME. Understanding the geochemistry and mobility of metals is a necessary part of understanding how they move through the regolith in groundwater. It relates to at least three of the likely

mechanisms/processes for metal mobility: advection, convection and diffusion. This is also a necessary part of understanding how anomalies develop in areas that are covered, or not, with transported regolith, i.e., improving mineral exploration under cover.

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

- New experimental data on gold solubility and complexes (chloride, bromide iodide, thiosulphate), metal sorption on goethite, solubility of hemimorphite, copper and zinc transport, metal fractionation between water/brine and ferruginous materials;
- New and/or refined thermodynamic properties of solubility, aqueous complex and sorption reactions for gold-, copper- and zinc-bearing chemical systems;
- Predictive numerical models of optimal environments for leaching, transport and deposition of gold and some base metals;
- Improved understanding of gold and other metal mobility (dispersion, concentration) in the regolith, especially in waters and brines;
- Applications of gold and other metals solubility and reactive transport numerical models to field studies of gold mineralisation and distribution in the regolith – *in situ* and transported cover;
- Improved understanding of the effects of microbiota on gold distributions and mobility in the regolith;
- Establishment of experimental facilities in LEME for studying metal transport in groundwater (low salinity to brines) and the regolith;
- Combination of CRC LEME Open File Reports, journal articles and conference presentations, as well as 3 or more Honours and 3 or more Ph.D. theses, and;
- Improved understanding of how geochemical anomalies form in the regolith, including the dispersion mechanisms that transport metals, both of which will result in improved exploration strategies in areas of *in situ* and transported regolith.

Milestones: *(dates of significant events marking scientific progress)*
Years 2003-2005; most of these have been accomplished

- Establishment of experimental methodology for measuring native gold (or Au(I) salts) solubility;
- Establishment of reactive transport experiments (column experiments);
- Preliminary results of gold solubility and reactive transport experiments;
- Analytical (from field samples) and experimental results related to the microbial effects and gold distributions and transport in the regolith;
- Analysis of groundwater samples from in and around gold ore deposits in the Yilgarn and Gawler Cratons for major, minor and trace element chemistry;
- Measurement of oxidised Au(III) UV-Vis spectra over wide range of chloride concentration (0-15 molal);
- Measurement of Cu(II) and Zn(II) sorption onto goethite as a function of pH and NaCl and Na_2SO_4 concentrations;
- Measurement of hemimorphite solubility;
- Sampling and bulk geochemical analysis of regolith samples from the Reliance zinc oxide ore deposit, SA; and

- Measurement of gold solubility in saline to hypersaline brines;
- Quantitative interpretation of gold experimental data (UV-Vis) to derive thermodynamic properties;
- Completion of Cu and Zn sorption experiments by Ph.D. student Chris Gunton;
- Completion of molecular microbiology studies by Ph.D. student Frank Reith;

Year 2005-2006 (completed and/or ongoing)

- Completion of gold halide speciation by UV-Vis spectrophotometry experiments (complete);
- Native gold solubility experiments (nearing completion; awaiting INAA analytical results from Becquerel Canada);
- Completion of interpretation of experimental data (nearing completion from UV-Vis experiments; still to do for native gold solubility experiments)
- Numerical models of aqueous speciation and solubility of gold (ongoing);
- Reactive transport experiments (Cu through goethite- and hematite-coated sand – natural regolith) and reactive transport models to compare with the experimental data (complete);
- Development of reactive transport experimental facility (installation and testing of in-line EC and pH electrodes);
- Conference presentations (Goldschmidt (2) and LEME Symposia (4));
- Publication and submission of manuscripts international journals (4);
- Development of methodology for measuring trace metal incorporation and leaching from ferruginous materials and preliminary results (yet to come, and ongoing).
- Ph.D. students: Frank Reith (completed), Chris Gunton and Alistair Usher (ongoing);
- Honours students Jennifer de Livera (complete) and Nathan Emselle (ongoing);
- Summer scholars (Vidura Jayaratne, Gabrielle Yates); and

Year 2006-2007

- Continuation and completion of experiments to study transport of base and precious metals through regolith;
- Continuation and completion of experiments to study fractionation of metals between water, brine and ferruginous regolith material;
- Continuation of field studies for groundwater and regolith geochemistry and transport of metals;
- Start of at least 2 Ph.D. students and completion of 2 or more Honours student;
- Conference presentations (national and international);
- Publication and submission of manuscripts for CRC LEME Open File Reports and/or national/international journals;
- Development of robust and reliable numerical models for the geochemistry (speciation, solubility, sorption) and transport (reactive transport) of base (e.g., Cu and Zn) and precious (e.g., Au) metals; and
- Application of experimental and model results to understand existing base and precious metal mineralisation and its dispersion, and to help develop new and more successful mineral exploration models.

Proposed publications

1. UV-Visible spectrophotometric studies of ligand competition and complex formation at Au(III) metal centres: Part I – gold chloride-bromide complexes. Geochimica et Cosmochimica Acta (Usher, McPhail and Brugger; submit September 2006; 3 weeks)
2. UV-Visible spectrophotometric studies of ligand competition and complex formation at Au(III) metal centres: Part II – pH dependence of Au(III) halide complex formation. Geochimica et Cosmochimica Acta (Usher, McPhail and Brugger; submit January 2007; 3 weeks)
3. The effect of NaCl on the sorption of CuII on synthetic goethite. Geochimica et Cosmochimica Acta (Gunton, Christy and McPhail; submit August 2006; 2 weeks)
4. Biomineralisation of gold – biofilms on bacterioform gold from Australia. Science (Reith, Rogers, McPhail and Webb; presently in revision; 3 days)

Confidentiality requirements: None at present

Project name: Minerals, lithologies and structural mapping using integrated techniques, incorporating hyperspectral, airborne EM, radiometrics, magnetics and gravity of regolith covered basement terrains (Olary District, Gawler Craton, Musgrave Block and Adelaide Geosyncline, South Australia)

Abbreviated title: Mineral Mapping South Australia

Type of project Centre
Themes: Regional exploration studies,
Geophysical mapping and modelling,
Making geochemistry work in areas of cover,
Regolith processes

Project Leader: Dr AJ Mauger
Start date and duration: 2001-2008

Participants: PIRSA, CRC LEME, University of Adelaide

Brief project description:
Relating mineralogy to the development, identification, characterisation and measurement of the regolith with the aim of establishing successful mineral exploration vectors using spectrally active minerals in covered terrain constitutes the core of this project. Utilising spectral geology at all scales of observation (hand specimen, drill core, airborne and space-borne) integrated with other geoscientific datasets, including regolith, geomorphological and geological mapping ("ground truthing"), the distribution and characteristics of different regolith units and their processes of formation from the various basement lithotypes will be identified. New aspects of the project include demonstration of new equipment (CSIRO HyLogger) and new techniques for the analysis of new datasets (in particular hyperspectral and multispectral remote sensing data such as HyMap, Hyperion and ASTER), integration and analysis of multiple datasets.

Particular project areas to come under the umbrella of this project include:

- Gibraltar, north-west of Tarcoola. Proterozoic acid volcanics with a superimposed Jurassic palaeodrainage system.
- Tarcoola Ridge. Examining in situ development of regolith over a known gold deposit and its associated alteration system. Use of CSIRO Automated Core Logger to map 3D distribution of spectrally active minerals.
- Beltana/Aroona/Reliance carbonate hosted willemite deposits. Examining mineral alteration vectors to a known deposit concealed by transported regolith
- White Dam, Olary Domain. Characterising regolith mineral expression of a known deposit to enable predictive exploration using hyperspectral data
- Central Gawler Gold, ASTER image analysis. Use of CSIRO HyLogger to characterise the alteration system associated with Proterozoic gold-only mineralisation.
- Pine Creek kimberlite province. Documenting the spectrally visible mineral expression of regolith covering known kimberlites.

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

- Synthesis of case studies conducted over SA
- New models for "seeing" bedrock through cover in SA basement areas
- New models establishing mineral relationships from bedrock to surface
- Accurate mapping of previously unrecognised saprolite at the surface
- Prediction tools for mineral exploration
- Training of students in regolith studies, geophysics, mapping

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

2001:	Project commenced
March 2002:	HyMap Surveys: Beltana, Pine Creek.
May 2002:	5th International Airborne Remote Sensing Conference, Miami
July 2002:	16th AGC, Adelaide
September 2002:	11th ARSPC, Brisbane
September 2002:	2nd Geological Hyperspectral Focus Grp, North Flinders Ranges
November 2002:	Honours Thesis on use of Hyperion over Tarcoola
January 2003:	Project review
September 2003:	ASTER Mini-Conference
November 2003:	Honours Thesis on Beltana
January 2004:	Complete acquisition HyLogger Phase one
July 2004:	PhD Thesis on White Dam
May-Dec 2004:	Supporting XRD & SEM analytical work for HyLogger Phase one
October 2004:	12th Australasian Remote Sensing Conference
January 2005:	Complete acquisition HyLogger Phase two
Feb-Dec 2005:	Supporting XRD & SEM analytical work for HyLogger Phase two
May 2006	Paper in IMMTrans
July 2006	Australian Earth Sciences Convention 2006
July-Sept 2006:	Supporting XRD & SEM analytical work
June 2008:	Compendium on use of Spectral Geology in Mineral Exploration through the Regolith: South Australian case studies.

Progress will be reviewed quarterly with sponsor reports on demand. Papers will be prepared for periodic conferences as appropriate.

Project name: The geochemical expression of komatiite-hosted Ni sulfide deposits in residual and depositional terrains with special emphasis on the behaviour of platinum-group elements in the regolith.

Abbreviated title: Ni PGE

Type of project **Centre**
Themes: Regional Exploration Studies
How geochemical anomalies form in complex landscapes

Project Leader: **Steven Barnes and Matthias Cornelius**
Start date and duration: 1st July 06; 18 months

Participants: CSIRO EM - Matthias Cornelius, Steven Barnes, Charles Butt, Ian Robertson, David Gray, Rob Hough

Brief project description:
One of the significant outcomes of the laterite geochemical atlas of the Western Yilgarn Craton has been the observation that lateritic gravel near magmatic sulphide deposits shows distinct Platinum group element (PGE) patterns. The PGE signatures in this gravel show trends that are very similar to those in fresh Ni sulfides and are different from signatures in lateritic gravel formed on peridotite and layered mafic-ultramafic rocks. Due to the increased sensitivity of analytical methods used for PGE analyses, the use of PGE in regolith materials for regional Ni exploration has the potential to provide a powerful and practical new exploration tool.

There is a unique opportunity to capitalize on the extensive regolith knowledge within CRC LEME and the research on PGE in the past (Ora Banda by C.R.M. Butt, I. Robertson and D. Gray, Mt Keith by N. Brand and C. Butt, and Yarawindah Brook by M. Cornelius). In addition, S. Barnes of CSIRO EM has world-class expertise on magmatic Ni sulphides and komatiitic rocks, and an extensive database on PGE contents of unweathered Ni sulfide ores. Combined, this know-how can be utilized to investigate the characteristics of PGE in regolith formed on Ni-sulfide deposits and to develop an efficient surface geochemical exploration method for Ni sulfide-PGE deposits that will greatly benefit the exploration and mining industry.

To date, there are no detailed studies available on the behaviour and dispersion of PGEs during lateritic weathering of type 1 (sulfide-rich) Ni sulfide deposits. The dispersion of PGE and other ore-related trace elements needs to be investigated on geologically well understood Ni deposits to establish an exploration model for massive and disseminated Ni sulfide deposits in different landform settings. The research sites will be selected based on deposit, regolith and landform characteristics.

This pilot study will focus on the development of regolith on one or two yet to be determined sulfide-rich Ni deposits in the Yilgarn Craton. We will investigate geochemical signatures in the residual regolith, from saprock to lateritic residuum, at the interface and within the transported cover, if present. Geochemistry and mineralogy of the regolith will be compared with those of barren and mineralized fresh rock. We will investigate the mineral hosts of PGE, Ni, Cu and Cr in the regolith profile and the fractionation of this element suite during the regolith

development. Textural and geochemical characteristics of various regolith materials will be compared and the study may also include analyzing historical samples (especially gossans), and other sample media. Groundwater investigations, in particular, will give fresh insights into dispersion processes.

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

1. The research is intended to have a significant impact on Ni-PGE exploration in the Yilgarn Craton and elsewhere in deeply weathered terrain by providing geochemical and mineralogical parameters for exploration that can aid the dominantly geological/ geophysical exploration as it is done to date.
2. The project will synthesize some of the work done by S. Barnes on the genesis and characteristics of Ni-sulphide deposits and work done by CRC LEME on regolith and landforms in the respective terrains hosting the deposits.
3. The project will add value to the Yilgarn Laterite Atlas and may attract additional funding for a continuation of this project in other parts of the Yilgarn and surrounding areas or for specific studies as part of exploration projects.
4. This understanding will lead to a practical exploration model for Ni deposits in different landform and regolith settings.
5. The investigation of mineral hosts of PGE in the regolith, relic fabric in ferruginous materials in the context of the primary magmatic features, and the local and regional geochemical signatures in different regolith materials will enable differentiation between different types of Ni sulfides, i.e., massive and disseminated, in ferruginous regolith materials.
6. The main outputs will be a CRC LEME report and a corresponding publication in an international scientific journal.

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

November 2006 –	Completion of sampling and field studies
June 2007 -	Completion of analytical work and micro-analytical studies
September 2007 -	Presentation of results at the IGES in Spain in 2007
November 2007 -	Completion of draft report and paper.

Results will also be presented at the CRC LEME exploration seminar in 2007.

Confidentiality requirements

Permission to sample Ni sulphide deposits may be subject to a short confidentiality clause pertaining to the data obtained for specific deposits. However, there is no confidentiality requirement for the release of the final report and paper.

Project name: Objective Logging of Regolith Materials

Abbreviated title: Objective Logging

Type of project Themes: **Centre**

Project Leader: Tim Munday
Start date and duration: July 2003-June 2007

Participants: CSIRO, GA, PIRSA, Industry

Brief project description:
The project aims to develop practical automatic interpretation tools for logging regolith materials returned as core, drill chips, or pulps. It also aims to better define the regolith mapping and predictive modelling capabilities of spectral data acquired from imaging spectrometers such as HyMap. The intent is to provide the exploration geologist, mining engineer, geomorphologist or environmental scientist with meaningful, objective information of regolith materials to aid geological, geophysical, geotechnical and geochemical interpretation. The goal is not to replace the experienced geological interpretation of materials in their spatial and temporal context, but to complement and refine this knowledge through the rapid analysis and presentation of mineralogical (spectral), geochemical (hand held XRF). The project technology will aid the definition of 3D and 4D models of regolith and landscape with exploration and environmental applications. Project activities will develop and support interactions with other LEME studies in SA, WA, NT and NSW, as resources permit.

The project will place particular emphasis on the development of spectral logging procedures, using CRC LEME's ASD and PIMA instruments, as these add significantly to our understanding of the nature and distribution of regolith materials in 3D. Spectro-mineralogical R&D will address issues arising from dealing with pulps (and chips) relative to spectral characteristics of equivalent whole rocks. We suspect some grain size, dilution or masking effects for certain types of pulps with certain minerals. We will develop new spectral library matching approaches specific to regolith materials based on *a priori* knowledge of proportions derived from XRD and XRF.

The potential for the commercialisation of algorithms and procedures will be investigated in conjunction with CSIRO EM Detection Technology Group who are planning commercialisation of Hylogging technologies.

We propose to develop and conduct a training workshop with AUSSpec for the mining and exploration industry and their service providers, to promote understanding and awareness of the developed technologies. We will explore opportunities for incorporation of objective logging technologies into the exploration workflow by developing one-to-one partnerships with exploration companies. This will assist in determining the nature and form of mineralogical and derived data that is of most value.

Specific Objectives for 2006-7 include:

1. Conclude the reporting of ***three*** case studies detailing the application of spectral logging through the regolith. This will include continued development of procedures to recognise and quantify various poorly ordered clay minerals and their mixtures. This will site studies at Lake Carey, Moolart Well, and one other site.

2. Conclude a study on the effectiveness of spectral logging in the identification of alteration mineralogy in the regolith in a collaborative study with industry (Barrick).
3. Investigate quantifying quartz and feldspar in regolith materials using the MID infra-red spectral data. This work will be conducted in collaboration with CSIRO L&W
4. Trail the application of spectral logging in the exploration workflow with a collaborative study undertaken with Genalysis. This work will explore the consequences of different sample preparation methods on spectral behaviour of drill core/chips/pulps. (Quasi-operational application of CRC LEME Logging table, as a precursor to the development of).
5. Conduct of workshop on *Spectral indices for use in regolith settings (August 06)* .
6. Solicit papers for the publication of a thematic issue of a prominent journal concerning the application of spectral mineralogy in exploration through the regolith and secure agreement for publication in 07-08.
7. Complete the development of regolith unmixing alogorithms and code in TSG.

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

Outputs

- Documentation of spectral and portable XRF techniques applied to control data sets and case studies from a range of regolith settings across Australia.
- Report on the value and relevance of spectral logging from a trial of automated logging procedures in the exploration workflow (results from the quasi-operational application of CRCLEME Logging table with Genalysis)
- Development of algorithms for the rapid, objective interpretation of multi-parameter logs and presentation of interpreted results, including new spectral matching techniques specific to regolith materials. Specifically this will entail the further development and reporting on automated unmixing algorithms and will involve:
    a) Development of "low frequency" spectral feature matching appropriate to unmixing algorithms
    b) Development of data compression techniques for processing and analysis
    c) Reducing the misrepresentation and poor estimation of particular mineral species
- Incorporation of regolith unmixing algorithms in TSG and commercial deployment.
- Refine specification of appropriate mineralogical interpretation software/algorithms for inclusion in commercial logging spectral software system,
- Technology transfer workshops with industry (including analytical labs) – to raise awareness and broaden industry acceptance and adoption of techniques developed.
- Report on a workshop to define regolith "Spectral indices" which can be incorporated into commercial software (TSG). Development of strategy for the commercial application and communication of this IP collaborative with CEM and other LEME partners eg PIRSA and GA.
- Agreement from Journal to publish a thematic issue on the use of spectral technologies in mineral exploration through the regolith

Outcomes

- Routine acquisition of mineralogical (spectral) data with geochemical data in exploration through the regolith, resulting in more effective exploration, targeting and priority setting.
- Better value from drillhole data, through the provision of regolith material and mineralogical information.
- Take up of auto-interpretation procedures by the exploration sector (through analytical labs?) to aid geological and geochemical interpretation in regolith settings
- More efficient and effective exploration in areas of cover, through ready identification of significant regolith boundaries, and better discrimination of bedrock/alteration variations in the regolith.

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

- August 2006: Workshop with CRC and interested scientists, to define and document "regolith spectral indices" for incorporation into TSG software as templates.
- September 2006: Report on spectral indices relevent to exploration through the regolith.
- October 2006: Summary report on commercialisation opportunities of CRCLEME objective logging technologies (Collaborative with CSIRO EM) following trial of Hychipper with Genalysis.
- December 2006: Agreement by Journal for publication for thematic issue on spectral technologies applied to exploration through the regolith.
- December 2006: Report on development of spectral unmixing techniques.
- June 2007: Submission of 2 papers for publication in thematic issue of refereed journal on spectral technologies for mapping and exploration through the regolith
- June 2007: Development and implementation of new algorithms (Regolith Templates) for the spectral interpretation and objective logging/analyses of regolith materials using TSG software.
- June 2007: Report summarising case studies concerning the application of spectral logging in exploration through cover.

Research progress will be formally reported through Quarterly reports and a final project report. Reports will be prepared in digital format for ready dissemination by electronic means.

Titles of proposed publications and journals where the papers will be submitted

1. The application of spectral mineralogy in the exploration through complex regolith cover (AJES thematic issue June 2006)
2. 3D regolith characterisation using objective logging techniques (AJES 2006)-

Titles of reports

1. Regolith Spectral Indices (September 2006)
2. Objective logging of regolith in the exploration workflow – the influence of sample preparation and material type(October 2006)
3. Spectral unmixing of regolith materials (Jan 2007)
4. The application of spectral logging in exploration through cover (June 2007)

Confidentiality requirements None

Project name: Predictive Geochemistry in Areas of Transported Overburden: Mechanisms of Anomaly Formation (AMIRA P778 Project)

Abbreviated title: **Predictive Geochem AMIRA P778**

Type of project Commercial
Themes: Mechanisms of anomaly formation

Project Leader: Dr Ravi Anand
Start date and duration: May 2006-May 2009 (CRC LEME participation expires 30 June 2008)

Participants: CSIRO Exploration & Mining, CSIRO Land & Water, Adelaide University, Curtin University, and AMIRA

Brief project description:
As the discovery rate of world-class mineral deposits continues to decline in Australia and other parts of the world, increased attention is being focused on geochemical exploration methods designed for covered terrains. If definitive, low cost surface or near-surface sampling surveys can be conducted in areas of shallow cover (say <30m), large areas can be tested and expensive unnecessary drilling can be reduced. In order to apply geochemical exploration methods confidently in a given area, or to be able to determine that such techniques are inappropriate, it is necessary that we understand the mechanisms by which surface expressions may form. Explorers will then be better able to decide whether to do further drilling given a specific response at the surface. Research is required that will determine which mechanisms can cause metal migration through post-mineralization cover.

As mineral exploration moves into regions dominated by shallow transported cover, conventional approaches are simply not applicable and thus increasingly there is a need for new innovative approaches to geochemical exploration. However to develop such new approaches there is a major need to identify the operating mechanisms capable of transferring metals from buried mineralization upwards through barren cover to the surface.

Understanding the processes of metal transport through transported overburden requires expertise and experimental techniques from a wide range of disciplines. In the proposed project the researchers will be using a combination of field and analytical techniques derived from soil science, botany, molecular microbiology, geochemistry, plant chemistry, hydrogeochemistry and regolith geology.

The main objective of the proposed project is to determine the mechanism(s) for formation of geochemical anomalies in transported overburden in a variety of Australian environments and, based on these mechanisms, to develop effective and reliable geochemical exploration techniques. The research focus will be on:

- Studies to develop practical sampling strategies and methodologies in areas of transported cover based on biota, soil and gas investigations.

- Experimental and theoretical work on the mechanisms leading to the formation of surface anomalies. This will provide the framework and constraints for the practical sampling methods.

The researchers will apply a range of techniques such as vegetation analysis of various plant species, metal uptake in the rhizosphere (plant-root zone), mass balance studies, in-house lab and greenhouse studies; groundwater geochemistry and redox analysis, microbial characterization including their role in gas generation and mineral-trace element biotransformation (solubilisation/precipitation) throughout the profile, isotope analysis to establishing source of metal in plants and soil, using artificial inserted adsorbent collectors to detect surface geochemical anomalies and utilising other research on soil desorption analysis to test gas migration possibilities. The researchers will use a combination of *in situ* and *in vivo* spectroscopic techniques such as synchrotron-based techniques, nanosims, electron microprobe and laser ablation ICP-MS to determine the nano-scale location of metals in vegetation and regolith materials.

Sponsors of the project: BHP Billiton, Cameco Corporation, Teck Cominco, Independence Gold, SGS Minerals, Barrick Gold, Inco and Newmont.

The project will cost AUD$3,040,351 over three years which includes AMIRA International's project development and administration fee but excludes the 10% Goods and Services Tax from Australian based companies. Total cash and in-kind contributions of AUD$1,984,151 (including AUD$255,000 cash from LEME) will be provided by CRC LEME through its core participants: CSIRO (as represented by Exploration & Mining and Land & Water), Curtin University, and Adelaide University. CSIRO would provide an in-kind contribution of $140,946 in the 2008/09 financial year. The balance of AUD$915,254 is obatined from industry through AMIRA. Companies who are members of AMIRA International the individual sponsorship required is AUD$38,100 per annum (exc. GST for Australian based companies) over three years and non-AMIRA members are required to pay a AUD$7,200 per annum surcharge.

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

Scientific Deliverables (new scientific advances)
(i) Improved scientific understanding of the mechanisms that are responsible for metal migration through transported cover;
(ii) Guidelines for assessment of which transported regolith environments metal dispersion is possible in and what sample media/techniques are most likely to detect it.
(iii) New cost-effective and practical exploration method(s), with higher reliability and probability of success; (distinction between negative and null result)
(iv) Potential to use new exploration methods in other parts of the world.

Deliverables to Client (Adoption mechanisms)
i. Technical reports describing the work completed at each study site;
ii. Technical report summarizing experimental and theoretical work on sampling strategies, sample preparation and sample analysis;

iii. Final report on mechanistic models to account for observed metal migration or its absence, integrating all aspects of the study including different regolith and palaeo-climatic controls on migration, and variations with respect to different commodity elements.
iv. National and international publications in peer reviewed journals.

Milestones: *(dates of significant events marking scientific progress)*
May 2006: Commencement of project
May 2007: Interim report on practical sampling strategies and results on mechanisms.
May 2008: Interim Report with emphasis on mechanistic and experimental studies
May 2009 Final Report

Confidentiality requirements
The outcomes will be confidential to sponsors during and up to one year after completion of the three year project, after which researchers have the right to publish.

Project name: Conference Attendance (presenters only)

Abbreviated title: **Prog 2 Communications**

Type of project Centre
Themes: Various

Project Leader: Ravi Anand
Start date and duration: July 2006 12 months

Participants: *IGES Spain:* Ravi Anand, Charles Butt, Matthias Cornelius, David Gray, Rob Hough, Mel Lintern, Ken McQueen, Ryan Noble, Ian Robertson
Goldschmidt Melbourne: Ravi Anand, Charles Butt, Rob Hough, Frank Reith
Minex Adelaide: John Keeling
LEME Minex Seminar Perth - 11 Aug 06
AESC2006: John Keeling
Conference in Santiago, Chile: Ravi Anand
5th Decennial Conference on Mineral Exploration, Toronto Canada September 9-12 2007: Tim Munday
ASEG 19th International Geophysical Conference and Exhibition, Perth Nov 2007: Tim Munday

Brief project description:
Request for provision of funds for staff presenting at various conferences during the 2006-2007 financial year. Funding for registration, air travel, taxis, accommodation and meals is sought.

Project name: **Metal migration: Tracing, timing and Modelling**

Abbreviated title: **T.R.I.M.M**

Type of project Centre
Themes: Understanding regolith processes
Regional exploration studies
How geochemical anomalies form in complex landscapes
Regolith geoscience and urban Australia

Project Leader: Robert Hough
Start date and duration: I July 2006, 2 years (June 2008)

Participants: CSIRO, ANU, PIRSA

Brief project description:
Step changes in exploration geochemistry will only occur if we can truly define where geochemical anomalies reside and how and when they got there. To achieve this we need to understand the fundamental dispersion processes. This has been the aim of the LEME initiative in Mineral Hosts and Mechanisms of Metal transfer and over the next two years, we, through the project proposed here will pursue focussed activities to capitalise on the progress made to date.

Hydromorphic dispersion is an important mechanism for the transport of metals to the near surface environment during deep weathering of ore deposits, and plays a key role in the final residence of metals in regolith minerals and hence anomaly formation. This project is a *fundamental* mineralogical and geochemical study of this dispersion into deeply weathered (both in-situ and transported) regolith environments together with developing a new understanding of solid gold grain provenance in these environments (supergene or primary). It also encompasses a study of diagnostic mineralogical clues to ore systems that can be recognised in samples from laterite geochemical anomalies (e.g. as achieved at Golden Grove).

In summary, we propose well defined outcomes from: 1. A study of phreatic mineral deposits such as alunite acting as a mineral host including a detailed description of how such minerals incorporate or adsorb metals. 2. Dating element dispersion by combining in-situ geochronological and geochemical analyses of the same samples. 3. 3. A pilot study to establish whether clues to ore systems, along the lines of the research carried out at Gossan Hill, can be recognised in samples from a variety of laterite geochemical anomalies in the Yilgarn craton. 4. Utilising gold crystallography to decipher supergene and primary origins and combined with chemistry to determine the effects of weathering on native gold occurring at or near the surface and how this modifies bulk gold chemistry. 5. Using reactive transport software (e.g. GWB, FastFlo and OS-3D) to develop increasingly sophisticated numerical simulations to understand mechanisms of near-surface geochemical anomaly formation. Initial research in this area has focussed on the behaviour of gold, and this work is to be continued, however subsequent work will also consider mechanisms for other commonly analysed indicator species such as copper and nickel. 6. Advanced study of gold anomaly formation in calcrete.

Aim: To determine the timing and role of hydromorphic dispersion in metal transport (including supergene gold) and the mineralogy of anomaly formation.

Objectives (2 years):

- Determine the role of phreatic minerals as hosts for Au and pathfinders using *in situ* electron optical techniques such as Synchrotron, nanosims, electron microprobe, laser ablation). Emphasis also to be placed on determining the oxidation state of metal species using Synchrotron techniques (XANES, µEXAFS, µsXRF) to investigate metal-host relationships and forms of metal binding c.f. incorporation/adsorption, and the presence of toxic species (e.g. As III or Cr VI). This is an important initiative as a precursor to the Australian Synchrotron coming online late 2007 and links to environmental toxicology studies.
- Use SEM/electron microprobe to study the detailed mineralogy of Yilgarn laterites that host geochemical anomalies to identify clues to buried ore systems.
- Numerical modelling capacity for generating a predictive understanding of geochemical anomaly formation in the regolith.
- Computational solutions for the generation of 3D images of the probability of ore occurring in a particular prospective area.
- New directions in combined crystallographic/geochemical observations of alluvial/lateritic gold grains to determine provenance.

This project pursues only focussed aims as a direct result of key successful directions from the recent work within LEME including Alunite studies, dating metal dispersion, gold grain provenance and the exciting possibility of 3D modelling. Importantly, it also cements our presence as a major player in new Synchrotron science initiatives for mineral exploration applications in Australia. It is a project focussed on natural sample analyses rather than experiment in direct contrast to the metal mobility initiative of Bear McPhail.

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

Outputs-year 1

- Submission of a journal paper on work conducted at Mount Gibson and Poona on phreatic minerals.
- Submission of a journal paper on weathering chronology and dispersion of Cu at Moonta.
- Submission of journal paper on ultra thin supergene gold crystals (Golden Virgin, WA)
- Submission of paper to GEEA, "Element dispersion under different weathering regimes in the Cobar region of western New South Wales"
- Scientific publication on the crystallography of gold occurring as nuggets.
- Quarterly reports
- Final reports in 2008.
- Presentations to LEME symposia including the exploration seminars and at international conferences (e.g. Goldschmidt and/or IGES).

Outcomes

- Recommendation of most suitable and cost effective exploration procedures and sampling strategies for regolith-dominated terrains.
- Identification and analyses of minerals related to phreatic processes (e.g. sulfates) as a vector for exploration. Be able to determine the timing of metal dispersion which is pivotal to understanding the origin and formation of anomalies and palaeoenvironments
- A new understanding of alluvial/lateritic gold grain provenance based on combined crystallography and chemistry.
- Develop a computational tool which explorationists will be able to use to identify the most cost effective sampling strategies in a wide range of regolith environments.
- Build a chemical (reactive transport) numerical modelling tool which will enable prediction of the location and relative tenor of geochemical anomalism in different regolith units depending on such factors as the:
  - Size, grade, sulphide content and attitude of the target orebody.
  - Chemical characteristics of the rock units that might host the target orebody.
  - Thickness and nature the regolith overlying the ore.
- An ability to date metal dispersion through combined *insitu* microchemical and geochronological analyses.
- International recognition and call for collaboration with gold grain studies worldwide.

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

- Sample collection at Mt Gibson, Moonta, Golden Virgin. September 2006
- Submit grant application to Australian Synchrotron research program for analysis of mineral samples. September 2006.
- NANO grant application in October 2006 for specialist TEM microanalyses.
- Complete Synchrotron spectroscopic analyses of selected samples. June 2007
- Journal submissions on Mt Gibson/Poona Alunite, Moonta Cu dispersion, Golden Virgin supergene gold, crystallography of gold nuggets and Element dispersion under different weathering regimes in the Cobar region of western New South Wales. June 2007.
- Technical report on Mt Gibson. June 2007

Confidentiality requirements None

Project name: Reactive Uranium anomalies in waters of the Western Australian Wheatbelt.

Abbreviated title: **Uranium in WA Wheatbelt waters**

Type of project Industry/Commercial*:*
Themes: Understanding Processes of Anomaly Formation

Project Leader: Grant Douglas
Start date and duration: January 1, 2006 – Dec 30, 2007

Participants: CSIRO EM - Grant Douglas, David Gray, Ryan Noble, Mindax Ltd

Brief project description:
In 2005 a study was initiated to examine management options for acid, saline waters in the Western Australian Wheatbelt in a joint study between the Department of Environment, the Department of Agriculture and CSIRO. A serendipitous outcome of the first year of study of acid, saline waters in the Western Australian Wheatbelt has been the discovery of anomalous uranium (U) concentrations (up to *ca.* 900ppb) in an widely dispersed suite of groundwaters, artificial drains and surface drainages.

Water geochemistry (groundwaters and/or artificial drain or surface-waters) can be a useful tool for the exploration of U ore deposits as a water sample integrates information over a large area and thus reduces the amount of samples required to identify potential U-rich areas. A high U concentration in waters does not, however, necessarily mean the presence of economic mineralization. In order to determine if a U-rich sample is prospective,, one can use U-series isotopes. For instance, it has observed that in an arid environment waters from economic uranium deposits are characterized by $^{234}U/^{238}U$ activity ratios near or at equilibrium (~ 1), whereas waters from non-economic deposits exhibit high $^{234}U/^{238}U$ ratios (> 2). Preliminary results on a subset of waters from this study show that not only they have a high concentrations in U (up to *ca.* 900 ug/L) but also $^{234}U/^{238}U$ near equilibrium (1.13-1.43), much lower than $^{234}U/^{238}U$ waters generally measured in arid environments (e.g. ~ 2 in South Africa). In addition, measured $^{234}U/^{238}U$ activity ratios in the U ore deposits of Yeelirrie, WA, are similar to those measured in the waters (1.12-1.37) in this study. Assuming that U mineralization is dissolved congruently, one can expect the same $^{234}U/^{238}U$ in the water and the U deposits leached. Thus, these preliminary results are consistent, but not a confirmation of, the presence of U mineralization of economic significance.

On the basis of the anomalies that have been identified in the first year of the study, a second year of confirmation and in-fill sampling around existing anomalies is proposed. In addition, further U-Th series isotope analyses will be undertaken to assess the utility of this technique to define potential areas of U mineralization. Consistent with the stated aims of CRC LEME a commercial partner, Mindax Limited has been engaged over the next two years to assist in the sampling and exploration activities. Contingent with the results of the confirmation and in-fill sampling, the program will develop to include such areas as regolith geology, mineralogy, geophysical investigations (radiometrics and magnetics) and reconnaissance drilling of prospective sites. .

Deliverables (outputs) and expected impacts of research (outcomes):
Scientific Deliverables (new scientific advances)

1. Numerical modelling capacity for generating a predictive understanding of geochemical anomaly formation in the regolith.
2. Computational solutions for the generation of 3D images of the probability of ore occurring in a particular prospective area.

Deliverables to Client (Adoption mechanisms)

1. Identification of Anomalous areas for dissolved Uranium in, and possibly adjacent to the Western Australian Wheatbelt.
2. Identification of geochemical and isotopic techniques for Uranium exploration in these environments:

Impacts

1. Increased efficiency of ore discovery within WA.
2. Commercial benefits through the licensing of such technology and the increased call on the regolith geochemistry expertise resident in WA from both national and international clients.

Milestones:

Initiate re-sampling of previous sites (March 2006)
New water sampling (June 2006)
Assessment of isotopic techniques (March 2007)
Completion of Project (Dec 2007)

Confidentiality requirements 3 Months