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## FROM THE CEO

Dear Mineral Explorer

Welcome to No 7 of our quarterly electronic brief on research being undertaken by LEME staff on topics relevant to mineral exploration. This edition appears on the eve of the biennial symposium of the **International Geochemical Exploration Symposium**, in which LEME is a sponsor, part organizer, and a substantial contributor. Much of the work that has been foreshadowed in this and previous editions of Minerals Brief will be showcased at the **22<sup>nd</sup> IGES**. This includes work on vegetation sampling, hydrogeochemistry, mineral hosts, residual phase geochemistry, metal mobility, microbial transformations, acid sulfate regoliths, and spectral logging.

LEME is now making great advances in the areas of generic processes and technology developments and I am confident that over the next three years there will be breakthroughs for the mineral explorer.

I will watch these developments with interest from a more independent position, because this will be my last imprimatur of Minerals Brief. I will be stepping aside as LEME's CEO in the next month, and I welcome my successor, Dr Steve Rogers - details of whom can be seen at <http://crclme.org.au/NewsEvents/index.html>. Our Research Program for 2005-2006 is also now on the web site <http://crclme.org.au/Research/programs.html>

**R Dennis Gee**  
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## REGIONAL STUDIES

### Yilgarn Craton

Anna Mahizhnan (PhD CUT: supervised by Ravi Anand, CSIRO EM) has demonstrated that red-brown hardpan is a useful sampling medium for Au in the Yilgarn Craton. Variably-cemented red-brown hardpan is extensively developed at or near the surface in colluvium throughout the craton. It is characterised by subhorizontal laminations of uncemented kaolinite and, commonly, ped surfaces coated by Mn oxides. At the Federal Au deposit, Broad Arrow, 40 km north of Kalgoorlie,

up to 50 ppb Au occurs in hardpan. Sequential extraction analyses reveal an association between Au and Ag, Ca, Ce, Co, Mg, Mn and Ni and suggest that the Au in hardpan is due to mechanical dispersion of Au-bearing clasts in the sediments and hydromorphic dispersion from underlying mineralisation. [ravi.anand@csiro.au](mailto:ravi.anand@csiro.au)

A geochemical database containing multi-element analyses of 4441 laterite samples from the central Yilgarn Craton has been compiled by a team from CSIRO EM as part of a collaborative project with Astro Mining NL to develop and test new techniques for diamond exploration. Sampling was done in areas of low relief, deep weathering and extensive lateritic or sandplain cover. Indicator mineral surveys of such areas may be ineffective because of the absence of drainage networks, destruction of indicator minerals by prolonged weathering and the lateritic/sandplain cover. **LEME Open File Report 188 - Laterite geochemical database for the Central Yilgarn Craton, WA.** AJ Cornelius et al. [amanda.cornelius@csiro.au](mailto:amanda.cornelius@csiro.au)

Steve Rogers (CSIRO LW) has sampled water from drains installed to control dryland salinity in the WA wheatbelt. Water from drains in the eastern part of the Avon catchment are generally highly acidic and contain up to 9000 ppb Cu, 7000 ppb Zn and 1000 ppb Pb with the sediments in the drains containing Cu, Zn and Pb sulfides. Ten of the 200 samples contain 6-10 ppb Au. Elevated U values (up to 900 ppb) occur in a single drainage catchment and possibly reflect localised U mineralisation in the regolith. Thus the drainage waters appear to reflect mineralisation within the region. [steve.rogers@csiro.au](mailto:steve.rogers@csiro.au)

## Lachlan Fold Belt

The late Peter Bamford (BSc Hons ANU: supervised Ken McQueen) has studied the regolith at the Wyoming One Au Deposit, 15 km N of Peak Hill, NSW. The deposit occurs under 30-50m of transported cover composed of an upper sandy and a lower mottled clay-rich unit. Detailed mineralogical study indicates that these two units have different provenances. Thus abundances of Au and chalcophile elements are low through the sandy unit, although there is some near surface enrichment in Au, As and W. Significant dispersion of As, Au and Cu is generally restricted to the basal portion of the clayey unit, probably as the result of mechanical dispersion. [kmg@ems.anu.edu.au](mailto:kmg@ems.anu.edu.au)



## BIOGEOCHEMICAL STUDIES

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Karen Hulme and Steven Hill (Adelaide University) are using the leaves of River Red Gums (*Eucalyptus camaldulensis*) in the Curnamona Province of SA and NSW to detect mineralisation within and through cover. Recent study of 215 samples along Pine Creek, adjacent to the Pinnacles Pb-Zn-Ag deposit reveals that the leaves close to the deposit have Pb contents up to 150 times background values (2 ppm Pb) as well as elevated Zn, Ag As and Sb contents. Excavation of a trench around the highly anomalous tree revealed weathered mineralisation representing a previously unknown Zn lode extension beneath 3 m of cover. Anomalous leaves from a tree 400m upstream from the Pinnacles mineralisation may also represent mineralisation under cover. [karen.hulme@adelaide.edu.au](mailto:karen.hulme@adelaide.edu.au)

Steven Hill and students (Adelaide University) have demonstrated the importance of correctly identifying species and sub-species during a biogeochemical study at the Tibooburra Goldfields in northwestern NSW. There Au occurs in Mesozoic cover rocks. Phyllodes and twigs from mulga (*Acacia aneura*) growing in sand dunes above Au-bearing regolith do not contain Au (<1 ppb) but those from bastard mulga (*Acacia clivicola*) do (up to 3 and 6 ppb, respectively). [steven.hill@adelaide.edu.au](mailto:steven.hill@adelaide.edu.au)

Ravi Anand, Matthias Cornelius and Cajetan Phang (CSIRO EM) are investigating the usefulness of biota in identifying Au and base metal deposits under cover in the Yilgarn Craton. (Results from the study at the Jaguar Cu-Zn-Ag deposit were reported in CRC LEME Minerals Brief 6). At the

Moolart Well Au deposit, beneath 8-20m of cover, the distribution of Au in gravels at about 7m mimics that in the underlying saprolite. Sampling of mulga phyllodes, bark, branches, roots and plant litter along a traverse across mineralisation indicates that all of these sample types show anomalous Au, As, Mo, and Ag above the mineralisation. [ravi.anand@csiro.au](mailto:ravi.anand@csiro.au)



## BIOMINERALISATION OF GOLD

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Using molecular techniques, Frank Reith (ANU) has succeeded in amplifying 16S ribosomal DNA from the majority of the gold grains obtained from the soils overlying two Au deposits in Eastern Australia. Results show that unique bacterial communities are associated with the Au grains and that metallophilic bacteria are present on all 16S rDNA-positive Au grains from both locations but not in the surrounding soils. These organisms are capable of actively accumulating Au in distinct areas close to their cell surfaces and being completely covered by Au to become additional passive nucleation sites for Au. Microscopic analysis of the biofilms on Au grains show that active DNA-positive cells cover the surfaces. In the deeper areas of the biofilms, Au-encrusted cell-like structures resembling the Au-covered bacterial cells are present. Thus, these bacteria appear to have a key-role in the authigenic formation of bacterioform Au grains and nuggets.

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## PARTIAL EXTRACTION STUDIES

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Duanne White (BSc Hons: supervised by Bear McPhail: ANU) has evaluated differences in the fractionation of Cd and Zn in soils in a semi-arid (Elura, NSW) relative to temperate zone (Queenstown, Tas). In both climatic zones, Cd and Zn are more concentrated in the Fe and Mn oxide coatings closer to mineralisation. However, in the semi-arid region, carbonate is more abundant in soil distal from mineralisation and that carbonate contains much of the Cd and Zn of the soil. These results suggest further studies are needed to decide whether these differences reflect the influence of mineralisation at depth or merely soil variability.

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## HYDROGEOCHEMISTRY

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David Gray (CSIRO EM) has sampled 73 groundwaters during a hydrogeochemical study over a 3x1.5km area about the Harmony massive Ni sulfide deposit, 11km NE of Leinster, WA. Two water samples have low pH (5.0 and 5.9) and may reflect sulfide oxidation. However, the waters are usually neutral and have low salinity, as is generally found in northern Yilgarn Craton waters. Thus their chemistry is controlled by lithological factors, and high Eh and Fe values in the Harmony groundwater may reflect ongoing sulfide oxidation. Anomalous Cr in groundwaters shows a broad anomaly which reflects the extent of ultramafic rock, whereas Ni, Co, Mo, Cu, Ge, V, Pt, Pd, W and Re more specifically reflect the mineralised unit. [david.gray@csiro.au](mailto:david.gray@csiro.au)



## HYPERSPETRAL STUDIES

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Balbir Singh and colleagues from CSIRO EM are continuing to evaluate the application of hyperspectral analyses to identify regolith materials in the Yilgarn Craton (see also CRC LEME Minerals Brief 3). They have found that kaolinite crystallinity indices (KCI) generally define the unconformity between thin sequences of sediment and saprolite but are less reliable when the

transported material is thick channel sediments. In a study at the Whirling Dervish Au prospect, Carosue Dam, they found kaolinite crystallinity shows a gradual change across a red-to-white colour change in some profiles. Study of the clay material reveals that the Fe-rich sediments in the basal sediments have been transformed into well-crystallised kaolinite below the water table. Thus it is important to define a KCl cut-off for saprolite and not rely upon colour during logging.  
[balbir.singh@csiro.au](mailto:balbir.singh@csiro.au)



## EXPERIMENTAL STUDIES

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Andreas Schmidt Mumm (Adelaide University) and Frank Reith (ANU) are undertaking experiments to determine whether biological factors influence the accumulation of Au in calcrete. They have collected calcrete from different depths in a dune above the Barns Au prospect, Gawler Craton, SA, under sterile conditions. Calcrete samples were impregnated with urea (a breakdown product of amino acids) and incubated for 24 hours. The amount of  $\text{NH}_4^+$  produced decreased with depth, demonstrating the presence of microbial communities with active urease enzymes and suggesting that calcrete formation can be at least partly biomediated through reactions like urea breakdown. [andreas.schmidtmumm@adelaide.edu.au](mailto:andreas.schmidtmumm@adelaide.edu.au)



## GEOPHYSICAL STUDIES

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John Joseph (Adelaide University) is evaluating the use of ground penetrating radar to generate shallow, high resolution responses from the regolith. At the EM frequencies used by ground penetrating radar the polar nature of water molecules causes displacement currents, high permittivity and lowering of the velocity of propagation of EM waves. Clays with their trapped ions behave similarly. Thus studies at the White Dam Cu-Au deposit (Curnamona Province: see CRC LEME Minerals Brief 5) readily defines the water table/conductive clay layer.  
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## TECHNOLOGY TRANSFER

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### 22nd International Geochemical Exploration Symposium 2005

Sheraton Perth Hotel, Western Australia, 19-23 September

LEME is a sponsor and major participant - details on IGES WEBSITE at:  
<http://www.promaco.com.au/conference/2005/iges/>

#### LEME KEYNOTE SPEAKERS (full program on IGES website)

- Dr Richard Mazzucchelli - inaugural winner of the CSIRO CRC LEME Butt-Smith Medal "Fifty years of geochemical exploration in the Western Australian goldfields"
- Dr Ravi Anand - Use of biota in areas of transported cover

#### OTHER LEME SPEAKERS: (full Program on IGES website)

Matthias Cornelius - *Laterite geochemical map of the SW Yilgarn Craton.*  
Keith Scott - *Rutile compositions at the Big Bell Au deposit as a guide for exploration.*  
Karen Hulme - *River red gums as a sampling media for mineral exploration*  
Melvyn Lintern - *The dual role of vegetation in anomaly formation at Barns Gold Prospect*  
Megan Lech - *Geohealth implications of the Riverina geochemical survey.*  
Robert Hough - *Revealing the structure of gold occurring in nuggets.*  
Balbir Singh - *Transformation of transported kaolin and its effect on crystallinity index.*

Tom Cudahy - *Mapping regolith and alteration by airborne hyperspectra.*  
Ryan Noble - *Locating ore undercover using a bacterial leach and other geochemical techniques.*  
David Gray - *Towards an integrated model for supergene gold redistribution in the Yilgarn Craton.*

**IGES SHORTCOURSES WITH LEME PRESENTERS (full program on IGES site)**

**Mineral exploration using groundwater geochemistry** - 17th September 2005

*Presenters: Patrice de Caritat, David Gray, Michelle Carey and 'Bear' McPhail*

**Regolith Mapping** - 17-18th September 2005

*Presenters: Mike Craig, Ravi Anand, Bob Gozzard and Tom Cudahy*

**Regolith 2005**

**CRC LEME Regional Regolith Symposia**

Eastern - Australian National University, Canberra 2-4 November

Central - Adelaide University, 9-10 November

Western - Curtin University of Technology, Perth, 16-17 November

**Registration and more information at**

<http://crcleme.org.au/NewsEvents/Events/newevents.html>

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