

# MINERALS BRIEF

## Regolith Science in Mineral Exploration

March 2006 Edition No 9



### From the CEO

Welcome to the new year and a new look CRC LEME Minerals Brief, a publication that continues to provide a quarterly update on how the Centre is applying regolith science to the challenges facing mineral exploration in Australia.

In this edition, Minerals Brief highlights the multitude of research programs underway at CRC LEME during 2006.

CRC LEME is seeking nominations for the Butt Smith Medal for excellence in regolith science. The Butt Smith Medal is awarded by CRC LEME and CSIRO every two years. The winner receives a \$15,000 grant and an opportunity to present a commemorative address about their work. In 2004, the inaugural winner of the Butt Smith Medal was Dr Richard Mazzucchelli, who amongst other notable achievements, played an integral role in documenting the close association between arsenic and gold mineralisation and the subsequent development of a new gold exploration technique by WMC Ltd. Nominations close on 28 April. For more information, or to download a nomination form, go to:

<http://crcleme.org.au/NewsEvents/index.html>

Finally, hot off the CRC LEME presses is the Regolith 2005, an annual publication from that provides a snapshot of the Centre's research activities during 2005. It contains the all of the research papers presented at the CRC LEME Regional Regolith Symposia held in Canberra and Adelaide during November 2005. The publication is a valuable tool for mineral explorers who want a guide to the different kind of regolith research projects underway in Australia.

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### Regional studies

Major periods of deep oxidation and ferruginisation have been defined at about 60 million years (early Palaeocene) and about 12

million years (Miocene) by Ken McQueen, Brad Pillans and Martin Smith in the Colbar region of New South Wales. A detailed study of the McKinnons Deposit has revealed that hematite from the earlier oxidation period is enriched in arsenic and lead, while the later period is enriched in copper.

The inclusion of lead and arsenic in the earlier period has been interpreted to reflect intense weathering under low pH, while the inclusion of copper in the more recent hematite could reflect local accumulations from partially weathered sulfides under alkaline conditions. The identified characteristics of each weathering period have implications to the successful interpretation of future geochemical data.

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### Biogeochemical Studies

PhD student, Anna Mayo, from Adelaide University under the supervision of Dr Steve Hill has analysed 110 leaves and leaf stems samples from plants growing in dunes adjacent to the Barns Gold Deposit in the Gawler Craton, South Australia.

While the vegetation chemistry does not reflect underlying bedrock, there is a good relationship between the chemical signatures of species associations and regolith-landforms. The findings suggest that eucalypt leaves from a particular landform unit have the potential to identify changes in bedrock geochemistry (see also CRC LEME Minerals Brief 6).

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Another PhD student from Adelaide University, Nathan Reid, under the supervision of Dr Steve Hill and David Lewis is conducting detailed botanical and biogeochemical sampling along a three kilometres north-south traverse across the Coyote Gold deposit in the Tanami Desert, Western Australia. Data assessment has indicated that bloodwood species (*Corymbia opaca*) are more abundant over mineralisation whereas snappy gum (*Eucalyptus brevifolia*) is more sparse. Nathan has also been able to determine that zinc levels greater than 17 ppm in spinifex (*Triodia pungens*) define the mineralisation. Despite its sparseness over the mineralised area, zinc in snappy gum leaves appear to reflect down slope and hydrological dispersion of the ore signature to the south.

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### Regolith Science in Mineral Exploration

#### Biogeochemical Studies (continued)

Australian National University's (ANU) Ian Roach and Shane Walker have been investigating leaf biogeochemistry from dominant plant species in the Tomingley area of the Lachlan Fold Belt. Leaves from the *Eucalyptus microcarpa* (Grey Box), *Callitris glaucophylla* (White Cypress) and *Casuarina luehmannii* (Buloke) species gave gold responses over known mineralisation and its likely northern extension. White Cypress leaves gave the largest and most consistent responses to the widest range of pathfinder elements. Sampling of Eucalypt and Casuarina leaves from 45° segments about the trees revealed that gold is concentrated on the northern side and arsenic on the southern side of the area. However, concentrations were more evenly dispersed in Callitris leaves.

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#### Experimental studies

ANU PhD student David Little, under the supervision of John Field, Sue Welch and Steve Rogers (LEME CEO), has treated rhizosphere and non-rhizosphere soils adjacent to *Eucalyptus mannifera* and *Acacia falciformis* trees in the Southern Tablelands of NSW with malic, oxalic and citric acids. Results show that low molecular weight carboxylic acids enhance the release of major ions, especially aluminium and iron by up to two orders of magnitude relative to inorganic control solutions. The findings show that organic acids tested have potential to facilitate soil weathering through dissolution in soil minerals. Many trace elements can also be preferentially mobilised by organic acids, particularly in rhizosphere soils.

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ANU's Sara Beavis, Fern Beavis, Peter Somerville and Sue Welch have undertaken dissolution experiments using jarositic material from an acid sulfate soil. Addition of water lead to a rapid fall in pH to 4.5 with potassium and sulfate being released. Iron was not released into solution, instead was precipitated as amorphous ferric hydroxide, which was expected to eventually change into goethite. Using oxalic acid to dissolve jarosite released strongly hydrolysed iron into solution, which generated acid over longer periods than inorganic solvents.

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ANU PhD student Chris Gunton under the supervision of Andy Christie and Bear McPhail is studying the effect of chloride and sulphate anions on the adsorption of copper and zinc onto goethite. Already, Chris has found that chloride has a greater influence than sulphate. The adsorption of copper is particularly strong in two molal sodium chloride at a pH<5, whereas zinc is less strongly enhanced by increased chloride content. In contrast to the sodium chloride experimental results, zinc adsorption is suppressed by increasing sulphate but

copper adsorption is unaffected by sulphate concentrations. Early conclusions suggest that copper adsorbed onto goethite in a moderately saline environment may be remobilised if the salinity changes in either direction.

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#### Calcrete studies

Adelaide University BSc Hons student, Sarah Gibbons, under the supervision of Steve Hill has evaluated calcrete as an exploration medium in the Tibooburra-Milparinka region of NSW, located 300 km north of Broken Hill. Although some quartz veins were mined in the region, most gold was recovered from alluvial sources. The calcrete occurs as hardpan over saprolitic Mesozoic sandstone along faults and is associated with weathered hydrothermal alteration. Calcrete from the latter association can contain up to 200 ppb gold and anomalous arsenic and copper. Results from more than 200 samples of calcrete have correctly identified all known primary mineralisation in the region, as well as three new areas with gold levels around 23-50 ppb.

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#### Hydrogeochemistry

CSIRO Exploration and Mining's Mark Pirlo and David Gray have studied groundwater samples from the Tunkillia region in South Australia's Gawler Craton (LEME Open File Report 194: CRC LEME Minerals Brief 5). Their studies have shown that dissolved tellurium, vanadium and the saturation indices of iron oxide minerals all show an association with mineralised areas. However, waters from the main mineralised area (Area 223) have lower gold than in a secondary mineralised area (Area 191 North). This difference most likely reflects the presence of kinetic barriers affecting gold dissolution and may be related to the higher sulphate/chloride ratio resulting in a greater sulphate release through sulfide oxidation in the secondary mineralised area.

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ANU PhD student Kamal Khider under the supervision by Ken McQueen and Bear McPhail is currently investigating the nature of groundwater in the Hermdale area of the Lachlan Fold Belt, NSW. Kamal's investigations have found that groundwater is moving slowly through the regionally-extensive, partially



weather sandstones and siltstones in the area, heading in a north-easterly direction. Salinity and  $36\text{Cl}/\text{Cl}$  isotopic ratio values indicate that mixing of unconstrained groundwater is likely. The groundwaters are undersaturated with respect to oxidised copper and zinc minerals but calculated saturation indices for  $\text{ZnSiO}_3$ , malachite and tenorite appear to show a vector towards the known mineralisation in the area.

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### Mineral Host Studies

Determining the distribution of metals in different regolith environments are Maite Le Gleuher, Ravi Anand, Tony Eggleton and Nigel Radford, from ANU, CSIRO EM and Newmont respectively (see CRC LEME Minerals Brief Issue 8). At the Scuddles Base Metal Deposit, located in the Murchison region of Western Australia, their studies have found that while copper and zinc are severely depleted during weathering, up to 440 ppm antimony, 220 ppm molybdenum may be incorporated into the goethite located in the mottled saprolite. Bismuth was also found to be concentrated as submicroscopic lead-bismuth minerals in bleached kaolinitic material. The results suggest trace element dispersion appears to be strongly controlled by the presence of suitable host regolith minerals and that goethite can trap base metals but kaolinite does not.

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ANU BSc Hons student Nathan Emselle under the supervision of by Bear McPhail and Sue Welch is studying the nature of zinc distribution in the regolith above the karst-associated Reliance Deposit of willemite and smithsonite located in the northern Flinders Ranges of South Australia. Nathan has discovered substantial amounts of zinc in dolomite, as well as clay minerals and iron oxides found in the mineralisation. This concentration is believed to occur during the weathering, mechanical dispersion of zinc-rich dolomite. However, the observed association of zinc with secondary calcite and weathered dolomite suggests that surficial zinc is either residual or the result of the physical dispersion of the zinc-bearing outcrop material.

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### Geophysics

John Joseph and a team from Adelaide University and Adelaide Resources Ltd have conducted a Transient Electromagnetic (TEM) geophysical study (using a 20 x 20 m loop) near the Baggy Green Gold Prospect in the Gawler Craton, South Australia. Results have shown that aeolian sand overlying a Proterozoic basement contains conductive saprolitic clay which passes into a more resistive saprock at 25-40 metres depth. However, at the boundary between the Proterozoic and Archaean (the Sleaford Complex) rocks, a resistive body is present. Integrating the TEM and magnetic

data has suggested the body is either felsic, siliceous or possibly mylonitic in nature. Further work is required to evaluate its significance.

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### Regolith Geology and Mineral Exploration Masters Shortcourse

From 3-14 April, CRC LEME will conduct a 11 day introductory regolith geology for mineral explorers course. The course will feature integrated lectures and at Fowlers Gaps and field trips around Broken Hill, Curnamona and northwest North South Wales. Attendance at this course can gain relevant master degree credits at CRC LEME core party universities.

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### LEME Technology transfer

#### Upcoming presentations 2006:

- 27-29 Mar - AGES 2006, Alice Springs, NT
- 1-3 May - AIG-AMEC Conference, Kalgoorlie, WA
- 24 May - LEME Minex Seminar, Sydney (TBC)
- 2-7 Jul - Australian Earth Sciences Convention LEME session and field trips Melbourne, Vic
- July - date tbc - LEME Minex Seminar, Perth, WA
- 27 Aug - 3 Sept - Goldschmidt Conference, Melbourne

#### LEME - MCA Regolith Geoscience Course Programme for 2006:

- 20-24 Feb - Regolith Geology and Geochemistry, Wilson's Promontory, Vic
- 27-31 Mar - Introduction to Hydrogeochemistry, University of Melbourne, Vic
- 3-14 April - Regolith Geology and Mineral Exploration (Masters Course), Fowlers Gap, via Broken Hill, NSW
- 10-14 April - Regolith Mapping and Field Techniques, Fowlers Gap, via Broken Hill, NSW
- 5-9 June - Advanced Remote Sensing (RSM) University of Adelaide, SA
- 19-23 June - Environmental Mineralogy, Australian National University, ACT

#### Recent Publications

(available via our web site <http://crlceme.org.au>):

- Regolith 2005 -Ten years of CRC LEME (Roach IC).
- OFR 196 - Atlas of Regolith Materials of the Northern Territory (Robertson IDM, Craig MA and Anand RR) to be launched at AGES 2006.

Past issues of the Minerals Brief can be downloaded from: <http://crlceme.org.au/Pubs/index.html>

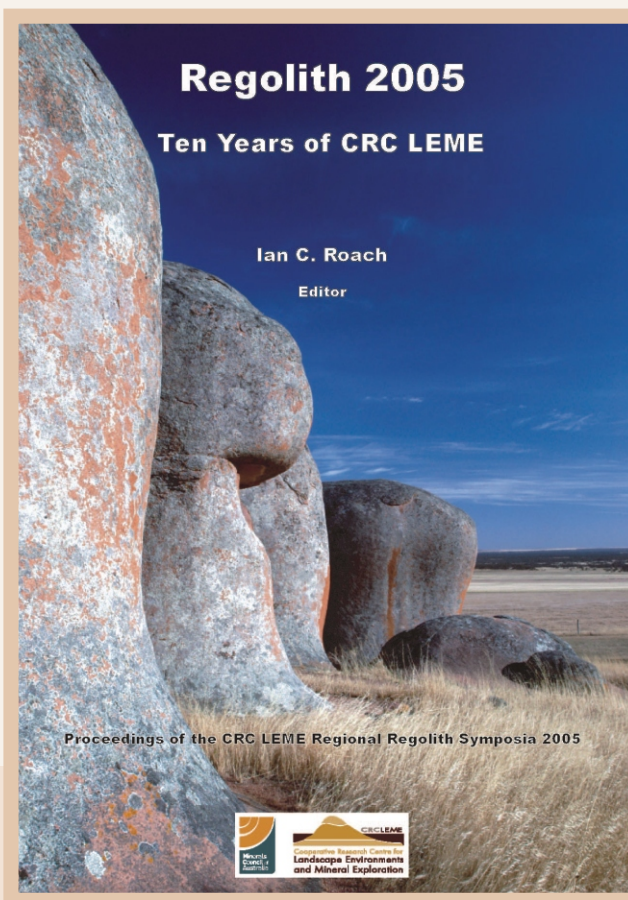
## Regolith 2005: Proceedings of the CRC LEME Regional Regolith Symposia

### Celebrating ten years of CRC LEME.

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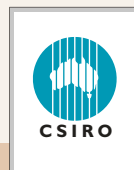
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CRC LEME is the cooperative research centre for regolith geoscience with some 130 contributing researchers from eight Core Parties around Australia. We generate and apply regolith knowledge for mineral exploration and environmental management.



**Your organisation can benefit from CRC LEME expertise.**

<http://crcleme.org.au>