

CONTENTS

REGIONAL STUDIES (page 1)

Yilgarn Craton
Curnamona Province
Lachlan Fold Belt
Central Gawler Craton

DATING REGOLITH (page 3)

GROUNDWATER STUDIES (page 3)

EXPERIMENTAL STUDIES OF SECONDARY Zn MINERALS (page 4)

CALCRETE STUDIES (page 4)

GEOPHYSICAL METHODS OF EXPLORATION IN THE REGOLITH (page 4)

LEME KNOWLEDGE TRANSFER (page 5)

Editor: Keith Scott
CRC LEME keith.scott@csiro.au



FROM THE CEO

Dear Mineral Explorer

Minerals Brief No 4 was prepared during “Regolith November” when we openly shared emerging results of our science via a series of Regolith Symposia in Adelaide, Perth and Canberra. These also serve as a ‘gathering-ground’ to subsequent wider and more focussed presentations to mineral explorers. For example we will stage a new MINEX Seminar in Kalgoorlie on 14-15-16 February 2005, in addition to the usual MINEX Seminar later in Perth in May 25. This *Minerals Brief* is also concurrent with the release of the LEME 2003-04 Annual Report, and the revamp our website. Both of these outlets have comprehensive but succinct reports on our research projects, and I commend them to you.

CRC LEME is now in mid term of its first renewal, and our research programs are in full delivery stride. Future *Minerals Briefs* will bring directly to your desktop advances in regolith research that will be of relevance to you. You can revisit previous *Minerals Briefs* on our website at <http://crclleme.org.au/Pubs/monographs.html>. Also, I draw your attention to a wonderful compendium of the regolith expression of some 76 Australian ore systems on our website, which you can visit at: <http://crclleme.org.au/Pubs/Monographs/RegExpOre.html>

R Dennis Gee, Chief Executive Officer dennis.gee@csiro.au Tel: 08 6436 8695



REGIONAL STUDIES

Yilgarn Craton

At Gossan Hill, Golden Grove, Ray Smith (CSIRO EM) is demonstrating that diagnostic features like tuffaceous textures with cassiterite, micron-scale sulfide inclusions in quartz, Au

inclusions and ferruginous pseudomorphs after sulfides, are all recognisable in clasts in lateritic cover 10 m thick and at least 250 m off strike from the massive sulfide system. Frequency of indications of mineralisation in clasts gives an indication of proximity to mineralisation provided the palaeotopography is understood. Recognition of such mineralised clasts can add value to drill-hole information, as well as improving the “certainty” of interpretation when exploring in areas of cover. raymond.e.smith@csiro.au

Matthias Cornelius and Ravi Anand (CSIRO EM) continue to evaluate the role that laterite geochemistry and biogeochemistry can play for exploration in areas of cover in the Yilgarn Craton (see CRC LEME *Minerals Brief* 3). At Freddie Well basemetal deposit, recent drilling has found buried lateritic gravels (10 m deep) containing 400 ppm Zn, 26 ppm Mo and 18 ppm Bi well to the south of gossanous outcrop. Twigs and bark of *Acacia* spp above this anomalous zone show elevated Ni, Mn, W, Li and Zn with a single point Mo anomaly occurring directly over the mineralised zone. Thus the geochemistry of buried gravels and biogeochemistry may show characteristic geochemical signatures which indicate proximity to buried volcanogenic basemetal mineralisation. matthias.cornelius@csiro.au

Curnamona Province

Biogeochemistry is also being used in regional exploration in the Curnamona Province of SA and NSW by Karen Hulme (Adelaide University). That work is using river red gums (*E camamdulensis*) because of their extensive tap roots and their widespread occurrence in transported regolith in arid environments. Preliminary studies over prospective Au-mineralised areas indicate that twigs (and to a lesser extent leaves) are good media for indicating Au mineralisation, but bark is not. However, because Zn is always strongly concentrated in leaves, it is the Zn content of twigs and bark that gives the best indication of buried basemetal mineralisation. These results show that sampling of different parts of the river red gums is necessary to evaluate the potential for different commodities. Current work also shows significant seasonal variation in metal accumulations in plant tissue, suggesting biogeochemical anomalies are enhanced during times of high transpiration. The results offer promise of a rapid sampling technique in areas of transported cover. karen.hulme@adelaide.edu.au

In the Benagerie Ridge area (50 km north of Olary), Cu-Au-Mo mineralisation may occur under more than 70 m of Cainozoic sediments at Portia and North Portia deposits. Kok Piang Tan (Geoscience Australia) has studied the nature of gold at the two deposits. At North Portia, two populations of primary Au with 9.5 and 24% Ag respectively occur with Cu and Mo sulfides. However at Portia, irregular grains of Au occur in the sandy base of the cover sequence. The presence of sulfide inclusions in such grains indicates a primary origin, modified by partial dissolution and mobilisation resulting in precipitation of Au-rich rims and formation of small (1-2 μm) diagenetic Au grains. kokpiang.tan@ga.gov.au

Lachlan Fold Belt

During a recent study of the regolith and landscape evolution of the Cobar region, Melissa Spry (supervised by Ken McQueen, ANU) has mapped regolith materials over 15000 km² of this low relief region. Mapping indicates that Eromanga Basin sediments were never extensively developed over the region and erosional rates, from Cretaceous to the present, were low. By at least Early Tertiary, the Cobar region was a structural high, and drainage systems had assumed their current configuration. Lag throughout the region commonly includes a transported component but is a good indicator of the underlying saprolite provided results are interpreted relative to the position of lag in the landscape. However, because stream channels may have changed within a particular area, relating stream sediment anomalies to mineralisation may be difficult. Calcrete and silcrete are widely distributed and may also be useful as sampling media. kmq@ems.anu.edu.au

Central Gawler Craton

Regolith studies at Edoldeh Tank (ET) Au prospect by a team led by Mel Lintern (CSIRO EM) have evaluated the effectiveness of using transported overburden to detect buried Au deposits in the western Gawler Craton. They found that Au was concentrated in calcrete located near the surface and above leached zones in the *in situ* saprolite. The surficial Au anomaly extends into transported regolith and, in places with thin (<5 m) sand cover, may be locally enhanced, possibly due to Au additions from mineralisation in the transported cover. Calcrete represents a better sampling medium than soil, vegetation or silcrete.

mel.lintern@csiro.au



DATING REGOLITH

Geological evidence indicates that most of the Australian continent has experienced extensive subaerial weathering over extended periods and commonly with superimposition of several distinct periods of weathering. Brad Pillans (ANU) has been dating the Australian regolith by palaeomagnetic means. This method relies upon remnant magnetism in hematite reflecting when that hematite formed. Results from 30 sites (mostly mine sites) and dominantly in the Yilgarn Craton, suggest three major periods of hematite formation: 1) Mesozoic or older, age, 2) 50-60 Ma event when the climate was cool and wet, and 3) a young 10 Ma event when the climate was drier. The two major episodes of hematite formation in the Tertiary occurred under different climatic regimes and those conditions control the elements available for incorporation into neo-formed Fe oxides.

brad.pillans@anu.edu.au



GROUNDWATER STUDIES

During a recent PhD study, Mark Pirlo (CSIRO EM) analysed groundwater from the Frome Embayment of SA, and constructed geochemical models of the equilibrium state of the groundwaters. The modelling shows that amorphous UO_2 , rather than the ore minerals, coffinite and uraninite, is the mineral phase that controls groundwater U concentration. The UO_2 saturation index does not show any systematic variation with ore grade or proximity to mineralisation. Inherent limitations on the information provided by mineral saturation indices restrict their exploration application, particularly in the high salinity palaeochannel groundwater environments commonly found in Australia. mark.pirlo@csiro.au

Hydrogeochemical studies in the Yilgarn Craton, conducted by David Gray (CSIRO EM) in areas of deep weathering show that Cr concentrations of groundwater can be very high and have no pH relationship. Waters in contact with fresh and weathered ultramafic rocks contain consistently high (10 – 430 ppb) dissolved Cr, whereas waters in contact with other lithologies contain <5 ppb Cr. The Cr in the ultramafic-associated non-reducing (Fe and Mn-poor) groundwaters is present as Cr^{6+} (CrO_4^{2-}) which has much higher solubility than Cr^{3+} and is stable and potentially mobile. Thus the Cr content of groundwater offers a potential method for recognising the presence of ultramafic rocks, even where they are intensely weathered. Early work is also showing very high levels of Ni in groundwater in the vicinity of known nickel deposits. david.gray@csiro.au



EXPERIMENTAL STUDIES OF SECONDARY Zn MINERALS

Non-sulfide Zn deposits commonly contain hemimorphite ($\text{Zn}_4\text{Si}_2\text{O}_7(\text{OH})_2 \cdot \text{H}_2\text{O}$) and willemite (Zn_2SiO_4). Thus Ned Summerhayes (ANU) has determined the thermodynamic properties for the solubility reaction of hemimorphite at 50^o and 80^oC and compared them to those of willemite. He found that between 50^o and 80^oC, under atmospheric CO₂ and with abundant silica, hemimorphite is less soluble than willemite. However willemite will form instead of hemimorphite if the activity of water is reduced. This experimental information was applied to understand the genesis of Zn minerals at Billy Springs Mine in the Flinders Ranges of South Australia. There the chemical environment that deposited smithsonite (ZnCO₃) either had higher than atmospheric abundances of CO₂ or was undersaturated with respect to quartz, as no hemimorphite was found with smithsonite. Sauconite (Zn-bearing smectite also found at Skorpion Deposit, Namibia) is found as a late coating on other minerals.

bear.mcp@mail@ems.anu.edu.au



CALCRETE STUDIES

Geochemical analyses of calcrete from the Olary Region of South Australia have been related to the position in the landscape by Paul Wittwer and Karin Barovich (Adelaide University). They found that abundances of pathfinder elements, like As, Bi, Mo and W, increased as the relief of the landscape decreased and that fragmental hardpan calcrete showed higher trace element abundances than nodular calcrete. Thus the calcrete morphology, distribution and landform setting should be considered when planning a calcrete sampling program. Calcrete developed over mafic dykes contains elevated basemetal and Au contents, but that over Adelaidean sedimentary rocks contained lesser concentrations of these elements. The linkage between calcrete geochemical signatures in shallow cover and the underlying lithology also provides clues to refining interpreted geological maps and thus will aid further mineral discoveries. Karin.hatch@adelaide.edu.au

A detailed study of calcrete and calcareous sands from a six-metre high aeolian sand dune at Barns Au deposit in the Central Gawler Gold Province has been undertaken by Liam McEntegart and Andreas Schmidt-Mumm (Adelaide University). They found 18 ppb Au associated with calcrete at about 2 m depth (3 ppb at the surface of the dune). Detailed sampling along that calcrete zone indicated that Au is particularly enriched in calcrete cement about roots. andreas.schmidtmumm@adelaide.edu.au



GEOPHYSICAL METHODS FOR EXPLORATION IN THE REGOLITH

Audio-magnetotellurics (AMT) is a ground-base technique which uses reflected natural electromagnetic energy to measure the 3-D electrical structure of the earth. Anton Kepic and students (Barrett Cameron and Brendan Corscadden) at Curtin University have updated the technique to speed up and improve the analytical method. Their innovations have produced a system that can measure the electrical structure of the earth down to 200 m in less than 2 minutes. Such a system can be used where an airborne survey is expensive and where a ground survey would not normally cover a sufficient area. kepic@geophy.curtin.edu.au



LEME KNOWLEDGE TRANSFER

LEME presentations:

- 14 Feb 05 Commemorative Address by Butt-Smith Medal Winner **DR RICHARD MAZZUCHELLI** “50 years of Geochemical Exploration in the Goldfields” WA School of Mines, Kalgoorlie. Enquiries to: susan.game@csiro.au
- 14-15-16 Feb 05 **LEME-GSWA Minerals Exploration Seminar (incl above Address), WA School of Mines, Kalgoorlie. Enquiries to: susan.game@csiro.au**
- 3-7 Apr 05 8th Int Conference on Biogeochemistry of Trace Elements (ICOBTE), Adelaide. Enquiries to: steve.rogers@csiro.au
- 24 May 04 LEME Minerals Exploration Seminar, Kalgoorlie
- 25 May 05 LEME Minerals Exploration Seminar, Perth.
- 19-23 Sept 05 22nd International Geochemical Exploration Symposium, Perth.

Recent Releases

- **LEME Annual Report 2003-2004** (.pdf on the web site and available in hard copy on request)
- **PACRIM 2004 Proceedings -**
<http://www.shop.ausimm.com.au/bookdetails.php?BookID=270>
Keynote address R D Gee and R R Anand, “**Advances in Regolith Research - a CRC LEME Perspective**” **plus other LEME presentations -
 - P de Caritat and D Kirste. *Groundwater Geochemistry as a tool for mineral exploration under cover - the Curnamona Province*
 - K G McQueen and A McRae - *New ways to explore through the regolith in Western New South Wales*
 - K P Tan et al - *The Controls on element distribution in the regolith at the Portia and North Portia Prospects, Curnamona, SA*
 - K M Scott - *Weathering of base metal deposits and implications for exploration in the Lachlan Fold Belt*
- **REGOLITH 2004.** Proceedings of the LEME Regolith Symposia held in Adelaide, Perth and Canberra, November 04. Papers can be downloaded from the LEME website (Publications/Monographs) and the volume is also available to purchase as CD or hard copy.

** This paper can be downloaded from the LEME web site,
<http://crclleme.org.au/Pubs/articles.html>

For further details, visit the LEME website at

<http://crclleme.org.au/>