Cooperative Research Centre for Landscape Environments and Mineral Exploration

CRC LEME Minerals Brief

Regolith Science in Mineral Exploration

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FROM THE CEO

Dear Mineral Explorer

Welcome to the next LEME Minerals Brief – bringing to you short sharp summaries of recent research by CRC LEME that will be of relevance to you. I hope that you find this form of communication useful and convenient. The objective is to land it on your desk so that you can read it in ten minutes, and pass it on to your colleagues. Please feel free to contact via email any of the people indicated. A quick note on the LEME website crcleme.org.au. It is undergoing constant change both in terms of content and functionality. I suggest it would be a good idea to devote a few minutes every week to revisiting it.

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

REGIONAL STUDIES

Yilgarn Craton

Matthias Cornelius (CSIRO EM) has been evaluating the role that laterite geochemistry can play for exploration in areas of cover in the Yilgarn Craton. Recent studies at **Jaguar and Teutonic Bore** have shown that multi-element geochemical signatures in transported gravels are displaced at least 4 km downstream at the latter deposit. Thus understanding the palaeotopography and hence the probable direction of dispersion is critical in interpreting the laterite geochemical data and vectoring toward mineralisation. Because of the enormous data base which already exists for lateritic residuum, integrating that data with depths of cover available from company drilling) and the landform will, in many cases, be sufficient to interpret geochemical trends in areas of cover. matthias.cornelius@csiro.au

At **Lake Lefroy,** David Gray and Balbir Singh (CSIRO EM) have demonstrated that using a portable hyperspectral analyser (ASD-Fieldspec Pro©) can distinguish rock types in saprolite and differentiate lake sediments from *in situ* regolith. Along an E-W section through the Intrepide Au Deposit, both intermediate and ultramafic rocks (which may be weathered to 50m) are present below 10-12 m of lake sediments. The unweathered ultramafic rocks are characterised by the presence of chlorite which weathers to form a Fe-rich kaolinite which can be readily identified in saprolite. The lake sediments are identified by their distinctive response in the 500 nm spectral region. david.gray@csiro.au

Curnamona Province

In the **Pinnacles area, SW of Broken Hill**, Melissa Quigley (CSIRO EM) has produced an airborne hyperspectral map of the regolith and weathered rocks in a 48 km^2 area. Thirteen minerals, kaolinite, halloysite, Al-rich white mica, Al-poor white mica, hornblende, actinolite, calcite, chlorite, jarosite, garnet/FeOH, goethite, hematite and gypsum, were identified and mapped from 5 lines of HyMap™ data which were processed into seamless, GIS-ready mineral maps. Many bedrock units were successfully mapped by their characteristic primary minerals (*e.g.,* hornblende) or specific secondary mineral products (*e.g.,* goethite). Discrimination between *in situ* and transported regolith was achieved in many areas by mapping the kaolinite crystallinity and calcite distribution. melissa.quigley@csiro.au

Central Gawler Craton

The **Harris Greenstone Belt, SE of Tarcoola**, in the Central Gawler Craton is a recently outlined greenstone province with potential for Ni and Au mineralisation. However 95% of it is under regolith cover. Thus Malcolm Sheard (PIRSA) and Ian Robertson (CSIRO EM) have characterised the transported cover and *in situ* weathered bedrock to identify the underlying mafic and ultramafic rocks. Results show that the greenstones are commonly more deeply weathered than adjacent felsic rocks and may be prefentially eroded and covered by up to 80 m of channel fill sediments. Where the cover is <5 m, the geochemistry of the cover usually reflects the underlying greenstone. Where recognition of the cover/weathered greenstone is difficult, zircon contents may be useful as a discriminant.
sheard.malcolm@saugov.sa.gov.au

The **Earea Dam Goldfield, SE of Tarcoola**, occurs in rolling hills of 30-40 m relief and in an area with only thin alluvial/colluvial cover. Mel Lintern (CSIRO EM) has studied the deposit and found that the Au mineralisation is associated with Ag, Bi, Cu, Sn, Te, U and W. Dispersion about the mineralisation is mainly mechanical, with the high concentrations of Au found in calcrete due mainly to the inclusion of hematite-quartz fragments. By 200 m downslope, soil samples contained close to background levels of Au (2-3 ppb) but Ag and W may be more widely dispersed than Au. The Au in soils is concentrated in both the fine (<75 µm) and coarse (>2 mm) fractions but only the former is richer in Au in the depositional regime downslope from mineralisation. Calcrete is poorly developed in such depositional areas. Because of the limited geochemical dispersion halo for Au, exploration for this style of mineralisation is expected to be difficult unless closely-spaced (25 m grid) calcrete and/or transported/in situ interface sampling is adopted. mel.lintern@csiro.au

MINERAL HOSTS

Ken McQueen (ANU) has been considering how elements move within the regolith and what their mineral hosts are in different parts of the regolith. In the **Cobar region of the Lachlan Fold Belt,** mineralogical and geochemical trends at the New Cobar Au-Cu deposit reflect progressive changes from primary sulfides and Pb and Cu arsenates in the lower part of the weathering profile to goethite and hematite toward the top. (Mn oxides and alunite-jarosite minerals may also be locally developed as important mineral hosts.) Goethite is an important host for Zn, Cu, As and, to a lesser extent, Pb, Bi and Sb. Hematite is a good host for Cu, Pb and Sb. Once these elements are fixed within the Fe oxides they show limited chemical mobility but can be widely dispersed mechanically. kmq@ems.anu.edu.au

Another study of mineralogical hosts for pathfinder elements has been undertaken by Ravi Anand and a team from CSIRO and ANU at the **Lancefield Au deposit, 8 km N of Lav**erton. There the mineralized Archaean mafic and ultramafic rocks have been overlain by up to 20 m of sediments (Permian fluvioglacial deposits, Tertiary palaeochannel clays and hardpanised colluvium and soil). Separation of the mottled Permian and Tertiary sediments into Fe- and clay- rich fractions reveals that Au is slightly enriched in the clay fraction but As, Cu and Zn are very strongly concentrated into the ferruginous portion of Permian material. In the overlying Tertiary material, although Cu and Zn are concentrated in the ferruginous fraction, As is not so strongly enriched and in the hardpanised colluvium, Cu and Zn are present in poorly crystalline goethite. Thus recognition and targeting the ferruginous material of the Permian material provides a method to enhance geochemical anomaly detection in the multiple-source transported material. ravi.anand@csiro.au

GROUNDWATER FLOW AND ELEMENT DISPERSION

Recent experimental studies at Monash University by Michelle Carey (supervised by Bear McPhail ANU) demonstrate how hypersaline plumes form under playa lakes and affect the dispersion of Au and other elements in groundwater systems. The hydrogeochemistry of the **St Ives Goldfield** was studied by analysing the waters from a 100 km^2 well field bordering Lake Lefroy and numerically modelling the geochemistry of Au under hypersaline conditions. Experiments were conducted to define the shape and extent of the hypersaline plume, as well as the timeframe of its development. A model for density-driven convective flow around the playa lake and the Au mineralisation explains the dispersion of Au in St Ives area. bear.mcphail@ems.anu.edu.au

BIOLOGICAL INFLUENCES IN THE REGOLITH

Microorganisms are likely to have played a significant role in the formation of the regolith with about 5000 microbial species identified. However this figure is likely to represent only 5% of those actually present. Steve Rogers (CSIRO LW) has developed new techniques based on direct extraction of nucleic acids (DNA and RNA) to study the role of biota in the transformation of minerals within the regolith. In particular, he has successfully extracted and amplified DNA from a single Au grain to confirm that the microbial; biofilm thought to be

responsible for solubilisation and precipitation reactions (as reported in Minerals Brief 1) is "alive". steve.rogers@csiro.au

GEOPHYSICAL METHODS FOR EXPLORATION IN THE REGOLITH

Sub-Audio Magnetic (SAM) Technology is an active source geophysical method that channels current into conductive sub-surface features (at up to 200m depth), generating an electromagnetic field that is detected at the surface as a total field magnetometric response (TFMMR) and total field magnetometric induced polarization (TFMMIP). Jayson Meyers and Nigel Cantwell (CUT) have utilised the TFMMR signal to define a mineralised shear and zones of deep weathering in ultramafic rocks at the **Songvang Au deposit, near Agnew**. The TFMMR of the SAM signal is similar to apparent conductivity results obtained from gradient array IP surveying but has greater resolution. TFMMR highs were drilled and found to correlate with increased pyrite and Au development. meyersj@geophy.curtin.edu.au

Graham Heinson and Hashim Carey (AU) have worked with Mike Sexton (Newmont Australia Ltd) in utilising downhole-to-surface electrical geophysics to determine the special extent of mineralisation beneath cover at **Scuddles, Golden Grove**. The target is a conductive band of massive sulfide, 80m thick, occurring below 80-100m of conductive regolith. Quantitative information from the residual surface potentials can be used to represent the subsurface charge distribution that occurs at resistivity boundaries. Rather than 3D forward and inverse modelling, they recommend defining a 3D scanning function and determining a spatial correlation with measured fields in order to know where the charges are located spatially rather than in terms of their electrical potential response.
graham.heinson@adelaide.edu.au

LEME TECHNOLOGY TRANSFER

LEME staff and students be presenting at:

- AusIMM PACRIM 2004 - 19-22 Sept, Adelaide.
- SEG/SGA 2004: Predictive Mineral Discovery Under Cover - 27 Sept to 1 Oct, Perth
- Clay Mineralogy and Geophysics for Environmental Management and Mineral Exploration - 27 Sept - 3 Oct 04, Adelaide
- Volcanic Hosted Cu-Zn deposits in WA: An update - 2 Oct 04, Perth
- **CRC LEME REGOLITH SYMPOSIA 2004**
  Central Symposium: 10-12 Nov, Adelaide University
  Western Symposium: 18-18 Nov, Curtin University, (ARRC) Perth
  Eastern Symposium: 24-26 Nov, Australian National University, Canberra
- 8th Int Conference on Biogeochemistry of Trace Elements (ICOBTE) - 3-7 April 05, Adelaide
- 22nd IGES - 19-23 Sept 05, Perth.