# EXPLORATION THROUGH TRANSPORTED COVER: SUMMARY OF APPROACHES AND METHODS

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PIRSA through CRC LEME aims to develop improved methods to detect mineralisation buried by sediment cover. This requires knowledge of likely metal transfer mechanisms, and modification and optimisation of detection technologies to suit the particular environment being targeted by mineral exploration. The following is a brief summary of possible metal transfer mechanisms through transported cover (after Aspandiar, 2005) and geochemical techniques currently under investigation in the Curnamona mineral exploration project.

**TRANSPORT MECHANISMS INCLUDE:**

- Water table fluctuation
- Vegetation
- Gas migration
- Dilatancy pumping
- Microbial activity
- Bioturbation
- Redox anisotropy
- Diffusion
- Thermal convection in groundwater
- Evaporation and capillarity
- Barometric pumping

**EXPLORATION APPROACHES INCLUDE:**

- Soil sampling (partial leach, total leach)
- Targeted sampling media and depth (e.g. calcrete/ferricrete/silcrete)
- Vegetation sampling
- Soil gas (SDP)
- Geophysical (electro-magnetic, magnetic, induced polarisation, resistivity and gravity)
- Electrochemical (CHIM and its derivatives)
- pH and conductivity measurements
- Radon detection
- Hydrogeochemistry

A number of these exploration approaches are being investigated as part of the CRC LEME Curnamona project in areas of sedimentary cover, in particular:

**PARTIAL LEACH SOIL GEOCHEMISTRY**

Partial leach methods selectively dissolve components of the sample to improve the sensitivity for target elements. Leachates can be customised to the mineralogy of the sample media (e.g. selective dissolution of Fe and Mn-oxides, selective dissolution of organic matter, provide buffering of reaction in samples with high pH values to ensure complete dissolution of the target phase) (Bajc, 1998; Hall & Bonham-Carter, 1998; Smee, 1999). Partial leaches have been used successfully elsewhere in areas of deep cover (commonly up to 20-50m). The effectiveness of partial leach methods is being compared at the Kalkaroo Cu-Au-Mo, Polygonum multi-element, and Christmas Ball Cu-Au prospects (Fabris *et al*., 2006).

**SDP**

SDP (*soil-gas desorption pyrolysis*) measures volatile compounds absorbed on clay-sized (<2 micron) particles in soil. Volatiles migrate readily through rock and sediment to reach the surface. While most volatiles are lost to the atmosphere, some are adsorbed on the surface of soil particles. The gas content of near-surface soil above a buried ore deposit can be quite distinct from the regional background (see www.sdpsoilgas.com). Trials of the technique are currently in progress at the Goulds Dam sedimentary uranium prospect and Kalkaroo Cu-Au-Mo prospect.

**CHIM**

The electrochemical CHIM (CHastichnoe Izvlechennye Metallov) technique was developed in Russia and modified versions have been developed in the US and China (Hoover *et al*., 1997; Leinz, *et al*., 1998). The method relies on the leakage of ions from an ore body to the surface (Golberg, 1998) where the applied current has potential to collect the ions from a much larger volume than would be feasible with traditional soil sampling methods.

The Chinese version uses specially coated carbon electrodes placed in the soil and connected to a DC power source. Trials with this method have been completed recently at Challenger Gold Mine, Kalkaroo Cu-Co-Mo Prospect and Goulds Dam sedimentary-U Prospect (Keeling *et al*., 2006; Fabris *et al*., 2006).

**VEGETATION**

Vegetation is able to accumulate elements from the subsurface via its roots. The depth of penetration of the tap root is critical in determining whether the target plant species is sourcing elements in the subsurface, or recycling a soil anomaly (Aspandiar, 2004; Hulme & Hill, 2005b).

CRC LEME research has evolved a vegetation sampling methodology and demonstrated success using plant foliage and plant litter of particular species, including River Red Gum and Mulga (Hulme & Hill, 2005a; Anand *et al*., 2005).

**CALCRETE**

Metal ions released into the soil may be temporarily fixed in the root zone and zone of high soil water evaporation. In arid environments this is also the site of carbonate precipitation and calcrete development. Regolith carbonate accumulations (calcrete) may therefore retain metal ions accumulation over long time periods. Selective sampling of 'calcrete' has been used in the central Gawler Craton to successfully locate gold mineralisation in areas of deeply weathered bedrock, including areas of thin, transported sand cover.

**RADON DETECTION**

Radon is a naturally occurring radioactive gas. It forms from the radioactive decay of uranium and thorium. Uraniferous sediments/rocks will produce increased levels of radon relative to their surroundings. Radon gas moving through soil pore spaces and cracks can be detected at the surface with radon detectors. The use of radon and alpha particle detectors is currently being investigated at the Gould's Dam sedimentary uranium prospect.

**CONCLUSIONS**

Areas of variable thickness of sedimentary cover over known mineralisation in the Curnamona Province, including Cu-Au-Mo, Pb-Zn, and uranium prospects, were selected for trials of a range of surface geochemical techniques to assess their potential as an aid to mineral exploration in the district. Techniques tried to date include partial leach, CHIM, SDP, calcrete, and vegetation. Results of individual trails will be reported separately as data become available.

**REFERENCES**

ANAND, R., CORNELIUS M. & PHANG C. 2005. Use of biota in mineral exploration in areas of transported cover in the Yilgarn Craton. 2005 *Minerals Exploration Seminar Kalgoorlie*, Abstracts, CRC LEME, Perth, 63.

ASPANDIAR M.F. 2004. Potential mechanisms of metal transfer through transported overburden within the Australian regolith: a review. *In*: Roach I.C. ed. *Regolith 2004* CRC LEME, Perth, 17-20.

BAJC A.F. 1998. A comparative analysis of enzyme leach and mobile metal ion selective extractions: Case studies from glaciated terrain, northern Ontario. *Journal of Geochemical Exploration* 61, 113-148.

CAMERON E.M., HAMILTON S.M., LEYBOURNE M.I., HALL G.E.M. & MCCLENAGHAN M.B. 2004. Finding deeply buried deposits using geochemistry. *Geochemistry, Exploration, Environment, Analysis*, 4, 7-32.

FABRIS A.J., KEELING J.L. & FIDLER R.W. 2006. A comparison of geochemical exploration techniques at prospects in the Curnamona Province. *In*: Korsh R.J. & BARNES R.G. (compilers) Broken Hill Exploration Initiative: Abstracts for the September 2006 Conference, *Geoscience Australia*, *Record* 2006/21, 46-49.

GOLDBERG I.S. 1998. Vertical migration of elements from mineral deposits. *Journal of Geochemical Exploration* 61, 191-202.

HALL G.E.M. & BONHAM-CARTER G.F. (Eds) 1998. Selective extractions. *Journal of Geochemical Exploration* 61.

HAMILTON S.M. 2000. Spontaneous potentials and electrochemical cells. *In*: HALE M. ed. *Geochemical remote sensing of the subsurface*. Elsevier, Amsterdam, Vol. 7, 421-426.

HOOVER D.B., SMITH D.B., & LEINZ, R.W. 1997. CHIM – an electrogeochemical partial extraction method: an historical review. U.S. Geological Survey, open file report 97/92, 35pp.

HULME K.A. & HILL S.M. 2005a. Mineralisation discovery through transported cover using River Red Gums (*Eucalyptus camaldulensis*). *2005 Mineral Exploration Seminar* Abstracts, CRC LEME, Perth, 31-33.

HULME K.A. & HILL S.M. 2005b. River Red Gum biogeochemistry associations with substrate: bedrock penetrators or stream sediment amalgamators? *In*: Roach I.C. ed. *Regolith 2005 – Ten Years of CRC LEME*, CRC LEME, Perth, 146-151.

KEELING J.L., LUO X., HOU B., FIDLER R., FABRIS A. & ZENG N., 2006. Chinese CHIM – electro-geochemical survey of extensions to the Challenger Gold Mine, South Australia. *Australian Earth Sciences Convention, Melbourne 2006,* Extended Abstracts.

LEINZ R.W., HOOVER D.B., FEY D.L., SMITH D.B. & PATTERSON T. 1998. Electrogeochemical sampling with NEOCHIM – results of tests over buried gold deposits. *Journal of Geochemical Exploration* 61, 57-86.

SMEE B.W. 1999. The effect of soil composition on weak leach solution pH: a potential exploration in arid environments. *Explore newsletter,* 102, 4-7.