BIOGEOCHEMICAL RESIDENCE AND DISPERSION OF TRACE METALS IN THE NEW BENDIGO INLIER AND MARGINS, NORTHWEST NSW

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INTRODUCTION

The New Bendigo Inlier near Tibooburra in northwest New South Wales is within a regolith-dominated terrain that is highly prospective for various mineral resources, in particular Au. Determining meaningful Au assays of biogeochemical media has been a major challenge for characterisation of trace metal behaviour in prospective areas of transported regolith, such as near Tibooburra and Milparinka (Hill 2005). A detailed examination of the New Bendigo Inlier provides a better understanding of the characteristics and mechanisms involved in controlling trace metal dispersion and residence within the transported regolith along sedimentary basin margins.

The New Bendigo Inlier area contains constrained mineralisation and associated alteration zones that are exposed and buried. Along the margins of the inlier, Mesozoic Eromanga Basin sediments bury the bedrock and associated mineralisation zones, and therefore conceal the extent of the mineralisation.

Two detailed study sites are in separate catchments with ephemeral streams draining off the New Bendigo Inlier. The "Eagle Nest" catchment contains sub-cropping mineralisation. In contrast, the "White Elephant" catchment is dominated by transported regolith and much of the mineralisation at this site is concealed. To provide an understanding of the biogeochemical characteristics of each site and its mineralisation, 250 plants were sampled and 190 soil samples were collected for chemical assay. Preliminary results and interpretations are presented here.

SETTING

Location and Land use

Tibooburra is approximately 300 km north of Broken Hill in northwestern New South Wales. The New Bendigo Inlier is south of the Warratta Inlier, 30 km southeast of Tibooburra (Figure 1). The two study catchments are on the western flank of the northern part of the New Bendigo Inlier. This area is mainly used for pastoral grazing but a portion of the area was annexed to form Sturt National Park, once part of the former Whittabrinna Station.

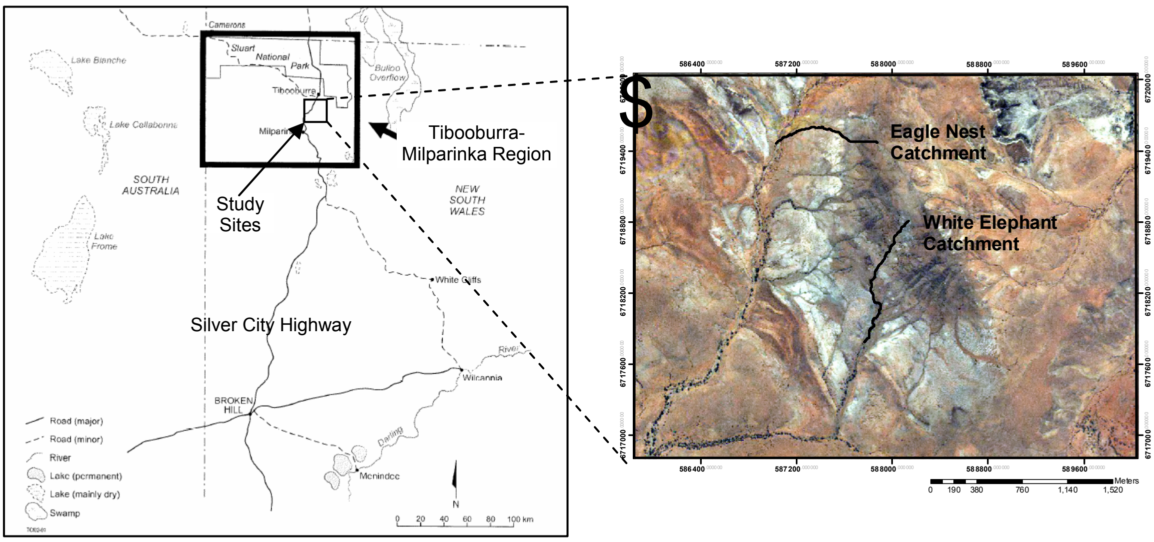

Figure 1: The two study sites, Eagle Nest and White Elephant catchments, in the Tibooburra-Milparinka Region from Hill (in prep).

Climate

The northwest of New South Wales has an arid climate (Hill 2005). The rainfall tends to be slightly summer-dominated with a mean annual rainfall recorded for 2004 as 228 mm. The average daily maximum temperatures vary over the year, with the mean daily maximum for summer up until 2004 being 36°C and the mean daily maximum for winter being 18°C (Bureau of Meteorology 2004).

Regional Geology and Geomorphology

The study sites are adjacent to the boundaries between the Delamerian, Lachlan and Thomson orogens. This area is in the south of the Eromanga Basin and along the Grey Range drainage divide between the Lake Eyre Basin to the west and the Bulloo-Bancannia Basin to the east (Hill 2005).

The oldest bedrock sequences in the area are Late Cambrian to Early Ordovician interbedded metasandstones and metasiltstones. These metasediments are highly cleaved with auriferous quartz veins and associated alteration zones. The veins mostly trend northwest to southeast, parallel to the cleavage of the metasediments. Thalhammer *et al.* (1998) reported that whole-rock K-Ar dating from metasedimentary rocks revealed metamorphic cooling ages between 440 and 420 Ma, corresponding with the development of the cleavage and Au-bearing quartz veins. Late Jurassic to Early Cretaceous Mesozoic sediments of the Gum Vale Formation unconformably overlie the metasediments in the area. These sediments are the local equivalents of the Cadna-owie Formation (Hill in prep). These sediments include fine to medium-grained sandstones with thin bedding and ferruginous lenses. Placer mineralisation is associated with the unconformity between the metasediments and the basal conglomerate of the Mesozoic sediments. The mineralisation has been progressively incised and reworked by younger drainage channels. Alluvial diggings in the region have exploited this mineralisation. The two study catchments contain each of these main geological units, quartz vein sets and localised relict Au diggings.

Vegetation

The vegetation of the region is highly variable due to the diversity of landforms and erratic rainfall patterns. The understorey component of both study catchments is moderately dense chenopod shrubland dominated by *Maireana pyramidata* with some *Maireana sedifolia* and *Atriplex vesicaria*. Chenopod shrublands become very sparse towards the upper sections of the rises and low hills. The overstorey vegetation is mainly open woodland dominated by *Acacia aneura*, restricted to the higher sections of topographic relief. Stands of tree species including *Atalaya hemiglauca, Acacia victoriae* and *Myoporum montanum* occur along drainage depressions and channels. *M. pyramidata* and *A. aneura* are mostly restricted to exposed or sub-cropping metasediments, particularly along inlier margins. *A. vesicaria, Enchylaena tomentosa* and *A. cana*, become more prevalent with thicker sedimentary cover.

METHODS

Vegetation Sampling and Analytical Methods

M. pyramidata twigs and *A. aneura* phyllodes were selected to be used in a biogeochemical survey of the two catchments, partly based on their local abundance as well as encouraging results from previous work conducted in the Tibooburra-Milparinka region (Hill & Hill 2003, Hill 2004,2005). *M. pyramidata* twigs and *A. aneura* phyllodes were collected during autumn over a few days to avoid any variation that may be attributed to changes in climate. Plant organs were dried at low temperature, milled and sent to ACME Laboratories, Canada, for Inductively Coupled Plasma Mass Spectrometry (ICP-MS) analysis for 53 elements.

Soil Sampling and Analytical Methods

In winter, soils were collected from sites adjacent to each of the *M. pyramidata* plants sampled. The sampling was done over a period of 6 days. Soil samples were taken from the top 5 – 10 cm at each site using a clean plastic scoop. The samples were then separated into coarse (>200 μm), medium (75-200 μm) and fine (<75 μm) fractions using plastic sieves and nylon mesh. Concurrent to soil collection, pH was also tested using an Inoculo field test kit. Based on an orientation survey as part of this study in April, the medium fraction was selected to be sent to Ultratrace Laboratories, Perth for ICP-MS analysis of 28 elements, with a further 7 elements analysed by ICP-Optical Emission Spectrometry (ICP-OES).

Mapping

Geochemistry

The assays obtained from the samples were plotted in Arc GIS to produce EDA point maps. Datadesk was used to produce Box and Whisker Plots so the values could be used to generate the divisions of the elemental concentrations on the EDA point maps. Iogas was used to produce X-Y scatter plots, statistic summaries and probability plots.

Regolith-landform, geology and vegetation

Regolith-landform, geology and vegetation maps were constructed for both study catchments at 1: 7, 500 scale. These were produced from fieldwork and aerial photograph interpretation. The map grids for all maps produced conform to the Australian Map Grid (AMG) using the GDA datum 1994 and UTM Zone 54. The aerial photography was obtained from the Geological Survey of New South Wales' Koonenberry Geoscience Database Version 1 CD-ROM (Needham 2002). A Global Positioning System (GPS) receiver with barometer was used to take height measurements (± 2 m) at various sites within the catchment areas to produce a Digital Elevation Model (DEM) for each catchment. Mapping of dispersion vectors used 'litter-dams' as per Brown & Hill (2003). This information was then integrated into regolith-landform maps.

BIOGEOCHEMICAL RESULTS

To distinguish patterns in the Au concentration within the study sites, a geochemical atlas was generated for each species sampled across the catchments (Figure 2). Levels of Au in *M. pyramidata* are greatest in shrubs growing directly over mineralisation on the topographically higher sections of both catchments. Maximum Au concentrations (ranging from 1.0 to 7.8 ppb) are irregularly distributed across the catchments. Moderate values of Au were expressed in *M. pyramidata* in the southeastern corner of the White Elephant catchment. Expression of Au concentrations in *A. aneura* trees is similar to that of *M. pyramidata*. In both catchments, the majority of high Au assays were from samples taken directly over or proximal to mineralised areas or mine workings. The bedrock lithology and underlying geology has a strong influence on Au distribution within the landscape. Both plant species detected Au on erosional rises where mineralisation was sub-cropping. The movement and dispersion patterns of Au indicate geological and landscape setting controls have a combined influence on its distribution.

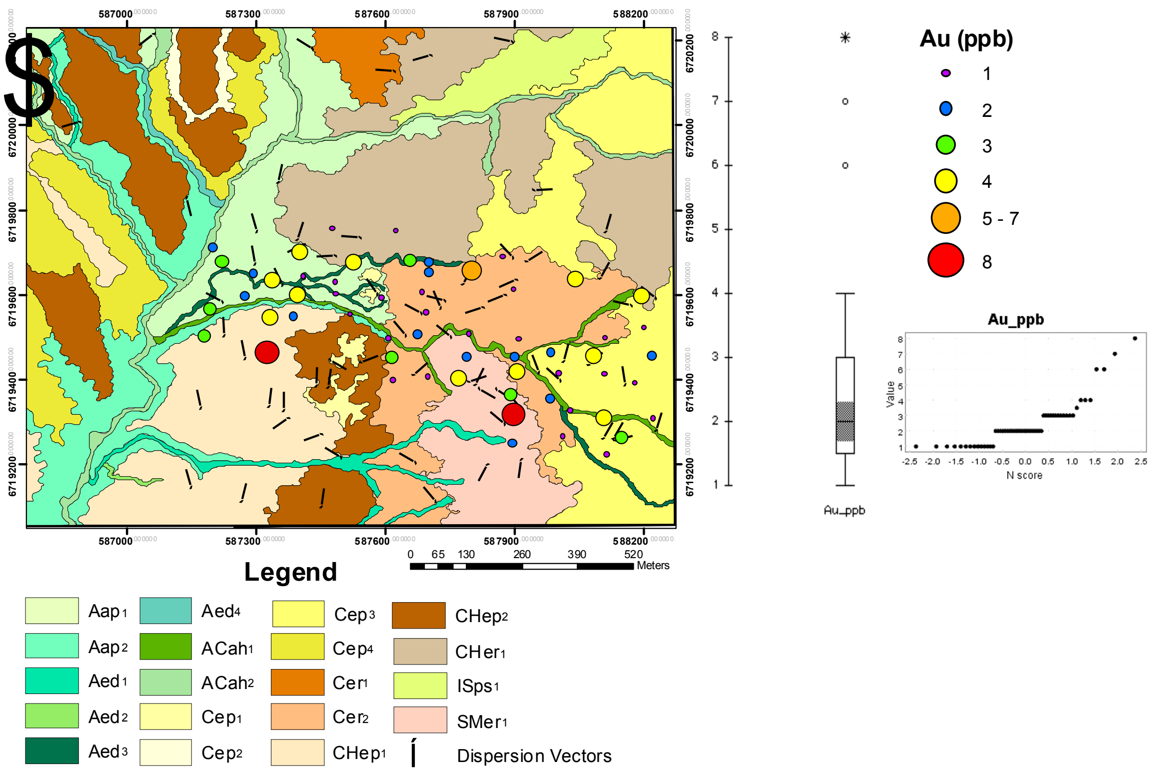

Figure 2: A geochemical atlas showing the concentrations of Au in *Maireana pyramidata* shrubs overlain onto the regolith map of the White Elephant catchment.

The levels of Au within the topsoil samples vary markedly between catchments, with concentrations of Au in the Eagle Nest catchment being much higher than those recorded for the White Elephant catchment. Also, the level of Au in soils is much greater than those in plants, with the highest soil concentrations reaching up to 80 ppb. Gold assays in soils from the White Elephant catchment are comparable to those recorded for *M. pyramidata,* although they are still higher, averaging Au concentrations of 2 ppb. The geochemical assay results show that Au assay patterns reflect areas containing auriferous quartz veins and associated alteration zones within the phyllite.

CONCLUSION

The plant and soil surveys conducted across Eagle Nest and White Elephant catchments on the New Bendigo Inlier were able to distinguish the biogeochemical and geochemical expression of sub-cropping and more deeply buried mineralisation. Regolith-landform and geology maps provided essential foundations for the interpretation of the chemical assay results. This information was necessary to confirm known regions of mineralisation and alteration zones, identify sites of elevated Au content indirectly associated with known mineralisation and determine the geological and landscape effects on elemental dispersion and residence.

REFERENCES

BROWN A. D. & HILL S.M. 2003. Litter Dams: A new method of mapping surface dispersion vectors at the White Dam Prospect, Curnamona Craton, SA. *In*: ROACH, I. C. ed. *Advances in Regolith*. CRC LEME, 24-28.

BUREAU OF METEOROLOGY 2004. Climate averages for Tibooburra Post Office. http://www.bom.gov.au/climate/averages/tables/cw_046037.shtml

HILL L.J. 2004. Biogeochemical and geochemical dispersion and residence in landscapes of western N.S.W. CRC LEME, Department of Earth and Marine Sciences, Australian National University, (unpublished).

HILL S.M. & HILL L. J. 2003. Some important plant characteristics and assay overviews for biogeochemical surveys in western New South Wales. *In*: ROACH I.C. ed. *Advances in Regolith*. CRC LEME, 187-192.

HILL S.M. 2005. A new understanding for the use of biogeochemistry to express mineralisation through transported cover in regional and prospect scale mineral exploration. University of Adelaide, CRC LEME, Adelaide, South Australia.

HILL S.M. 2005. The regolith and landscape evolution of far west New South Wales. *In*: ANAND R.R. and DE BROEKERT P. eds. *Regolith Landscape Evolution Across Australia*. CRC LEME, Perth, 130-145.

HILL S.M. (in prep). Regolith-landforms of the Tibooburra-Milparinka region, far northwestern NSW: Field Guide. CRC LEME **Report**.

NEEDHAM J. 2002. Koonenberry Geoscience Database Version 1. New South Wales Department of Mineral Resources, Geological Survey of New South Wales.

THALHAMMER O.A.R., STEVENS B.J.P., GIBSON J.H. & GRUM W. 1998. Tibooburra Granodiorite, western New South Wales: emplacement history and geochemistry. *Australian Journal of Earth Sciences* **45**, 775-787.

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