

# **A NEW UNDERSTANDING FOR THE USE OF BIOGEOCHEMISTRY TO EXPRESS MINERALISATION THROUGH TRANSPORTED COVER IN REGIONAL AND PROSPECT SCALE MINERAL EXPLORATION**

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## **INTRODUCTION**

In recent years a range of regolith biogeochemistry research projects have been undertaken in the Curnamona Province and immediately adjacent areas in western New South Wales and eastern South Australia. The biogeochemistry of tree and shrub species (as summarised in Hill & Hill, 2003) has been the main focus of the research although increasing consideration is being given to faunal biogeochemical characteristics. This manuscript provides a brief overview of some of the highlights of this research program.

## **RESEARCH STRATEGY**

The ultimate aim of the research program has been to develop the application of biogeochemical sampling media for use in mineral exploration and environmental chemistry sampling programs (Hill, 2004). There is more to this than simply picking parts of plants and sending them off to the laboratory for analysis. Biogeochemical sampling media are typically dynamic and complex, however by having some respect for the characteristics of the media to be sampled a suitable sampling strategy can be developed. The sampling strategy needs to be rigorous and robust, with a major aim being the collection of consistent and therefore comparable sampling media. Once the sampling and then the sample preparation and assay technique have been decided upon the assays generated can be used for establishing knowledge of the biogeochemical characteristics and then interpretations of biogeochemical mechanisms and controlling factors. These are important because they are major aspects of biogeochemical dispersion and residence models, which ultimately determine the type of application that particular biogeochemical media can be used for, and how the assay results will be interpreted.

One way to consider the array of biogeochemical sampling available in most landscapes is that once characterised and understood, each medium can be seen as a sampling and chemical processing tool within the larger biogeochemical toolbox within the landscape.

Some media will be best used for regional sampling media programs. These will typically have a widespread distribution across large geographical areas and either occur within a range of regolith-landform settings or within a widespread regolith-landform setting which is of regional significance (e.g. along major drainage channels). They will also derive their biogeochemical signatures from broad areas (kilometre to 100s of metres dispersion pathways), either through amalgamation of the chemistry from a large area (such as extensive root systems) or else from a substrate that is an amalgamation of regional chemical signatures (e.g. stream sediments, particularly fine-grained overbank deposits). These attributes produce regional sampling media that derive their biogeochemical signatures from broad areas and can be sampled on relatively large sample spacing, to efficiently account for large regions. Examples of regional sampling media developed by this research program include regional river red gum sampling and macropod (red and western grey kangaroo) scat sampling.

Other media are best suited to local-scale, detailed sampling programs. They are typically sensitive to local substrate chemical changes (e.g. plants with restricted root systems), and are

best sampled at relatively close sample spacings. It is recommended that these media may be used to refine and further constrain interesting regional sampling media results, rather than being used on a regional scale sampling programs, where they are associated with dispersion pathways operating on the scale of metres to 10s of metres. Plants used in this way may have root systems restricted to either mostly vertical penetration of the regolith to the underlying bedrock or aquifer systems, or else have root systems that amalgamate chemical signatures from locally derived regolith materials. Examples of locally applicable sampling media include prickly wattles (*Acacia victoriae*), mulga (*Acacia aneura*), and chenopod shrubs (e.g. *Maireana spp.* and *Atriplex spp.*).

### **SAMPLING AND ASSAY APPROACH**

The early stages of this research program have focussed on establishing a robust and rigorous sampling strategy. This included extensive reading and review of previous literature as well as the trial of different approaches specific to both the particular indigenous flora being sampled, and the specific goals of particular sampling programs. Many of the details of this stage of project development are outlined in L.Hill (2002), with more recent accounts specific to particular species such as river red gums (*Eucalyptus camaldulensis*) (Hulme & Hill, 2003; 2004). Sample preparation approaches adopted are outlined and discussed in L.Hill (2002; 2003) and Hulme & Hill (2003). One component that has been found to be extremely important as a framework for conducting and then interpreting biogeochemical surveys is the provisional of a suitable regolith-landform map. Regolith-landform setting is a major control on the biogeochemical assay results (e.g. Hill, 1995; Brown & Hill, 2003; 2004). The regolith-landform maps used need to have meaningful descriptions and subdivision of the regolith-landform units as well as the potential to show dispersion pathways, and hopefully some vegetation community and dominant species information (S.Hill, 2002; Brown & Hill, 2003).

### **BIOGEOCHEMICAL CHARACTERISTICS**

In order to establish some of the chemical and parameters specific to individual biogeochemical sampling media, sampling studies have been undertaken in both 'background' and 'extreme' chemical landscape settings. These 'extreme' settings have included sites overlying or proximal to mineralisation (e.g. Jones, 1999; Debenham, 2000; Senior, 2000; Dann, 2001; Hill & Hill, 2003; Hulme & Hill, 2003; Brown & Hill, 2004), or bedrock types with extreme rock chemical compositions such as serpentinites and other ultramafic rocks (Hill 1998; Hill & Hill 2003; Barratt & Hill 2003). An summary of some of the 'extreme' assay results from trees and sampled near the Junction Mine on the Broken Hill Line of Lode are given in Table 1. For the biogeochemical sampling media and elements listed here, many of the elements (e.g. Ag, Pb, Cd, Sb) are typically in concentrations below the detection limits of the assay techniques, or in the case of Zn, are typically in concentrations of 10s of ppm rather than the elevated figures shown here.

Determining meaningful Au assays of many biogeochemical media has been a major challenge for characterisation in areas prospective for Au (such as Tibooburra and at the Williams Peak Prospect near Kayrunnera. Firstly many media assayed for Au have also have high Na contents, which interfere with obtaining Au assays at low detection limits. This was a major problem for bladder saltbush (*Atriplex vesicaria*) and many other chenopod leaf assays that feature salt secretion glands, and has been overcome by preferentially sampling the twigs from these shrubs (Brown & Hill, 2004). The Au content also appears to be extremely heterogeneous and seasonally variable within many plants, such as river red gums (Hulme & Hill, 2003; 2004), and large robust sampling approaches within optimal seasonal conditions have been recommended when sampling for Au assays (Hulme & Hill, 2004).

## **LOCAL SAMPLING MEDIA: TENEMENT & PROSPECT SCALE BIOGEOCHEMISTRY**

Many of these studies have been based on characterising and testing the biogeochemical expression of a site of known mineralisation or a substrate of 'extreme' chemical characteristics such as ultramafic bedrock. At the local-scale, plant biogeochemistry may be useful for chemical characterisation at the individual tenement- or prospect-scale by providing a chemical signature that:

1. amalgamates the chemical characteristics of an otherwise heterogeneous sampling media; and,
2. penetrates the regolith substrate and extracts a chemical signature from specific materials that may be otherwise covered (e.g. covered bedrock or aquifers).

Many of the chenopod shrubs appear to be chemical amalgamators from within the regolith substrate overlying bedrock, such as black bluebush (*Maireana pyramidata*) at the Flying Doctor Prospect (Hill *et al.* in press), and to some extent bladder saltbush (*Atriplex vesicaria*) at the White Dam prospect, although the bladder saltbush also appear to gain chemical signatures from below the base of the transported regolith interface (Brown & Hill 2004).

Two of the best examples of plants that are deriving chemical signatures derived from weathered bedrock underlying shallow transported regolith are the prickly wattles (*Acacia victoriae*) at the Flying Doctor Prospect (Hill *et al.* in press), and the mulgas (*Acacia aneura*) that colonised aeolian regolith that overlies mafic and ultramafic bedrock. In these cases the surface and near surface regolith materials have either a poor or insignificant chemical signature of the underlying bedrock, however the trees appear to have 'penetrated' this shallow (< 5 m thick) regolith and contain chemical signatures indicative of the underlying bedrock. This characteristic is extremely important for mineral exploration programs based in areas with shallow transported regolith that extends over a very large proportion of the Curnamona Province and adjacent areas. It suggests that these trees are recommended sampling media ahead of surface transported regolith materials and the more expensive shallow drilling and costean digging.

## **REGIONAL SAMPLING MEDIA: WIDE-SPACED CHARACTERISATION**

The two main regional biogeochemical sampling media that have been developed within this research program are river red gums (*Eucalyptus camaldulensis*) and macropod scats.

River red gums form extensive riparian woodlands along many of the major drainage lines in the region. Their root systems extend for many 100s of metres laterally and 10s of metres vertically, where they may interact with regolith substrates (mainly stream sediments), shallow aquifer systems and the underlying bedrock (Hulme & Hill, 2003). Hill (2004) shows some exciting assay results from a river red gum leaf sampling survey conducted along Pine Creek and extending past the Pinnacles Mine, west of Broken Hill. The very high Pb content in the leaves at the Pinnacles Mine sample (over 300 ppm!) and the exponential decrease in Pb assays to eventually reach background levels (below detection limits) downstream, are typical of the results that would be expected if this chemical signature reflects a downstream dispersion plume within the stream sediment substrate. Further research by Karen Hulme has re-sampled leaves from these trees and further assays not only repeat these results, but further assays following ultra-sonic washing of the leaves also repeated these assay results (indicating that the Pb is not due to Pb-rich detrital contamination on the leaves). The geochemical 'footprint' associated with other elements such as Zn covers a much greater area multi-element assays of this media may be the most useful approach in regional sampling programs.

Western NSW has been the location of some very detailed study by ecologists based at the Fowlers Gap Arid Zone research Station, who have been trying to better understand the behaviour of kangaroos. Particular attention has been given to understanding their grazing

preferences and home-range (via radio tracking). Based on some of the results from this ecological research, sampling of scats from red and western grey kangaroos has been undertaken on an approximately 5 km sample spacing across large parts of western NSW. The assay results show high trace metal contents for elements such as Pb, Cd and Zn in the vicinity of Broken Hill and some high contents near the Pinnacles (Hill, 2004). These chemical signatures reside within the macerated vegetation fraction of the scats, however it is unclear whether the high assay results centred on Broken Hill are detecting a centre of mining and previous smelting, or if they represent a natural chemical 'footprint'. Further work is being undertaken to better understand these results, however they show enormous potential for possibly being able to:

- be used as a regional chemical sampling media across large parts of Australia to detect mineralised provinces, or chemical pollution;
- reflect chemical background levels of important trace metals (e.g. at the very least the results so far show a measure for the environmental metal enrichment in the Broken Hill landscape); and,
- show that if macropod droppings are included in surface regolith samples they may account for some of the trace metal contents.

## CONCLUSIONS

The results from this research have led to the development of several new and innovative biogeochemical sampling media and approaches that could be adopted in mineral exploration and environmental chemistry sampling programs, particularly based in areas with shallow transported regolith. Different biogeochemical media may be adopted for different roles including local and regional surveys, as well as for the amalgamation of otherwise heterogeneous chemical signatures with the regolith, or the penetration of transported regolith and expressing chemical signatures from the underlying bedrock.

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