Biogeochemistry
in Mineral Exploration

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Photos courtesy of Colin Dunn

Biogeochemistry, or more precisely, phytogeochemistry, uses plants as the sample medium for exploration, in particular when soil samples cannot be taken due to inaccessibility or in areas of transported overburden. Vascular plants have evolved over 400 Ma to survive a wide range of physical and chemical conditions, and have developed mechanisms to absorb and scavenge elements and translocate them to foliage, twigs, bark, flowers and seeds. Some plants are able to solubilise gold by releasing such ligands as cyanide (observed in Acacia and Eucalyptus[1]).

Biogeochemistry is particularly useful as a guide to the underlying geology in areas of transported cover, where the signature in the vegetation can be better than the soils[4]. In arid and semi-arid conditions[2] roots can penetrate several meters to reach permanent water source (Table 1), for example **roots of Spinifex have been observed in mine pits at depths to 30 m and below**[3].

Table 1. Maximum rooting depths, in various ecosystems (Canadell et al. 1996)

Ecosystem type	Range of rooting depths (m)
Boreal Forests	1.2-3.3
Desert	1.8-53
Coniferous forest	2.0-7.5
Tropical forests	2.0-18
Tropical grassland and savannah	1.6-68

Vegetation is widespread and **samples are easy and cheap to collect, with a low environmental impact**, compared with more invasive exploration sampling techniques. The levels of metals in plants are low, compared with soils, so care must be exercised to minimise contamination during when sampling.

Sampling

Where? Sample around a tree or shrub at about the same height, taking samples of approximately the same age. The site should away from areas of anthropogenic impact. Collect enough to fill a large soil sample packet or a small calico bag and air dry in the field if possible. To prevent mould, do not store samples in plastic bags for long periods.

Which species? One or several targeted species, typically the most widespread with high chance of being deep-rooted[5]. If there is existing knowledge on particular plant species in your area this may also influence the choice of target species. Out of 138 scientific studies, which were analysed at Intertek, the most popular species successfully used in exploration studies in Australia are **Acacia** and **Eucalyptus, Spinifex, Tea tree**, Fuschia bush, Monterey pine, Black oak and Cassinia. Some plants hyperaccumulate certain elements to very high levels, to name a few Australian plants (Fig.1): Shrub Violet (*Hybanthus floribundus*, **Ni and Co accumulator)**, Black Nightshade (*Solanum nigrum*, **accumulator of Cd**), Flat-topped saltbush (*Atriplex codonocarpa*, **accumulator of Hg**), Dysentery Bush (*Alyxia buxifolia* accumulator of Cr and Cu). *Polycarpaea spirostylis* is known to grow on soils rich with Ag, Pb and Cu however this species is endangered in Australia and should be used only as an indicator. Among unusual, but very successful media to sample are kangaroo scats and termites.

What part of plant tissue? Uniform plant tissue (foliage of uniform age/maturity, twigs of similar diameter, bark, flowers, seeds, litter) can be analysed and a small orientation study is recommended to determine the most useful species and the tissue types. **Foliage and bark often give the strongest geochemical signatur**e.

When? Limitted time period (2-3 weeks) as live plant tissue exhibit seasonal variations, but this is generally less than 20%. Dead tissues such as outer bark or litter yield small or no change in composition during seasons [5].

How much? Optimal size from 20g to 100-300g.

Other media to sample? Biogeochemistry has been proven to be a successful exploration tool on its own, however, for a comprehensive program it is recommended to sample other media together with plant tissue such as soil for Partial Digest and, if samples are accessible, surface water/groundwater or stream sediments for Hydrogeochemical analysis.

Analysis

Samples are prepared in dedicated facilities in the laboratory. Samples are dried, the foliage is separated from twigs and extraneous material removed from litter, as required, before being milled in specialised equipment. Soft leaves and bark usually is easy to prepare, whereas thick twigs require more work.

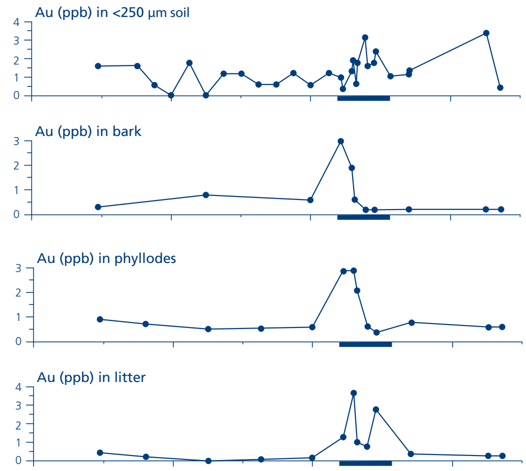
The pulped sample is digested using a modified aqua regia digest and analysed by ICP-OES and ICP-MS. Multi-element analyses are most useful for biogeochemical interpretation and depending on the project budget, Intertek offers various packages however, for an initial small orientation study the full suite of elements is recommended. Detection limits for salt bush leaves (not twigs) and other samples that are particularly enriched may be higher if extra dilutions are required however, most popular plants used in biogeochemistry do not require this. For quality control we have a wide range of Australian vegetation standards to match the sample matrix.

The map on Figure 2 shows the geography of only a few successful scientific studies of biogeochemistry expression over various mineralisation zones in Australia and some elements, which had anomalous values over those zones. Majority of studies (46 %) were devoted to identify Au mineralisation. In studies for Au mineralisation the major plant tissue were leaves and leaflet b ranchlets (87%), b ark (7.8%), twigs (3.1%) and litter (1.6%). Bark and leaves on average gave the highest values for gold anomalies. In 86% of cases anomalous Au values were present in plant tissue over mineralisation zone.

The map highlights applicability of biogeochemistry method for exploration in a wide range of arid environments.

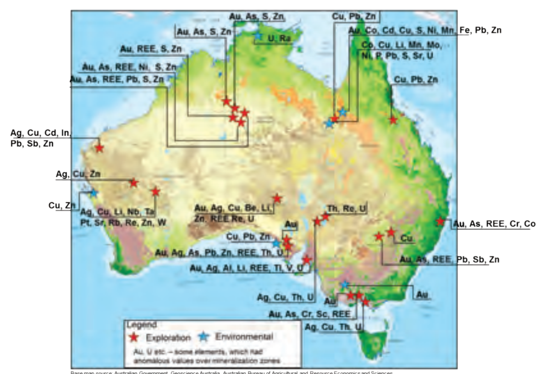
Various preparation options are available with analysis packages.

Figure. 1. Gold in soil and vegetation at Moolart well gold deposit (Anand et al. 2007).



*Gold in soil and vegetation at Moolart well gold deposit (after Anand et al., 2007).

Figure 2. Geography of successful research studies on biogeochemistry over various mineralization zones in Australia.



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