PLANT BIOGEOCHEMICAL EXPRESSION OF URANIUM MINERALISATION IN AUSTRALIA: RESEARCH OUTLINE AND PRELIMINARY RESULTS

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INTRODUCTION

With expanding interest in uranium in the global market, coinciding with its development as a more socially acceptable energy source, Australia finds itself in an enviable position as a major source of supply. With global demand set to rise on the back of increased oil prices and concerns over global warming, the ability to delineate and secure future resources is of obvious interest. As such, an understanding of the biogeochemical and geobotanical associations related to uranium mineralisation offer a great deal of potential to both industry and wider society.

Due to the historically ephemeral nature of uranium demand and subsequent exploration, little research has been done into the applicability of biogeochemistry as a tool for exploration in Australia. This can be largely attributed to the success of 'traditional' methods at a regional scale, such as airborne radiometrics and aeromagnetics, which have been able to constrain drilling programs at a local scale. Biogeochemistry aims to complement rather than circumvent these methods at both scales. While little is known on the subject for Australia, a more extensive body of work has been completed on varying aspects of uranium biogeochemistry in Canada, including the role of soil geochemistry in uranium uptake by plants (Dunn, 1983a) and plant physiology-uranium biogeochemical relationships (Dunn, 1983b). These studies have been able to detect uranium mineralisation situated below up to 150m of cover.

Little is also known about the processes of phytoremediation and phytomining of uranium, whereby the hyperaccumulation of elements by vegetation is used as a mechanism for the removal of specific elements or metals from the soil (Dunn et al, 1996). With management of both uranium and the environmental impact of the minerals industry commonly seen as contentious issues, these two 'phyto-metholds' have the potential for considerable benefit in reducing the environmental impact of uranium production and processing.

A key factor in the success of biogeochemistry is the ability of plant roots to penetrate through regolith material, often for tens of metres. As outlined by Hill & Hill (2003), vegetation also offers other advantages over traditional sampling media such as soils and stream sediments. Of particular relevance to this study are:

• the extraction and accumulation of specific elements by plants;
• the ability of plants to generate a geochemical signature from beyond their root zone; and,
• the widespread distribution and ease of sampling of biogeochemical media.

The orientation stages of this project were in the Curnamona Province of South Australia. The Curnamona hosts major uranium mineralisation and deposits (McKay & Miezitis, 2001), yet little is known of this from a geobotanical and biogeochemical perspective. One of the only significant studies into uranium biogeochemistry in Australia was carried out by Cruikshank & Pyke (1986), who were able to partially constrain the role of soil geochemistry and plant physiology in the geochemical associations. However, given the physio-climatic differences between the Ranger Uranium Mine and those hosted in the Curnamona Province, and in other parts Australia, little to nothing is known beyond this study.

STYLES OF MINERALISATION

Uranium mineralisation is delineated into fifteen types, with Australia's key economic resources found in four of these styles. Listed in approximate economic importance to Australia and with selected examples, these are (from McKay & Miezitis, 2001):

• Breccia complex deposits – Olympic Dam, SA;
• Unconformity-related deposits – Ranger and Jabiluka deposits, NT;
• Sandstone hosted deposits – Beverley and Honeymoon deposits, SA;
• Surficial deposits – Yeeliree, WA (calcrete);
• Metasomatite deposits;
• Metamorphic deposits – Mary Kathleen zone, east of Mount Isa, Qld;
• Volcanic deposits;

- Intrusive deposits – Crocker Well, Mount Victoria, Radium Hill, SA;
- Vein deposits;
- Quartz-pebble conglomerate deposits;
- Collapse breccia pipe deposits;
- Phosphorite deposits;
- Lignite deposits;
- Black shale deposits ;
- Other – e.g. Jurassic Todilto Limestone, Grants district, New Mexico, USA.

Given the various conditions under which each of these styles of deposit occur, and their subsequent mineralogy, it is expected that there may be some differentiation between their biogeochemical signatures.

SETTING

The initial stages of this project were carried out in the Curnamona Province of South Australia, an important region for uranium biogeochemistry research, not only due to the abundance of uranium but also the occurrence of other different styles of mineralisation. The Curnamona Province is composed of two key sequences; late Paleoproterozoic metasedimentary and metavolcanic systems with intrusive Mesoproterozoic sedimentary, volcanic and granitic rocks; and more recent sedimentary aeolian and alluvial cover (Robertson et al, 1998). Uranium mineralisation in this region is found in two key areas; the Mt Babbage and Mt Painter inliers of the Northern Flinders Ranges; and in paleochannel systems in the greater Frome Embayment (McKay and Miezitis, 2001), with minor bedrock hosted occurrence in the southern areas, such as Radium Hill and Crockers Well.

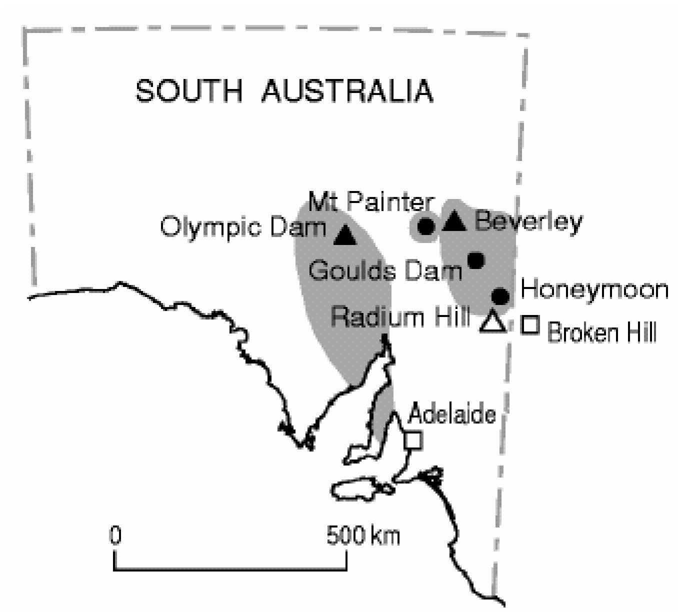

Figure 1: Selected major uranium occurrences in South Australia (adapted from McKay and Miezitis, 2001). Shaded triangles represent operating uranium mines, shaded circles major resources and unshaded triangles closed mines.

METHODS

Biogeochemical sampling was undertaken in autumn of 2006 over prospects with known uranium mineralisation. A variety of regolith-landform settings were chosen as a result. Where possible, geobotanical and other distributive constraints were isolated in order to assist in selecting appropriate species and sites. Across a broad range of settings, the following species were sampled:

- *Eucalyptus gillii* – Curly Mallee
- *E. intertexta* – Gum-barked Coolabah/Red Box
- *E. camaldulensis* spp. *obtusa* – River Red Gum
- *Eremophila freelingii* – Rock Emubush
- *Xanthorrhoea quadrangulata* – Grass Tree/Yacca
- *Triodia sp.* - Spinifex
- *Cassinia sp.*

- *Acacia sp.*
- *Senna sp.*
- *Ptilotus obovatus* - Silvertails
- Wiera Bush
- *Acacia aneura* - Mulga
- *Heterodendrum* - Rosewood
- Mistletoe

Samples were collected, using the methodology outlined by Hill (2002), from a variety of regolith-landscape settings and mineralisation styles. Portions of vegetation were removed while wearing powder-free latex or nitrile gloves and were stored in paper bags to minimise the risk of mould and fungal damage and to facilitate drying, as per Cruikshank & Pyke (1983). Samples were oven dried at ~60ºC for forty-eight hours prior to milling at the University of Adelaide. Prepared samples were analysed by ACME Laboratories, Vancouver, Canada, using ICP-MS (Group 1VE-MS) for a suite of 53 elements.

PRELIMINARY RESULTS

From the suite of samples collected during autumn 2006, preliminary results indicate that vegetation can successfully express uranium mineralisation. Tables 1-3 give an outline of selected prospects in the northern Flinders Ranges, SA, and selected biogeochemical results.

Table 1: Selected biogeochemical assays from Armchair prospect, Northern Flinders Ranges, taken during April 2006

Armchair prospect	**U range (ppm)**	**Cu range (ppm)**	**Ag range (ppb)**	**Th range (ppm)**
Acacia sp.	<0.01-0.46	3.92-9.98	2-12	0.06-0.07
Eremophila freelingii	0.02-0.94	10.65-24.9	6-70	0.08-0.1

Table 2: Selected biogeochemical assays from Gunsight prospect, Northern Flinders Ranges, taken during April 2006.

Gunsight prospect	**U range (ppm)**	**Cu range (ppm)**	**Ag range (ppb)**	**Th range (ppm)**
Acacia aneura	<0.01-0.02	2.83-5.73	2-7	0.04-0.09
Eremophila freelingii	0.02-0.05	3.62-13.99	<2-3	0.09-0.19
Eucalyptus intertexta	<0.01-0.52	1.52-9.86	<2-3	0.01-0.06

Table 3: Selected biogeochemical assays from Radium Ridge prospect, Northern Flinders Ranges, taken during April 2006.

Radium Ridge prospect	**U range (ppm)**	**Cu range (ppm)**	**Ag range (ppb)**	**Th range (ppm)**
Eucalyptus gillii	0.12-6.59	4.79-33.42	<2-74	0.01-0.02
Eucalyptus intertexta	0.06-6.49	2.74-12.21	<2-10	0.01-0.04
Xanthorrhoea quadrangulata	<0.01-0.09	1.14-3.13	<2-2	<0.01-0.02

Table 4: Selected biogeochemical assays from Streitberg Ridge prospect, Northern Flinders Ranges, taken during April 2006.

Streitberg Ridge prospect	**U (ppm)**	**Cu (ppm)**	**Ag (ppb)**	**Th (ppm)**
Acacia sp.	0.03	4.77	7	0.05
Eremophila freelingii	0.36	19.44	41	0.09
Eucalyptus intertexta	0.81	6.24	5	0.02
Xanthorrhoea quadrangulata	0.02	1.49	<2	0.02

FURTHER RESEARCH

There is significant scope for the expansion of this research to investigate the biogeochemical associations of styles of mineralisation other than those investigated to date. Areas of interest include, but are not limited to:
- sandstone-hosted mineralisation in paleochannels in the Curnamona Province;
- surficial calcrete hosted uranium, Yeeliree, WA;
- unconformity-related mineralisation, NT;
- rare-earth/uranium mineralisation, South-east coast, NSW.

Greater understanding of uranium and plant physiology could also prove to be of great value. Establishing target species and organs would contribute greatly to legitimising biogeochemistry as a uranium exploration tool. Such an understanding could also prove beneficial for establishing species suitable for phytoremediation.

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