BIOGEOCHEMICAL EXPLORATION UNDER COVER: NAPPERBY PROSPECT (DAY PALAEODRAINAGE) ORIENTATION PROJECT

FIELD RESEARCH COMPLETION REPORT
REPORT FOR TORO ENERGY

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SUMMARY – OVERVIEW

This report provides an overview of the fieldwork for the orientation program characterising the biogeochemical expression of uranium mineralisation buried under the transported cover of the Napperby Prospect, Northern Territory. Fieldwork was conducted over 2.5 days by Steven Hill (University of Adelaide) between 17-19 October, 2007. Plants, and some termitaria and surface regolith carbonates were sampled from along three transects crossing the Day Creek palaeodrainage system, which hosts U-mineralisation.

This plant biogeochemical program aims to: 1. compare the biogeochemical characteristics of a suite of common plants with the previously obtained drilling results in this area, in particular to assess whether the plants can provide a representative assessment of underlying U-mineralisation; and, 2. assess the potential for the development of plants as a regional-scale to local-scale sampling medium. A total of 171 plant samples were taken during this program. The main plant species sampled were: 63 plants of *Eucalyptus gamophylla* (blue mallee); 41 plants of *Triodia pungens* (soft spinifex); 19 plants of *Eucalyptus victrix* (smooth-barked coolibah); 18 plants of *Melaleuca glomerata* (inland tea-tree); 11 plants of *Acacia aneura* (mulga), 11 plants of *Acacia kempeana* (witchetty bush); 2 plants of *Corymbia opaca* (desert bloodwood); 2 plants of *Acacia ligulata* (umbrella bush); 2 plants of *Acacia victoriae* (prickly wattle); 1 plant of *Corymbia aparrerinja* (ghost gum); and, 1 plant of *Hakea lorea* (corkwood).

Although we await final biogeochemical assays, it is already apparent that a range of plant media are abundant and widespread across the study area that has potential to be suitable for developing as exploration sampling media. Of particular encouragement is that although surface soils were particularly dry during the sampling period, the general good health and in many cases new growth for many of the sampled plants suggest that they are directly accessing groundwater. This observation is also consistent with previous results obtained from the nearby Tanami region and elsewhere in Australia.
1. INTRODUCTION
The Napperby region of the Northern Territory is highly prospective for U mineralisation. The region hosts U–rich bedrock that may include primary mineralisation (e.g. Nolans Bore) as well as act as being a source for secondary mineralisation. Furthermore, extensive and well preserved Cainozoic palaeodrainage systems provide both transport conduits as well as chemical and physical ‘traps’ for secondary mineralisation. A challenge for exploration in the area however, is the widespread transported regolith that may conceal underlying mineralisation. Previously characterisation of the secondary mineralisation in palaeodrainage systems also suggests that it is quite heterogeneous and therefore difficult to confidently represent or characterise. Techniques are therefore needed that can efficiently and effectively ‘explore’ through and within the transported cover of the region. This study provides an orientation assessment of phyto-exploration (plant biogeochemistry) techniques in this region.

Recent research breakthroughs by regolith geoscientists at the University of Adelaide have refined the application of biogeochemical methods for surficial exploration through transported cover (eg Hill & Hill, 2003; Hill, 2004; Reid et al., in press). A range of plant species and termites (and their termitaria) has been shown to have great potential for applications in biogeochemical exploration programs in regions such as the Tanami, Curnamona Province, Thomson Orogen and Gawler Craton. In particular, many of the outcomes from the research in the Tanami may have further implications for mineral exploration programs in the Napperby region, where there are similar regolith-landform setting and plant species. This project proposes to characterise and evaluate the phyto-exploration potential for a range of common and widespread plant species in the Napperby region. The main focus of sampling was to target plants along three main transects that cross the surface projection of mineralisation and the flanking unmineralised areas. This report provides an account of fieldwork and sample collection and preparation that was conducted over a 2.5 day period.

2. PREVIOUS WORK
Phyto-exploration programs from the region have not been previously reported or published. Recently a phyto-exploration trial is believed to have been undertaken in the Nolans Bore area by Arafura Resources, and particularly targeted desert bloodwood (Corymbia opaca) and mulga (Acacia aneura), which are abundant in that area. Initial results are thought to have been encouraging enough for Arafura Resources to have now undertaken follow-up sampling transects across the Nolans Bore prospect area. A regional phyto-exploration program has also been undertaken in the region by Nupower Resources, mostly to the north of the Napperby Prospect.

An earlier phyto-exploration study was also undertaken in the Lander River valley immediately to the north of this regional study area. The Lander River study was focussed on Au-exploration implications as part of Tanami Gold’s tenement holdings in that area. That program sampled spinifex (Triodia pungens), mulga (Acacia aneura), and river red gums (Eucalyptus camaldulensis), although the program returned encouraging results, this
exploration approach was not further adopted, mainly because of changes in staffing and exploration focus by Tanami Gold.

A geomorphology-landscape evolution study of the Lake Lewis Basin by English (2005) refers to the palaeodrainage system that this study is focussed on as the “Day Creek palaeochannel”. As the palaeodrainage feature contains channel facies as well as overbank and later induration modification the more general term “Day Creek palaeodrainage system” is used here.

3. SAMPLING SITES
Plant sampling was primarily focussed on three transects crossing part of the Day Creek Palaeodrainage system. Access to the site is along the Tanami Track, approximately 12 km south-east of Tilmouth Well Roadhouse. Full sample coordinates are given in the Microsoft Excel spreadsheet of Appendix 1, only a brief outline is given here.

**Transect 1 (‘Pit transect’)**
This transect approximates easting 0258800 mE, for approximately 1684 m, between 7465804 mN and 7464120 mN. It crosses near the deep pit at 258823 mE – 7464461 mN. The northern end of this transect contains a sparse woodland of *Eucalyptus victrix* trees with *Melaleuca glomerata* shrubs and *Triodia pungens* hummock-grasses. This part of the transect hosts ephemeral flooding associated with the main conduit of surface flow. The central parts of this transect are dominated by *Eucalyptus gamophylla* shrubland with thickets of *Acacia kempeana*. These areas are dominated by sheetflow landscape processes and have a pedogenically modified (nodular) groundwater carbonate less than 1 m below the landsurface. The southern end of the transect is dominantly an acacia woodland-shrubland with *Acacia aneura* thickets and *Acacia kempeana* shrubs. This area is dominated by ‘hummocky’ groundwater carbonate exposures, with local topographic depressions corresponding to local groundwater recharge zones and are typically colonised by thickets of larger trees such as *Acacia aneura* and *Corymbia opaca*. Sampling is at 50-100 m spacing at either end of the transect and is <50 m in the central part, with a particular focus on *Eucalyptus gamophylla* shrubs. Recent drilling by Toro Energy has been completed in the area of this transect and will provide a framework to compare the plant biogeochemistry assays.

**Transect 2 (‘Compound Transect’)**
This transect approximates easting 0259800 mE for approximately 1277 m, between 7465684 mN and 7464407 mN. It passes close to the equipment compound constructed for the current exploration program in the area. The northern end of this transect is within an open *Eucalyptus gamophylla* and *Melaleuca glomerata* shrubland with a *Triodia pungens* hummock-grassland understorey. These areas are dominated by sheetflow landscape processes with a pedogenically modified (nodular) groundwater carbonate less than 1 m below the landsurface. The southern part of this transect is dominantly an acacia woodland-shrubland with *Acacia aneura* thickets and *Acacia kempeana* and *Acacia victoriae* shrubs. This area is dominated by ‘hummocky’ groundwater carbonate exposures, with local topographic
depressions corresponding to local groundwater recharge zones and are typically colonised by thickets of larger trees such as *Acacia aneura* and *Corymbia opaca*. The area of this transect is proposed for upcoming drilling by Toro Energy, and the timing of this should closely correspond with the availability of the plant biogeochemistry assay results.

**Transect 3 (‘Cross-line Transect’)**

This transect approximates easting 262900 mE, for approximately 2753 m, between 7468036 mN and 7465283 mN. It generally follows and old drill line track that crosses the palaeodrainage system. The northern end of this transect is within an open acacia woodland with thickets of *Acacia aneura*. This area contains calcareous soils, likely to be associated with an underlying regolith carbonate. The main central part of this transect passes through an open *Eucalyptus victrix* woodland with *Melaleuca glomerata* shrubs and *Triodia pungens* hummock-grassland understorey. The *Eucalyptus victrix* woodland becomes more dense towards the south, corresponding to the lowest part of the transect and therefore the part most likely to be ephemerally flooded. The southern part of this transect is dominantly an acacia woodland-shrubland with *Acacia aneura* thickets and *Acacia kempeana* and *Acacia victoriae* shrubs. This area is dominated by ‘hummocky’ rises of groundwater carbonate exposures, with numerous local topographic depressions (‘sinkholes’) corresponding to local groundwater recharge zones and are typically colonised by thickets of larger trees such as *Acacia aneura*, *Corymbia opaca* and *Corymbia aparrerinja*. Presently there is not a proposed drilling program for the area of this transect, with only historical drilling providing a very broad framework. The results from this transect will therefore approximate samples obtained from an unknown exploration field.

**Pit samples**

Individual plants were sampled from near the walls of the deep pit at GDA 0258823 mE – 7464461 mN. In these cases the pit exposes the vertical extent of root systems that extend vertically downwards at least 4 m to the groundwater. The assay results from these plants can potentially be constrained and compared with the subsurface regolith and groundwater in these cases.

The area of this pit also seems to closely correspond with major transitions in the previous exploration drilling results. From the pit eastwards and north-eastwards subsurface samples to be more enriched in U than sites to the west and south-west. This therefore provides an ideal setting to assess the lateral heterogeneity of mineralisation and compare this with lateral heterogeneity within adjacent plant samples. A population of adjacent *Eucalyptus gamophylla* trees extending for over 100 metres from the pit were sampled to characterise and assess the potential for this heterogeneity.
4. SAMPLE SPECIES

This section provides a brief description of the species sampled as well as notes on their distribution and ease of sampling in the study area. The nomenclature and descriptions mainly follow Moore (2005).

**Mulga** (*Acacia aneura*): 11 samples

Small upright tree up to 14 m tall, but also forms bushy shrubs 3-5 m tall. Variety of shapes including upright branches, ‘Christmas tree’ shape (*Acacia aneura var. conifera*). Grey-green phyllodes, mostly narrow-linear, but can be broader, 3-11 cm long x 0.7-3 mm wide, with parallel veins. Yellow, cylindrical flower spikes, 8-25 mm long, usually after significant rain. Papery to woody, brown seed pods, 1-6 cm long and 0.4 – 2 cm wide. Variable intergrading and hybridising forms, including at least 10 varieties of *A. aneura*.

Mulga is the most abundant and widespread tree in the region, particularly on sheetwash plains. It is estimated to be 100-200 years old at maturity. Phyllodes are generally easy to sample and detach from twigs relatively easily, although in areas of increased grazing some trees without low branches can be difficult to reach.

**Witchetty bush** (*Acacia kempeana*): 11 samples

Rounded shrub or multi-stemmed tree to 4 m high. Phyllodes are narrow elliptic up to 8 cm long and 15 mm wide with a rounded tip. Flower spikes are dense golden 20 mm long. Pods are oblong, short and broad, flat, thin and papery.

Widespread and abundant in thickets in areas with calcareous regolith. Low branches make phyllodes easy to reach and they are reasonably easy to remove from stems.

**Umbrella bush** (*Acacia ligulata*): 2 samples

Bushy shrub to small tree, typically branching from near ground level. Linear-oblong phyllodes 30-80 x 4-14 mm and prominent yellow mid-vein. Globular flowers are deep golden. Pods are linear, thick and woody.

Widespread in areas of sandy and calcareous regolith, although not locally abundant. Examples from near the deep pit show roots penetrating at least 4 m to access the groundwater.

Phyllodes are reasonably easy to access and remove from stalks.

**Prickly wattle** (*Acacia victoriae*): 2 samples

Tall, dense, multi-branched shrub, 2-5 m tall. Phyllodes are grey-green (can be variably glaucous), broad linear, 2-5 cm long and 3-7 mm wide, rounded at the end and may have a short, stiff point with one central vein. Globular flower heads, pale-cream to yellow, 5-6 mm wide, typically with 15-30 flowers per head. Seed pods are broad, flat, 4-7.5 cm long and 6-13 mm wide, straight, with rounded seeds. Fast growing and fairly short-lived (Moore, 2005).

The prickly wattle is a widespread small trees – large bush, where it mostly grows on ephemerally flooded areas with calcareous regolith. It has a large tap-root that penetrates the regolith for depths of at least 3 metres (observed in pit sections), and it is generally short-lived (10-15 years).

Although samples are generally easy to access, the spiny branches can make sampling very uncomfortable. Sampling by closing fingers around stems and running fingers down the stem avoids most prickles, although can tear sampling gloves.

**Ghost gum** (*Corymbia aparrerinja*): 1 sample
Tree to 18 m with pendulous bright green foliage and distinctive white, smooth, powdery bark. Narrow lanceolate, bright, glossy green leaves and obscure veins. Cream flowers in short dense clusters, and fruit are thin walled and taper to a short thick stalk.
Widespread and locally abundant along drainage channels. May co-exist and hybridise with river red gums.
Leaves are very easily removed from stems and are easy to handle after sampling. The lack of lower branches can limit sampling availability.

**Desert Bloodwood** (*Corymbia opaca*; formerly *Eucalyptus terminalis*): 6 samples
Tree to 15 m, brown, tessellated bark, flaking to orange-brown underneath and extending to branches, although upper branches may be smooth cream. Distinctive urn-shaped fruit, 16-29 x 12-19 mm long. Leaves dull green, 9-17 cm x 10-35 mm. White flowers in terminal clusters of 7. Buds ovoid, pale brown.
This species is widespread on the alluvial plains, particularly in the upper reaches of the catchments in the study area (e.g. Nolans Bore). Its leaves are very easily removed from stems and large waxy leaves provide a clean and large sampling medium.

**Blue mallee** (*Eucalyptus gamophylla*): 4 samples
Mallee to 6 m high with rough fibrous bark peeling to smooth waxy white or grey on upper limbs. Leaves are opposite and joined at base, dull blue-grey, rounded or tapering to pointed tip. Cream flowers in clusters of 3-7, with rounded bud cap. Fruit is glaucous.
Although this tree was limited in distribution at the sampling bores it is locally abundant in the middle to lower reaches of alluvial systems in the region, particularly on aeolian sandplains and areas with subsurface regolith carbonate.
The leaves are extremely easy to strip from stems and the glaucous nature tends to ensure they are clean of detrital inputs. Their blue-grey colour makes them distinctive and easy to locate in the field.

**Smooth-barked coolibah** (*Eucalyptus victrix*): 19 samples
Spreading tree to 18 m tall with smooth white bark and typically with patches of flakey rough bark at trunk base. Leaves are lanceolate, dull green, 6-18 cm x 8-36 mm. Flowers are white with small buds with conical caps. Fruit is typically thin walled with slightly protruding valves.
Widespread and locally abundant on low-lying alluvial and sheetflow plains prone to frequent ephemeral flooding.
Its large waxy clean leaves are easily sampled and stored. Most trees have low branches and shoots although some individuals lack low branches that can restrict sample availability.

**Corkwood** (*Hakea lorea*): 1 sample
Small scraggly tree, 2-9 m tall, with rough, grooved, dark-brown or grey bark. Leaves are cylindrical, 21-40 cm long and 2-3 mm wide. Fruit are hard, narrow nuts.
This species is widespread but tends not to be locally abundant, where it mostly occurs as individuals on alluvial and sheetflow plains.
Its long leaves are reasonably easy to remove from stems and typically require folding over to fit into sample bags. Its corky bark and long leaves make it easy to identify, and although it may be similar in appearance to beefwood (*Grevillea striata*) from a distance, the later tree has flattened leaves with prominent longitudinal ridges.

**Desert Honey Myrtle** or **Inland Tea-tree** (*Melaleuca glomerata*)
Small to large bushy shrub to multi-stemmed tree with white papery bark. Branchlets and new leaves finely hairy. Grey, linear, finely pointed, alternate, hairy and soft leaves 15-50 x 1.5-2.5 mm. Cream to yellow flowers in rounded heads about 15 mm diameter at the end of short stalks. Fruit capsules about 2 mm across in dense clusters wrapped around stems. Clayey, saline areas with shallow groundwater and ephemeral flooding. The low bushy braches are typically easy to reach for sampling, however leaves can be difficult to remove from stems while on the tree. These separate better once the sample has been dried.

**Soft Spinifex** (*Triodia pungens*): 41 samples
Densely tufted hummock-grass that exudes sticky resin from the stems and leaves. Tussocks are 0.30-1 m high and 0.3 – 1.5 m diameter. Leaf blades may be flat or flexuous over 30 cm long and 0.8-1.2 mm diameter. Prominent stalked seeds up to 1.3 m tall. Long-lived plant of 10s to 100s years. Widespread across the area except for areas with calcareous regolith. Deep pits show vertical root penetration at least 4 m to the groundwater. Can be quite difficult to sample leaves partly due to spikey leaf tips, resinous leaf bases and the tendency for the entire grass shoot to detach from the plant when leaves are pulled upwards. Its widespread and abundant distribution as well as its proven deep vertical root penetration however, make this an appealing plant to sample, despite the discomfort.
5. METHODS

Sampling Program
Samples were taken as part of a wide-spaced regional program targeting water bores. Target species were widespread and abundant in the study area. Leaves (or phyllodes for acacias) were the target sample organ for all species, and mature healthy leaves were preferentially chosen.

Plant Sampling
The sample location was first recorded (GPS coordinates using GDA), and then the type and description of plant, and very brief regolith-landform site information. Photographs were taken of each of the sample trees (Appendix 2). Sites with greater chances of environmental contamination were avoided, with dusty vehicle tracks and sites of increased stock movement avoided where possible (although this was difficult do to the targeting of bores used for stock watering).

Unbleached paper bags were labelled with sample numbers (e.g. brown paper lunch bags). These bags minimise sample sweating and decomposition and minimise further contamination to the sample. The opening of these bags were folded over once the sample has been collected (avoiding use of metal fasteners for the bags, such as staples or pins, because these can be a source of metal contamination). Hands were clean and with any jewellery removed and covered with powder-free nitrile gloves for each sample. This minimises contamination while sampling. Samples were taken from a uniform height (typically between waist and head height) and from around the plant canopy. Several hundred grams (which usually comes to about half to three quarters a bag full) of sample was taken from each plant.

Sample Storage and Preparation
Sample decomposition and contamination were minimised during storage. A sheltered well-ventilated cardboard box was used, with the samples laid out on tables in the hotel room each night during the field sampling program. Samples may needed rotation during short-term storage to avoid irregular sweating and decomposition. Samples were then over-night freighted to the University of Adelaide for low temperature, clean oven drying, which desiccated and stabilised the samples. An oven temperature of <60°C for approximately 48 hours was used. Higher oven temperatures may volatilise some important chemical components from your samples. Once thoroughly dried, the samples were milled.

The sample milling was performed with a rotating blade, stainless steel mill, using the following procedure:

- Thoroughly clean mill using a combination of high purity ethanol, paper towel and compressed air. It is important to use the same degree of care to reduce contamination in the laboratory as was used in the field (e.g. wear powder-free latex or nitrile gloves);
- Pre-contaminate the mill with a small amount of the sample to be prepared. Use a short milling time and discard this preliminary material before adding the main part of the sample;
• Once the sample is milled to a fine powder (typically approaching a consistency approaching that of talcum-powder) then this can be removed from mill and stored in a labelled, snap-seal plastic bag; and,
• Re-clean mill.

Samples were then placed in labelled snap-seal plastic bags, ready for shipment to the analytical laboratory. Larger samples were split to allow for sample duplicates for analytical quality control – quality assurance purposes.

6. FURTHER WORK
The following is a proposed work plan for this orientation study:
• October 2007: collect samples for analysis. Prepare field completion report. Commence sample preparation for analysis
• Early November 2007: final sample preparation and submit samples to be submitted for analysis by Toro Energy
• December 2007: analytical results received
• January 2008; data interpretation

7. CONCLUSIONS
This report provides an account of the field sampling and sample preparation for analysis performed as part of a phyto-exploration orientation program in the Day Creek palaeodrainage system, Napperby region, Northern Territory. Widespread and common plant species were sampled along 3 transects across parts of the palaeodrainage system. The lack of recent rain and therefore the formation of dry surface soils are encouragement that the assay results for these plants will provide a biogeochemical expression obtained from groundwaters rather than surface soils.

8. REFERENCES
Reid, N., Hill, S.M. & Lewis, D., in press. Spinifex biogeochemical expressions of buried gold mineralisation: the great penetrator of transported regolith. Applied Geochemistry

APPENDIX 1: Excel spreadsheet of plant samples collected in this study