BIOGEOCHEMICAL EXPRESSION OF GOLD IN NATIVE TREE LEAVES AT WYOMING AND TOMINGLEY, NSW

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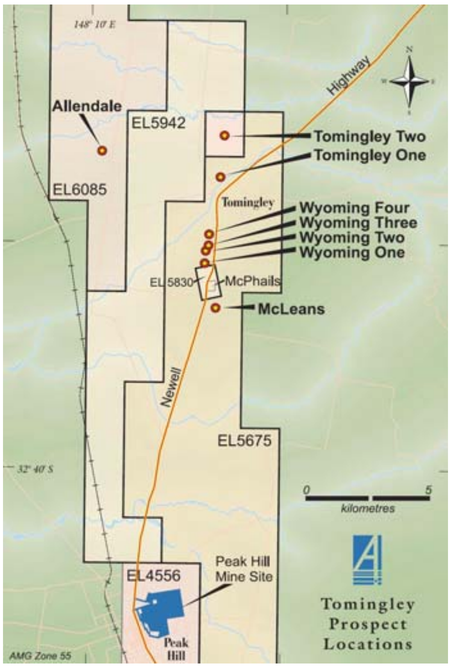

Figure 1: Location of the Wyoming and Tomingley Au deposits near Peak Hill in central NSW. From Alkane WWW site (http://www.alkane.com.au/).

INTRODUCTION

The Wyoming and Tomingley Au deposits are located ca. 15 km north of Peak Hill in central NSW (Figure 1). Alkane Exploration Ltd., following up on work by Sipa Resources, discovered the new deposits by drilling along strike from known deposits in 2001-02. Mineralisation is associated with feldspar porphyry intruding andesitic Goonumbla Volcanics, all of Ordovician age (Sherwin 1996). Gold is present in a series of roughly N-S oriented sheeted quartz veins and a roughly E-W oriented dilational fracture zone cutting through the sheeted veins (Alkane 2004, Rimas Kairatis, Alkane Exploration Ltd. *pers. comm.* 2005). The primary mineralisation at Wyoming 1 consists of visible and disseminated Au in quartz-pyrite-arsenopyrite veins with no other sulphides reported (Chalmers *et al.* 2003). The resource at Wyoming 1 currently stands at ca. 500,000 ounces of Au and many more hundreds of thousands of ounces are located in the other deposits along strike (Alkane 2004). The site is buried by variable-thickness transported regolith comprising clay-rich, sand-rich and maghemite-rich palaeochannel and flood plain deposits up to ca. 60 m thick (Chalmers *et al.* 2003, Bamford 2004). More detail on the geology, regolith, climate and discovery of the site is given in Cruikshank *et al.* (1999), Alkane (2003), Chalmers *et al.* (2003, 2004), Scott *et al.* (2003), Alkane (2004), Bamford (2004), Bamford *et al.* (2004) and Roach (2004).

This paper describes the early results of an investigation into the biogeochemical expression of buried Au mineralisation in the Wyoming area. Initial reconnaissance sampling by Roach (2004) was followed up by two new traverses: a detailed leaf, twig, bark, litter and soil sampling traverse across the Wyoming 1 deposit; and a leaf-only sampling traverse across inferred mineralisation at Tomingley. Results presented here include a generalised regolith-landform map of the area, leaf biogeochemistry results for both traverses across the area, results of aspect surveys of the three main remnant native tree species present over the two deposits and washing tests of leaf samples.

DOMINANT TREE SPECIES

The Wyoming-Tomingley area contains remnant native woodland limited to roadsides, shelterbelts along fencelines, random shade trees within paddocks, hilly terrain and areas of well-developed gilgai. Common species growing along the two traverses include Grey Box (*Eucalyptus microcarpa*), White Cypress Pine (*Callitris glaucophylla*—renamed from *columellaris*; Moore 2005) and Buloke (*Casuarina luehmannii*). Less common tree species include Yellow Box (*Eucalyptus melliodora*), Drooping Sheoak (*Casuarina stricta*), Rosewood (*Alectryon oleifolium*) and Weeping Pittosporum (*Pittosporum phyllyreoides*) (Costermans 1981).

SAMPLE COLLECTION AND PREPARATION

Samples were collected over a three day period in January 2005. In the Wyoming 1 traverse, leaf, twig, bark, litter and soil samples were collected from mature examples of the three main species (*E. microcarpa*, *Cas. luehmannii*, *Call. glaucophylla*) within a 20-30 m locus of the nominal sample site. Sites were spaced at approximately 100 m intervals of the Australian Map Grid measured by GPS. In the Tomingley traverse, only leaf samples were collected from the three main species. A number of sites hosted only one or two of the three main sampling species within the locus, so some samples were forfeited. However, enough of the three species were collected over each traverse to allow significant overlap. The location of each tree was also measured by GPS.

Sample collection and preparation procedures were similar to those of Hill (2002). At each site clean powder-free latex gloves were donned and the samples were collected proceeding from the cleanest (leaves) to dirtiest (soil) and placed into food-grade brown paper bags. Leaf samples were collected uniformly from around the circumference of the *Casuarina* and *Callitris* trees (which are quite low-growing). Samples from the much taller *Eucalyptus* were often limited to what we could physically reach with a teflon-coated 2 m extension pruner while standing on the rear gate of the 4WD vehicle. Bark samples were collected uniformly from around the circumference of all trees. Litter samples were collected from within 1-2 m of the trunks of all trees by scraping together fallen materials but not soil. Soil samples were collected from a site not more than 1 m from the trunk of each tree after scraping off the top layer of humus and taking the top 10 cm of soil. Analysis of twig, bark, litter and soil samples is ongoing and is not reported here.

Samples were dried and prepared according to the method described in Roach (2004) after Hill (2002). Alliquots of each sample were divided for Instrumental Neutron Activation Analysis (INAA) analysis at Becquerel Laboratories Inc., Ontario, Canada, and X-Ray Fluorescence (XRF) and Inductively-Coupled Plasma-Mass Spectrometry (ICP-MS) analysis at Geoscience Australia. A suite of elements, some complementary, was determined by each method: INAA - Sb, As, Ba, Br, Cd, Ce, Cr, Co, Au, Ir, Fe, La, Mo, Ni, Rb, Sm, Sc, Se, Ag, Na, Ta, Th, W, U, Zn; ICP-MS – As, Be, Bi, Cd, Ce, Cs, Dy, Er, Eu, Ga, Gd, Ge, Hf, Ho, La, Lu, Mo, Nb, Nd, Pr, Sb, Ag, Sm, Ta, Tb, Sn, Th, U, Y, Yb; XRF - Al, Ba, Ca, Cl, Cu, Fe, Pb, Mg, Mn, Na, Ni, P, K, Rb, S, Si, Sr, Zn, Zr.

REGOLITH-LANDFORM MAP

The regolith-landform map of the Wyoming-Tomingley area (Figure 2) was prepared from a 1:50,000 scale colour aerial photograph provided by the NSW Land and Property Information service. The map describes largely transported regolith materials on low relief topography. Transported regolith materials consist of clay- to silt-sized red-brown soils in the main part and clay- to fine sand-sized grey-coloured soils in the northwestern part. Soils in the south are derived from weathering of Ordovician Goonumbla Volcanics, Mungincoble chert, Ordovician-Silurian Cotton Formation, Silurian Mumbidgle Formation and Devonian Harvey Group rocks (Sherwin 1996). These have generated iron-rich fine to medium-grained sediments with coarse subangular lithic gravel interbeds. There may also be a significant aeolian component given the colour and texture of these soils. Soils in the northwest are derived from granitoids of the Yeoval Batholith to the east of the study area. Surface weathering products are distributed as channel, overbank and floodplain deposits, all transported roughly east to west in line with present topography. Well-developed gilgai are a prominent feature of the mapping area. Gilgai pits are filled with black-coloured clay-rich sediments whereas the rises are generally coarser-grained and reflect the local sediment source. Sediment provenance is easily recognisable in the radiometrics image of the Northparkes Geoscience Data Set of the NSW Department of Mineral Resources' Discovery 2000 program. *In situ* regolith in the eastern side of the mapping area consists of the previously listed rocks in erosional rises weathered to red, yellow and white hues

Landforms are generally of very low relief except for the weathered bedrock rises in the east of the mapping area. Total relief in the mapping area (Figure 2) is no more than 40 m and elevations vary from ca. 260 m ASL in the west to ca. 300 m ASL in the east.

LEAF BIOGEOCHEMICAL RESULTS

Leaf biogeochemical results for the Wyoming and Tomingley traverses are encouraging for use in detecting Wyoming-style Au deposits.

Anomalies

A suite of element concentrations is anomalous (i.e., > 2 times background) in all three tree species, but are commonly species-dependant. Elements showing anomalies across all species include Au, Ag, As and Ba. Significant element-species associations for the two deposits are listed in Table 1.

Table 1: Element-species associations over the Wyoming 1 and Tomingley biogeochemical traverses. W = Wyoming 1, T = Tomingley. "←" indicates westward dispersion of the anomaly.

	Eucalyptus		Callitris		Casuarina	
	Strong Assoc	**Weak Assoc**	**Strong Assoc**	**Weak Assoc**	**Strong Assoc**	**Weak Assoc**
Ag	T	W, T	W	W		W, T
As				T	W	T
Au	W, T		W, T		W, T	
Ba	W	T	W	T	W, T	
Co		W ←	T	W ←		W ←
Cr			W			W ←, T
Cu		W		T ←		W ←, T
Fe				W ← , T		T
Ga				T		W, T
Mn			W ←	T	T	W ←
Mo				W←		T
Nb				T		W←, T
Ni		W, T		W ←, T		W ←, T
REE		W ←, T ←		W←, T ←		W←, T ←
Sb				W, T		
W		W		W, T	W	
Zn		W, T		W ←, T	W ←	T

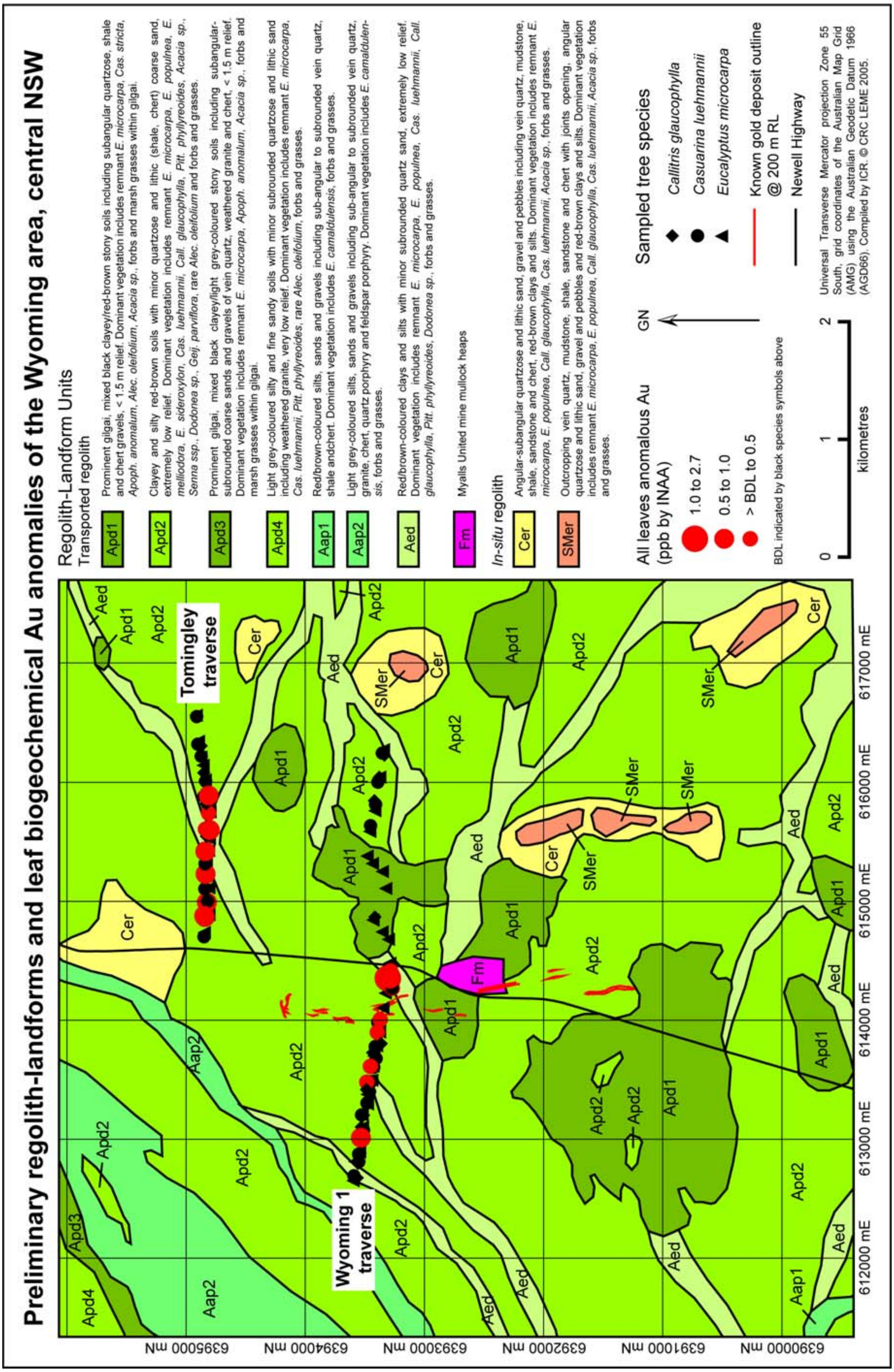

Figure 2: regolith-landform map of the Wyoming-Tomingley area with sample sites and leaf Au results.

Pathfinder element anomalies are diffuse or peaked depending on the element and on the tree species (e.g., Au and As; Figure 3). There is also some dispersion westwards from both deposits. Overall, the *Callitris glaucophylla* gave the largest and most consistent responses to the greatest range of pathfinder elements (Table 2). Gold and As INAA results for the three species are shown in Figure 3 for example. Mineral (dust) contamination was noted in several samples, manifested as elevated common rock-forming elements such as Si, Fe, Al, Ca and Mg. There may also be a fertiliser contamination problem on the Wyoming 1 traverse as the plant nutrients P and K are elevated towards the west of the traverse.

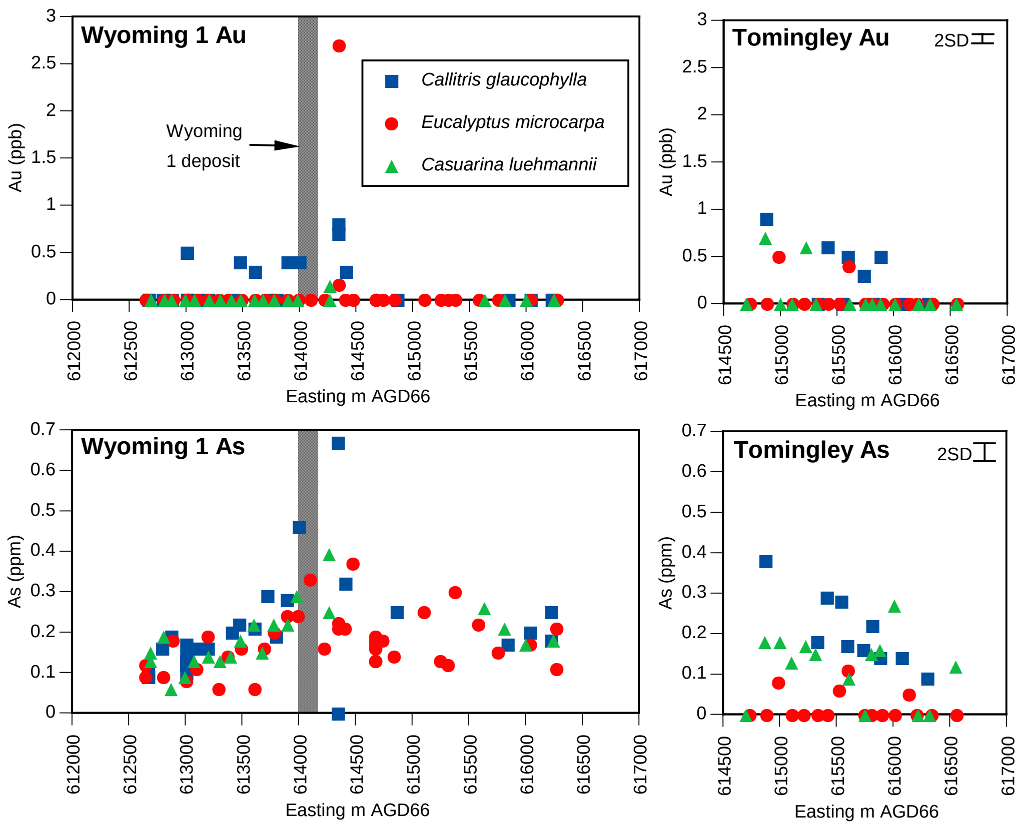

Figure 3: Gold and As distribution amongst the sampled species over the Wyoming 1 and Tomingley biogeochemical traverses. Gold tends to give a peaked anomaly dispersed westwards, whereas the As anomaly rises gently to a peak but is diffuse, particularly over Wyoming 1. Refer to Figure 2 for traverse locations. Uncertainties (2SD) are calculated using the method described under Table 2 (below).

Table 2: Minimum and maximum concentrations of target and pathfinder elements in the three major species for the Wyoming 1 and Tomingley traverses.

	Au* (ppb INAA)	Ag (ppm ICP-MS)	As (ppm INAA)	Ba (ppm INAA)	Zn (ppm XRF)
Callitris glaucophylla	BDL-0.9	BDL-0.5	0.1-0.68	BDL-100	12-36
Eucalyptus microcarpa	BDL-2.7	BDL-0.28	BDL-0.27	BDL-150	9-37
Casuarina luehmannii	BDL-0.7	BDL-.036	BDL-0.39	BDL-19	4-22
% uncertainty	15.38	85.29	18.75	7.62	5.15
2SD	0.11	0.19	0.05	3.88	0.82

% uncertainty and 2SD derived from 6 repeat samples of *Eucalyptus microcarpa*. * % uncertainty and 2SD calculated from 5 repeats of *Callitris glaucophylla*. % uncertainty calculated as (maximum – mean)/mean*100.

WASHING STUDY

Samples were not washed during the initial sampling because recent rain in the area was assumed to have washed the trees clean of most airborne dust contamination. However, reverse-circulation (RC) and diamond drilling has visibly contaminated the surface with drill spoil and unwanted RC samples have been dumped in a pit near the deposit. As a test for possible dust contamination, leaf samples from the three main tree species (*E. microcarpa*, *Cas. luehmannii*, *Call. glaucophylla*) over the Wyoming 1 deposit and from each end of the Wyoming 1 traverse were split for washing tests. Splits were placed into new, twice-rinsed, 500 mL Nilcra bottles, topped off with ultrapure water and agitated for 10 minutes in an ultrasonic bath. Wet samples were then drained and dried and processed according to the established protocol. The wash water was filtered through a 0.4 µm vacuum filter and waters and filter papers were kept for further analysis (not reported here). Washed and unwashed samples were then submitted to Becquerel, Ontario, for INAA analysis. Results (Table 3) were variable. In some cases the metal concentration was always reduced by washing (Br, Na), in others the metal was generally reduced (As, Ba, Ce, Fe, Sc, Sm, Zn), in a third case the metal concentration was variably altered (Au, Co, Cr, Rb, Th) and in the fourth case there was little or no change in metal concentration or results remained below detection (Sb, Cd, Ir, La, Mo, Ni, Se, Ag, Ta, W, U).

Table 3: Comparison of unwashed and washed (in brackets) samples of the three main species in the Wyoming 1 traverse. Examples include elements from each category above, including Au pathfinder elements. Samples are taken from the western end, over the Wyoming 1 deposit (labelled "centre") and the eastern end of the traverse.

	As (ppm INAA)	Ba (ppm INAA)	Br (ppm INAA)	Ce (ppm INAA)	Au (ppb INAA)	Fe (ppm INAA)	Rb (ppm INAA)	Sm (ppm INAA)	Na (ppm INAA)	Zn (ppm INAA)
Callitris west	0.10(0.09)	BDL(BDL)	8.4(7.4)	0.9(0.5)	BDL(BDL)	330(220)	3(3)	0.08(0.05)	320(160)	17(17)
Callitris centre	0.93(0.67)	85(93)	11.0(10.0)	1.9(1.5)	0.8(0.8)	980(750)	3(2)	0.19(0.15)	990(800)	14(14)
Callitris east	0.18(0.25)	BDL(BDL)	20.0(11.0)	0.3(1.2)	BDL(BDL)	170(650)	BDL(3)	0.03(0.13)	1300(1000)	15(12)
Eucalypt west	0.12(0.09)	BDL(BDL)	27.2(25.5)	1.2(0.8)	BDL(BDL)	120(110)	4(5)	0.09(0.08)	180(130)	15(15)
Eucalypt centre	0.24(0.21)	200(140)	32.9(24.4)	0.5(0.4)	BDL(2.7)	200(230)	2(2)	0.05(0.05)	230(180)	14(12)
Eucalypt east	0.21(0.11)	33(20)	28.8(23.7)	0.6(0.4)	BDL(BDL)	130(BDL)	BDL(2)	0.05(0.03)	730(280)	17(13)
Casuarina west	0.13(0.15)	BDL(BDL)	23.8(24.0)	0.9(0.9)	BDL(BDL)	310(310)	2(2)	0.09(0.09)	1900(1800)	BDL(10)
Casuarina centre	0.35(0.25)	BDL(BDL)	21.4(14.0)	0.3(0.4)	BDL(BDL)	230(160)	2(2)	0.04(0.03)	2000(1900)	12(11)
Casuarina east	0.18(0.18)	BDL(BDL)	20.6(20.3)	0.6(0.5)	BDL(BDL)	240(240)	2(1)	0.05(0.05)	1300(1300)	17(17)
% uncertainty	18.75	7.62	2.83	16.67	15.38*	9.09	2.86	20.00	7.69	0.13
2SD	0.05	3.88	1.16	0.18	0.11*	19.66	0.82	0.01	16.73	0.08

% uncertainty and 2SD derived from 6 repeat samples of *Eucalyptus microcarpa*. * % uncertainty and 2SD calculated from 5 repeats of *Callitris glaucophylla*. % uncertainty calculated as (maximum – mean)/mean*100.

ASPECT STUDY

A detailed investigation of element uptake versus aspect was conducted as part of the broader study. The aspect study involved sampling one healthy example of each the three main species (*E. microcarpa*, *Cas. luehmannii*, *Call. glaucophylla*) growing directly above the Wyoming 1 deposit. Trees were sampled in octants (i.e., in 45° segments) using magnetic north as the baseline. Some of the results for Au pathfinders and essential plant nutrients are presented in Figure 4. Results indicate that essential nutrients (e.g., P) are distributed more-or-less evenly around the circumference of each tree species, but that non-essential metals (Au and As are shown) may be preferentially distributed according to aspect. Gold tended to be concentrated on the north side of the three samples whereas As tended to be concentrated on the south side. This tendency is repeated in many of the other non-essential metals. Results also indicate that the *Call. glaucophylla* is the best overall sampling medium for Au and Au pathfinders at Wyoming-Tomingley.

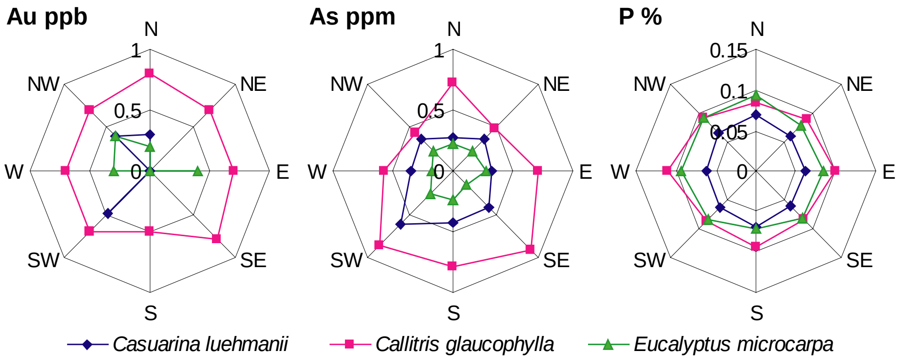

Figure 4: aspect study results of selected metals in the three main species sampled over the Wyoming 1 deposit. Uncertainty (2SD) of Au is 0.11 ppb, As 0.05 ppm and P 0.01 ppm.

CONCLUSIONS

Work to date has identified useful biogeochemical sampling media for Wyoming-style gold deposits in the NSW Central West and has also highlighted some of the exploration problems on the margins of the Eastern Highlands where moderate transported cover exists. Leaf biogeochemical results indicate that these deposits can be detected under several tens of metres of transported cover by using mature deep-rooted trees. However, Au results may not always be reliable where concentrations are low (e.g., < 0.5 ppb) or where detection limits of INAA are affected by interfering elements such as Na. Gold and pathfinder elements are detectable in all three of the main species growing over the deposit (*Callitris glaucophylla*, *Eucalyptus microcarpa* and *Casuarina luehmannii*), but *Callitris* produced the best overall results. Regolith thickness varies considerably at Wyoming and Tomingley because of incised palaeochannels hidden beneath the modern transported cover. Alkane's drilling program highlighted a maghemite-rich palaeochannel over the Wyoming 1 and 2 deposits (Figure 5). The Wyoming 1 traverse has a diffuse As anomaly which may be from As adsorbed to widely-dispersed maghemite in the palaeochannel, rather than to goethite-rich mottles in the lower transported regolith cover as was previously thought (Scott *et al.* 2003). In the Girilambone area Pahlow (1995) noted that *Callitris* needles had the strongest response to mineralisation and Cohen *et al.* (1996) indicated at Cobar that they had the least seasonal variability of species tested, and were resistant to dust contamination. Personal observation indicates that the *Callitris* evolve the most dust of the three species selected at Wyoming and Tomingley. The washing test showed that results vary widely once water is introduced; some elements are dissolved and removed, others are enhanced. The need for washing should therefore probably be restricted to "brownfields" regions where there is known contamination from mining. The aspect study showed that Au is best sampled from the north side of species that are difficult to work with, i.e., those that are very tall and hard to sample uniformly (the Eucalypts).

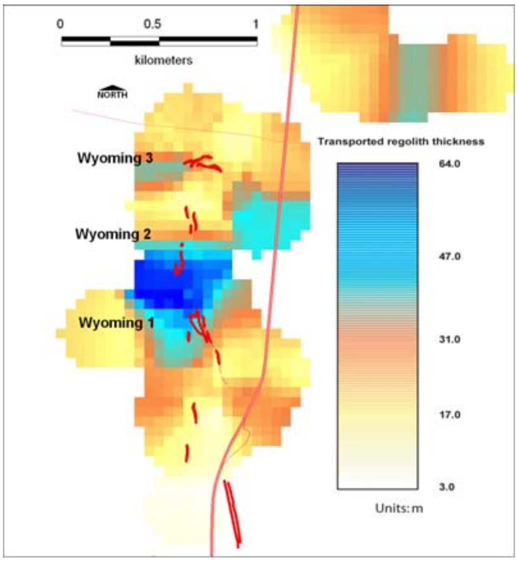

Figure 5: transported regolith thickness over the Wyoming deposits. Regolith thickness derived from Alkane drill hole logs. Map by ICR after Bamford (2004).

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