BIOGEOCHEMISTRY OF THE BULONG NICKEL-COBALT LATERITE DEPOSIT, WESTERN AUSTRALIA

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INTRODUCTION

Biogeochemistry is increasingly being employed in exploration surveys in Australia and it is also important in mine site rehabilitation especially with regards to plants that are metal-tolerant. Biogeochemistry is used in this study to investigate ore bodies within the deep weathering profile developed over an ultramafic lithology. The advantage that biogeochemistry has over soil sampling is an ability of the roots to sample material from greater depths and a wider area through the plant root system. Other advantages of biogeochemical exploration are low cost sample collection over large survey areas, less time consumed for the sampling program and low environmental impact (Kovalevsky, 1987). A pilot biogeochemical survey was carried out in Western Australia by Cole (1973) targeting nickel and its relationship to local plant species in Western Australia. However, most work has focused on gold (e.g. Lintern et al., 1997; Arne et al., 2001; Anand et al., 2005).

AIMS

Vegetation sampling within two areas of known Ni-Co mineralization was undertaken to investigate which plant species, tissue type and analytical methods could be used to detect the target and associated elements (Ni, Co, Cu, Cr, Fe), as well as to assess the suitability of biogeochemical techniques as an exploration tool.

THE STUDY AREA

Bulong Mine, operated by Preston Resources Ltd., is located 35 km east of Kalgoorlie, Western Australia. The Mount Magnetic ore body is located to the south of the Bulong Mine site and the Boulder Block ore body is located at Bulong itself (Figure 1). The Bulong Ni-Co deposit is hosted within a laterite weathering profile developed over the Bulong Complex ultramafic rock. This laterite profile comprises four zones; the oxidized bedrock zone, the saprolite zone, the clay zone and the limonite zone. High grade Ni is found in nontronite clay (Elias et al., 1981).

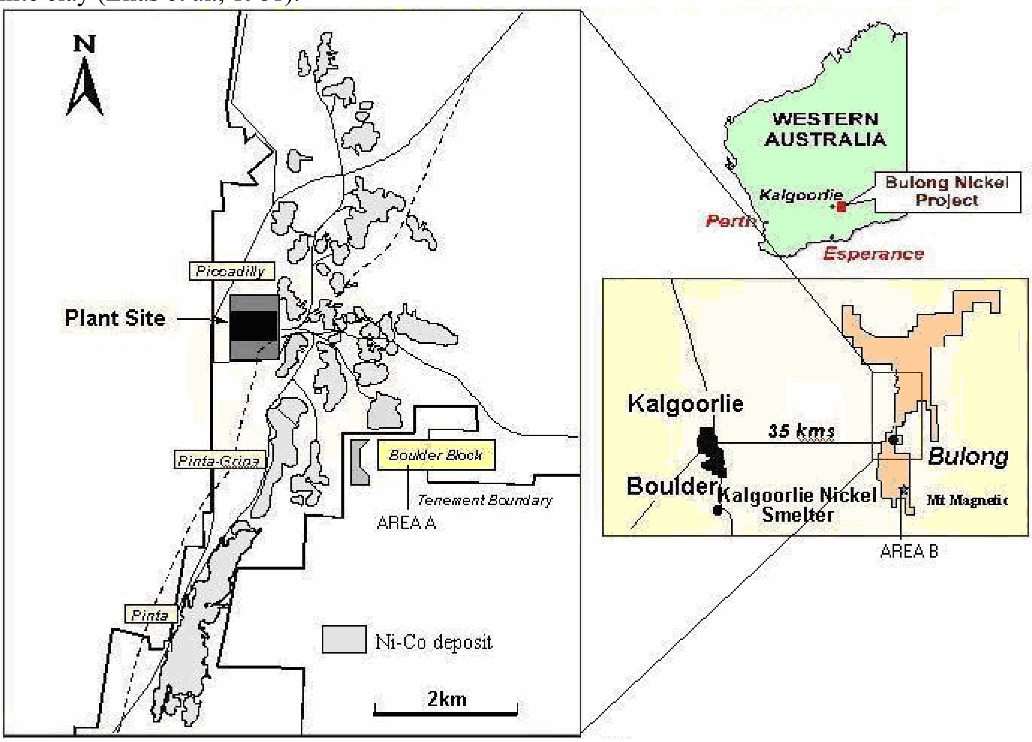

Figure 1. Location of study area: The Boulder Block (Area A) and Mt Magnetic deposit (Area B), Bulong Mine (Courtesy of Bulong Nickel Operations).

SAMPLING AND ANALYSIS

Both twigs and leaf samples were collected from twelve native species of open woodland shrubs and trees; Hybanthus floribundus, Eucalyptus striaticalyx, Alyxia buxifolia, Acacia brachystachya, Eucalyptus lesouefii (Blackbutt), Eucalyptus torquata (Coral gum), Eucalyptus salubris (Gimlet gum), Acacia collectioides, Acacia translucens (Poverty bush), Eremophila scorparia (Broom bush), Casuarina pauper (Sheoak) and Santalum spicatum (Sandalwood). They were collected in standard paper sample bags at intervals of approximately 40 metres along a single east-west transect over the Mount Magnetic Ni-Co laterite deposit, which was adjacent to a drill hole sequence.

All samples were oven dried in bags at 90 ^oC and then ashed at 450 ^oC for analysis by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following a 4 acid digestion (HCl, HNO_3, HF and $HClO_4$).

An initial study at the Boulder Block ore body was limited to four plant species (Hybanthus floribundus, Eucalyptus striaticalyx, Alyxia buxifolia and Acacia brachystachya), and to test three different analytical techniques: Instrumental Neutron Activate Analysis (INAA), Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) following a 2-acid digestion and ICP-OES following a 4-acid digestion.

RESULTS FROM THE BOULDER BLOCK

From the three techniques mentioned above, it was determined that ICP-OES, following a 4-acid digestion, was most effective at measuring Ni-Co and associated elements in vegetation (Table 1). Therefore, this technique was selected as a suitable analytical method for further study of the Mount Magnetic area.

Table 1: Comparison of Cr, Co and Fe concentrations in raw vegetation from Hybanthus floribundus between INAA, ICP-OES following 4-acid digestion and ICP-OES following 2-acid digestion techniques.

ELEMENTS	Cr	Cr *	Cr **	Co	Co *	Co **	Fe	Fe *	Fe **
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
SAMPLE (BNP)									
4144	7.5	8.6	0.06	78.50	45.23	0.48	480	540	4.2
4144a	4.7	4.1	0.04	46.90	82.66	0.72	295	330	2.99
4145	8.6	7.3	0.06	60.40	141.2	1.36	397	450	4.34
4146	14.7	9.3	0.08	26.80	79.38	0.71	559	580	4.74
4147	6.7	6.3	0.05	10.70	18.64	0.18	342	480	3.96
4148	8.0	7.1	0.05	19.60	20.25	0.2	440	530	4.3
4149	8.6	6.4	0.07	18.90	32.36	0.34	389	500	4.62
4150	13.3	10.4	0.08	17.90	29.28	0.29	535	490	4.5
4151	15.5	18.4	0.19	39.60	40.75	0.42	517	780	6.88
4168	9.3	5.9	0.05	15.80	22.14	0.24	470	400	3.92

Note: Cr = INAA, Cr* = ICP-OES following 4-acid digestion, Cr** = ICP-OES following 2-acid digestion

RESULTS FROM MOUNT MAGNETIC

A more extensive study at Mount Magnetic was aimed at investigating variations in the elemental uptake between plant species. Results revealed that Hybanthus floribundus contains both Ni and Co in much higher concentrations than adjacent soil samples (Figure 2). The more common and widespread Eucalyptus species and Casuarina pauper (Sheoak) also contained high concentrations of Ni (Figure 3). As these species are common and widespread, a biogeochemical survey of these plants has the potential to highlight Ni-Co mineralization in covered regions.

Alyxia buxifolia displays potential to uptake Cr and Cu over the Boulder Block deposit, whereas Acacia collectioides shows elevated Cr concentrations in the Mount Magnetic area. Santalum spicatum (Sandalwood) is widely distributed throughout the area and the only species found at every sampling location, however, it shows no elevated concentration of target elements and is therefore not suitable for biogeochemical prospecting. Of the other common shrubs studied, Eremophila scorparia (Broom bush), Acacia translucens (Poverty bush) and Acacia brachystachya, none appear to be effective in accumulating Ni or Co in the area (Figure 3).

Spearman Rank correlation coefficients indicate Ni displays a positive correlation with Co, although there is no relationship between elemental concentrations in plants and adjacent soil samples for either Ni or Co. Levels of both Ni and Co in soil correlate with Mn and Fe, suggesting Ni and Co are adsorbed onto Mn-oxides and scavenged by Fe-rich compounds in this area. For the plant samples, Fe also displayed a significant positive correlation with Cr and Cu. Results using INAA show significant positive correlations between Fe and Sc, Sc and Cr, La and Sm, and a negative correlation between Fe in soil and Au.

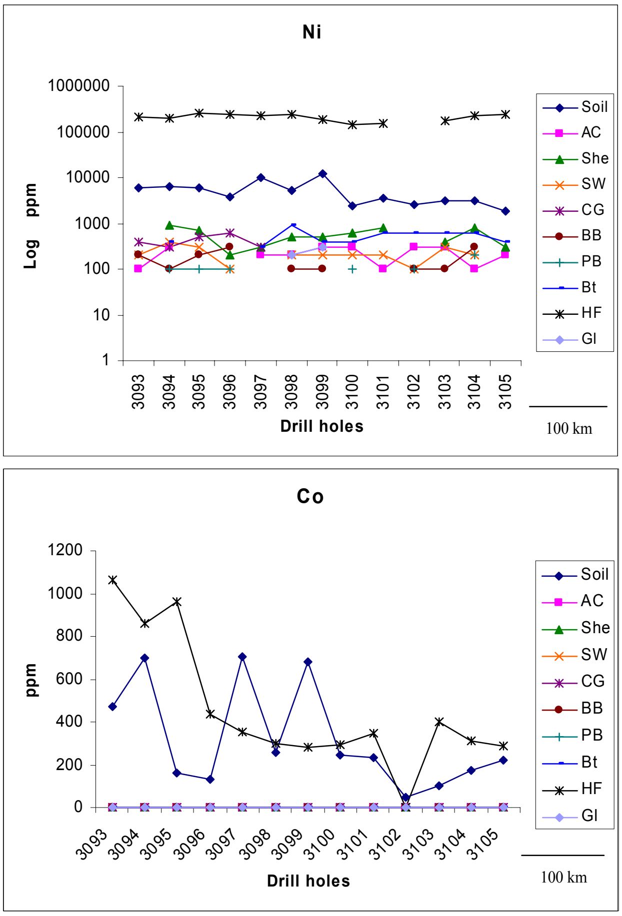

Figure 2. Element contents from biogeochemical data (ashed) and the shallowest regolith samples along the drill hole line (AC- Acacia collectioides, She-Casuarina pauper, SW-Santalum spicatum, Gl- Eucalyptus salubris, BB-Eremophila scoparia, PB-Acacia translucens, Bt-Eucalyptus lesouefii, HF- Hybanthus floribundus) and CG- Eucalyptus torquate.

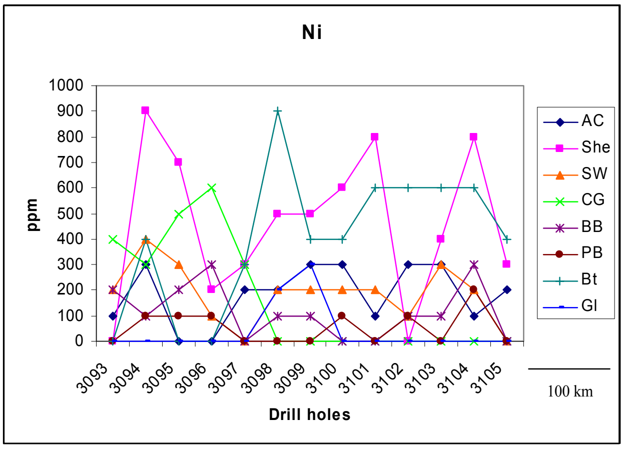

Figure 3. Element contents from biogeochemical data (ash) and the shallowest regolith samples along the drill hole line (AC- Acacia collectioides, She-Casuarina pauper, SW-Santalum spicatum, Gl- Eucalyptus salubris, BB-Eremophila scoparia, PB-Acacia translucens, Bt-Eucalyptus lesouefii, and CG- Eucalyptus torquate.

CONCLUSIONS

The data show that the ash of Hybanthus floribundus shows an extremely high uptake of nickel of about 40 times the concentration of Ni in the soil. Therefore, Hybanthus floribundus can be used as a tool to assist mineral exploration. There was no correlation between Ni and Co in the plants and Ni and Co values in shallow drill samples. Apart from this nickel indicator plant, eucalyptus species and Casuarina pauper (Black Sheoak) are also suitable plants for investigation in this area. Adsorption of elements onto Mn oxide and scavenging phenomena occur in soil from this area, and this may also occur within some of the plants examined. Inductively coupled plasma optical emission spectrometry (ICP-OES) following a 4-acid digestion is considered a suitable analaytical technique for Ni and associated elements (Co, Cr, Fe, Mn).

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