

***Macrozamia communis* (L Johnson) AS A BIOGEOCHEMICAL INDICATOR OF MINERALISATION ON THE SOUTH COAST OF NEW SOUTH WALES**

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INTRODUCTION

There is a large body of work on the application of biogeochemistry to mineral exploration, with the majority of studies being conducted in the northern hemisphere (See for example Rogers and Dunn 1993 & Cohen *et. al.* 1987), while, some successful studies have recently been conducted in Australia on the subject (See for example Cohen *et al.* 1998 & Arne *et. al.* 1999). The majority of the work in Australia has been conducted in western New South Wales where a thick, old and complex regolith is found (Hulme and Hill 2003, 2004, 2005, Hill and Hill 2003). In eastern New South Wales, because of higher rates of erosion, a younger, thinner and hence less complex regolith exists, which has discouraged biogeochemical studies, as there is a perception that there is little left to discover in the form of hidden mineralisation. It is assumed that the majority of deposits in this area would have had easily identifiable surface expressions and have been discovered already.

The perception that there is little left to discover in eastern New South Wales is most likely incorrect and this is attested to by the discovery of a range of different mineral deposits, in the not so distant past, in this region. In addition, biogeochemistry has not been widely used in southeastern New South Wales and no studies have been found on the application of this method on the South Coast of New South Wales after a careful literature search. This project was therefore developed to gain an understanding of the applicability of the biogeochemical method to this region. The primary aim was to determine the utility of a locally common plant, the cycad (*Macrozamia communis* (L Johnson)), as a biogeochemical exploration tool and to shed light on its biogeochemistry, as no quantitative information of the elemental stocks and flows of this plant have been found.

This project seeks to develop a biogeochemical understanding of the dominant understorey species in the coastal dry forests and was to be conducted in tandem with another project examining the overstorey biogeochemistry of the site to produce a holistic understanding of this forest type. Although this was desirable unfortunately the overstorey project did not reach completion. Never-the-less, the work that was completed has proved useful in the continuation of this study. Finally, as processing of all the samples is as yet to be completed, the aim of this paper is to discuss the preliminary findings on the biogeochemistry of the cycad *Macrozamia communis* (L Johnson).

STUDY SITE LOCATION

The site selected was a known auriferous deposit with a simple geology so as to limit the number of variables in the study. The site is the Tomakin Park Gold Mine, approximately 2 km northwest of the village of Tomakin and approximately 10 km southeast of the village of Mogo. The site is ideal for a biogeochemical study because it has only been mined from an adit, and much of the surface remains intact with standing mature vegetation almost a century after discovery. Furthermore, this was the site of a geobiological study into a soil bacteria and its relationship with the auriferous deposit (see Reith *et. al.* 2005) and hence made an excellent location for this related study.

GEOLOGY

The site is in the South Coast Antisynclinal Zone, which is a structural subdivision of the Lachlan Fold Belt. Specifically, the site is on folded interbedded metasediments consisting of Late Ordovician greywacke and shale, which formed in an arch trench gap (Scheibner, 1976). During the Devonian period this material was intruded by the Moruya Batholith, and as it cooled incompatible elements remained in the fluid. Some of this material intruded the remaining sediments and lithified forming the quartz vein mineralisation such as at the site of the current study. This mineralisation consists of a single quartz vein with a simple dip geometry containing arsenopyrite and associated gold. Assays of the gold content of this vein returned an average of 21 ppm gold (Bowman 1979).

VEGETATION

The dominant vegetation at the site is the coastal dry grassy forest type generally described as dry sclerophyll forest. The study site is dominated by the tree species *Corymbia maculata*, *Eucalyptus pilularis*, and *Eucalyptus paniculata* in the overstorey, *Macrozamia communis* in the understorey, and scattered native tussock grasses below these.

GEOMORPHOLOGY, SOILS AND REGOLITH

The site consisted of a gently to moderately steep south facing slope overlooking the Tuross River. The local landscape has rolling erosional hills, and depositional fills of coastal, marine and aeolian origin on the coastal plain. The site has been affected during recent geological time by northward migration of the river at this point. Erosion has undercut the lower parts of the slope, steepening and shortening the footslope below the site. The site has a moderately deeply weathered *in situ* profile where an A1 sandy loam horizon persists from the surface to 5 cm in depth followed by an A2 (also sandy loam) to a depth of 17cm. A B2 horizon of sandy clay extends from 17 cm to 42 cm and below this a C horizon or saprolite is present. The pH (in H₂O) of the A1 is 5.5, decreasing to 5.0 in the A2 and continuing this pH in the B2. Both the B2 and C horizon have evidence of the *in situ* quartz vein while on top of the A1 horizon there is a quartz lag. This lag indicates that colluvial processes dominate the modern landscape with little erosion at the site but rather significant mixing of surface materials (mostly by bioturbation) is occurring. For further information on the field site for this study, information on the vegetation associations, geology, geomorphology and background history of the site the reader is referred to Reith *et al.* (2005) and Moerkerken and Field (2005).

METHODS

Preliminary sampling was conducted over a two week period in September of 2005, during which time, six plant organs were sampled from a single plant over the ore body. The organs included the immature leaves; mature leaves, dead leaves still attached to the cycad, scales at the base of the leaves, contractile root pith, and the stem pith. Additionally, corresponding soil samples (beneath and adjacent to the plant) were taken at depth increments of 20 cm from directly below the cycad, 40 cm either side, and 1.2 m either side of the cycad.

The laboratory procedure involved first air drying the soil for one week at room temperatures, followed by mechanically breaking up the soil using a mortar and pestle. The soils were then sieved through a 2 mm sieve. The fraction that passed through was oven dried at 45 degrees over night. The plant samples were washed with deionised water, oven dried, and ground using a Breville Coffee 'n' Spice CG2B grinder. The plant samples were then oven dried as for the soil samples.

The oven dried samples were digested in concentrated acid to prepare a dilute solution that could be analysed using an Inductively Coupled Plasma Mass Spectrometer (ICP-MS). The digestion was performed using a nitric perchloric method where 10 ml of concentrated nitric acid is placed in 100 ml conical flasks following the addition of 0.44 g of sample. Five ml of perchloric acid is added last to reduce the risk of combustion, the samples are placed on a hot block and the temperature gently raised once the reactions have slowed. The samples were simmered down to approximately 1 ml. Once at this level the flasks were removed from the hotplate, cooled and then washed into filter funnels and volumetric flasks and the filtrate made up to a volume of 100 ml. All washing and other additions to make up volume were of distilled water.

RESULTS

From the preliminary analyses several biogeochemical trends were identified; for the most part these trends showed increasing concentrations of elements from dead foliage through mature foliage to the highest concentrations in the immature foliage. Of the 21 different elements recorded at detectable levels, this trend held true for 9 elements, namely Ge, Cr, Cu Zn, Ni Mo, W, P and K. On the other hand, the inverse relationship with trends to high levels of concentration in the dead foliage was identified for the elements Ca, Ba, Cs, B, Fe, Sr, Al and Pb. The final group of elements which showed trends for the highest concentration in the mature leaves were the elements Ti, Mn, Mg, Na, and S. For the other three plant organs trends are much harder to distinguish as the concentrations vary greatly both between organs and elements. However, for the most part concentrations seem to be highset in the leaf base scales overall.

For the soil samples the results were somewhat different. Elemental levels were much higher for all the elements in the soil as opposed to the plant organs except for Mo, W, B, Ca, Mn, Na, S and P, all of which were higher in the plant. Additionally a range of elements not detectable in the plant samples were detectable in the soil and one in particular (As), which was not detected in the plant organs, was in the order of 1000 ppm in the B horizon of the soil.

DISCUSSION

High levels of As in the soils over the orebody demonstrate that the plant tested was growing in soil over the mineralised body as this element is a common associate of gold mineralisation. Work by Reith *et al.* (2005) also showed elevated levels of As at this site. However, As was not detected in the plant, which is unusual considering that soils which contain this level often have plant species which do accumulate arsenic growing on top of them (Brooks 1972). Moreover, some do it to a spectacular degree, such as the Break Fern, which can grow on soils with 1500 ppm As and has a bioconcentration factor of 193 (Zang *et al.* 2002). However, the Cl ion is known to interfere with the detection of As when using ICP-MS with an isobaric interference at m/z 75 in the presence of chloride in a sample (Story *et al.* 1992). Therefore As may have been present in the vegetation samples but was undetectable because of interference by Cl ion from the acid digestion. Other problems also exist in the detection of the element Ag as chlorides can form when using this digestion method rendering this element undetectable. In further work alternate digestion acids will be considered to avoid this problem with As and Ag.

The levels of the elements Ca, K, P, Mo Cu, Zn, Mg, Mn, Ni, Zn and S detected in the plant samples were in the range required by plants for growth, but for the other trace elements identified in this study, levels were low. Nevertheless, at this stage it cannot be definitively stated whether or not *Macrozamia communis* will prove to be a biogeochemical tool until the final analysis of an additional set of samples taken across the country and mineralised rock areas has been completed, and statistical analysis of that data undertaken.

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