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Bio- and pedogeochemical investigations in Southern Australia : implications for mineral exploration and environmental assessment

Hamid Reza Hemmati Ahoei
University of Wollongong

BIO- AND PEDOGEOCHEMICAL INVESTIGATIONS IN SOUTHERN AUSTRALIA: IMPLICATIONS FOR MINERAL EXPLORATION AND ENVIRONMENTAL ASSESSMENT

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Hamid Reza HEMMATI AHOEI, M.Eng.

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Abstract

Leaves, twigs and bark of six different mallee species (*Eucalyptus oleosa, E. gracilis, E. socialis, E. eremophila, E. transcontinentalis and E. diversifolia*) and their adjacent soils have been collected from 94 sites in up to nine botanical regions spread over a wide area in southern Australia. All samples were analysed for 44 elements by INAA and ICP-MS techniques. The results of robust analysis of variance show that organs exhibit different behaviour with respect to elemental concentrations and their mobile nature. The nature of the underlying substrate (regolith or bedrock) is found to have a considerable influence on elemental composition of the plant organs. Some trace elements have higher contents from biosamples growing on substrates with powdery calcretes than either nodular or hardpan, suggesting that vegetation may more easily take up the species of trace elements that are dissolved in these regolith carbonates or it may arise from the influence of bedrock. The biological absorption coefficient (BAC), which is one of the biogeochemical parameters used in mineral exploration, was produced to characterize the absorption of chemical elements by plants from their substrate. It was concluded that the plants studied here have BAC values for trace metals higher than the average values cited in the literature and pose their eligibility for inclusion in regional biogeochemical exploration programs.

Pedo- and biogeochemical patterns based on the results of exploratory data analysis (EDA) techniques and robust-class selection was applied to the analysis of data. Regional biogeochemical maps of As, Au, Co, Cr, Mn and Ni show an association of these elements coincident with known mineralisation, and delineate anomalous sites where no mineralization is reported.

Several sampling sites were located directly over and adjacent to the Menninnie Dam zinc-lead prospect. The high levels of some trace elements, especially Zn at this site, are reflected in the chemical composition of all biological sample types.

Concerning environmental aspects, plants contributed very little to arsenic diffusion, cycling and transfer from soil and atmosphere to the biosphere in the study areas, since comparison of washed and unwashed plant parts in several sites throughout the area displays

no significant decreases in the assay values for washed samples and subtle differences between these two series of samples could be within the range of the natural variation.

Generally, the Cr concentrations found in the study area do not exceed the recommended contaminated level for soils related to ecosystems (210 ppm), except for 11 of the 81 sites investigated, which are located in the Yilgarn Craton near areas of known mineralisation in ultrabasic rocks. The concentration of Co and Ni in the soil samples of this research do not exceed the recommended guideline (40 ppm and 600 ppm, respectively).

This multi-elemental reconnaissance study has enabled us to get invaluable information about the natural concentrations of chemical elements in this substrate and to contribute to a baseline bio-soil geochemical survey established against which future changes can be quantified and to recognise new potential areas for mineral prospecting.

Declaration

This is to certify that the work described in this thesis is entirely my own, except where due reference is made in the text. No work in this thesis has been submitted for a degree to any other university or institution.

Hamid Reza Hemmati Ahoei

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And finally, but not least, I dedicate this thesis to my wife, Khadijeh Omidi and my daughter, Maryam for their veritable patience in the duration of this PhD. My wife left her job in our country and sacrificed her career to support me in my study. I tremendously relied on her, because I could not spend enough time with my daughter, even though we were far from home and relatives.

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Chapter 1 : INTRODUCTION

1.1 Introduction to biogeochemistry

Geochemical methods are used at all stages of exploration, from regional appraisal to local-scale evaluation. Geochemical relationships are established on the basis of the study of the distribution of chemical elements in various media such as rocks, soils and plants (Rose et al., 1979). It is obvious that the interpretation of results must be based on a knowledge of the distribution patterns of elements and on principles that govern the migration of these elements in each media (Komov et al., 1994). To discover increasingly difficult-to-detect new mineral deposits, exploration geochemists have available a wide array of geochemical procedures involving the analysis of air, water, stream sediments and bogs. These methods have become sophisticated and it is now realised that no one technique by itself can give a complete delineation or discovery of mineralisation. Biogeochemical methods of prospecting depend on the chemical analysis of elements in vegetation (Brooks, 1983), which are much younger than the associated field of geobotany.

The extent to which plants may be used in the search for minerals will depend on the nature and extent of the vegetation cover. About two thirds of the world's land surface is covered with vegetation of which 42% comprises forest, 24% grassland, and 21% consists of desert shrubs and grasses in semi-arid terrain. Since developed areas with less natural vegetation already will have been explored more thoroughly than more remote regions, and because most deserts will have some outcrops, it is likely that most of the world's remaining undiscovered mineral deposits will be hidden beneath

vegetation. For this reason, there should be increasing scope for the future use of biological methods in mineral exploration (Brooks et al., 1998a).

Applied aspects of biogeochemistry for mineral exploration began in the former USSR in the 1920s with the work of S.P. Aleksandrov, who discovered an increased concentration of V, Ra and U in plant ash at a U-V deposit, compared with plants collected outside the ore-bearing zones. The fundamental theory of biogeochemical studies for mineral exploration was later developed in the 1930s to 1950s by scientists such as Tkalich and Malyuga from the former Soviet Union and V.M. Goldschmidt, S. Palmquist, N. Brundin and H.E. Hawkes. The first paper on the methodology was written during this period by S.M. Tkalich (Kovalevsky, 1987).

Biogeochemical studies have been used with varying success mainly for gold deposits (Girling et al., 1979; Dunn, 1986; Huang, 1986; Warren and Horsky, 1986; Cohen et al., 1987; Siegel et al., 1991; Lintern et al., 1997a; Arne et al., 1999), and sulfide mineralizations (Adams and Hood, 1976; Akcay et al., 1998; Naseem and Sheikh, 2002; Fernandez-Turiel et al., 2003; Pujari and Shrivastava, 2003).

Geochemistry of rocks and related soils and vegetation in the Yellow Cat area, Grand County, Utah, USA was investigated by Cannon (Cannon, 1964). Also, gold and 20 other elements in 26 Equisetum (horsetail) from United States were determined by Cannon et al.(1968).

The tungsten content of the ash of the shallow-rooted tree ferns *Cyathea, Medullaris* and *Dicksonia squarrosa* (near Barrytown, New Zealand) correlated well with the concentrations of this element in the soil (Quin et al., 1974). Sampling of these species therefore provides a possible method of detecting general soil anomalies and moreover is considerably faster than soil sampling under local conditions.

According to Girling et al.'s work, plant analysis avoids the problem encountered in the sampling and sub-sampling of soil caused by the erratic occurrence of particulate gold (the so-called 'nugget' effect) (Girling et al., 1979).

In addition to exploration, other important fields of interest for biogeochemical investigations include phytomining (Robinson et al., 1997; Brooks et al., 1998a; Anderson et al., 1999), phytoremediation (Brooks and Wither, 1977; Ernst, 1996) and biomonitoring for environmental studies (Reimann et al., 2001b; Wang and Gao, 2001).

Plants that are able to accumulate high concentrations of heavy metals are known as hyperaccumulators. The concentrations accumulated are up to 100-fold of those that occur in non-accumulator plants growing in the same substrates. For most elements the threshold concentration is 1000 μg/g (0.1%) dry mass, except for zinc (10 000 μg/g), gold (1 μg/g) and cadmium (100 μg/g).

The technique of phytomining involves the use of hyperaccumulator plants to grow and concentrate a metal. Subsequently, the crop is harvested and the metal extracted. Hyperaccumulator plants were originally defined by Brooks et al. (1977) as taxa containing >1000 mg/kg (ppm) (in this first case, of Ni) in their dry biomass.

Heavy metals and organic pollutants as well as their mixtures are threatening human health by their impact on water and food quality and ecosystems. Therefore decontamination of soils is a priority topic in environmental legislation (Ernst, 1996). A "green" approach to such a task, 'phytoremediation', has received increasing interest.

Phytoremediation refers to the use of green plants and their associated microbiota, applied to soil improvement, and agronomic techniques to remove, contain, or render harmless environmental contaminants (Ernst, 1996; Freitas et al., 2004; Pratas et al., 2005). Phytoremediation of heavy metal-contaminated soils basically includes phytostabilization and phytoextraction.

Multi-element analysis of vegetation has become a powerful tool for biogeochemical prospecting, biomonitoring, and the study of the environment (Brooks et al., 1995; Dunn, 1995; Markert and Wtorova, 1995; Markert et al., 1996). In particular, regional surveys of the metal content of soil, vegetation and other media have been used to establish baseline concentrations and identify anomalies (Giovani et al., 1994; Markert et al., 1996; Reimann et al., 2001b). In addition, the gradual lowering of analytical detection limits for routine vegetation analysis has allowed the quantitation of elements long considered non-essential, and their role in plant growth and health is currently being re-evaluated (Ernst, 1996; Markert and Wtorova, 1995).

In spite of the effectiveness of these biogeochemical investigations and studies carried out worldwide, little biogeochemical research has been done in Australia (Lintern et al., 1997b; Cohen et al., 1998; Arne et al., 1999; Hill et al., 2000; Hulme and Hill, 2003).

In particular, in regions with transported cover or deep weathering, there is a strong potential for biogeochemistry as an alternative to other methods (Cohen et al., 1999). Indeed, the most obvious advantage of geobotany and biogeochemistry is in regions where there is no surface expression of mineralization and where mineralization at depth is masked by a geochemical barrier such as calcrete (Brooks, 1983).

Pedogenic calcrete results from the relative accumulation of carbonate in the soil moisture zone, by movement of percolated rainwater and/or soil water, such as eluviation/illuviation or as a product of biological activity such as a root respiration (Cerling et al., 1989). The carbon pool in soils is dominated by CO_2 derived from plant respiration and decay (Quade et al., 1995 for areas of southern Australia).

Calcretes have a wide distribution in southern Australia (Figure 1.1) and this introduces some advantages and disadvantages for mineral exploration (Milnes and

Hutton, 1983; Chen et al., 2002). For example, it has been mentioned that where regolith has transported material exceeding 10 m in thickness, it is unlikely that any response in the calcrete can be directly attributed to underlying mineralization (Lintern, 2002). In such cases, biogeochemistry may apply as an alternative to calcrete sampling.

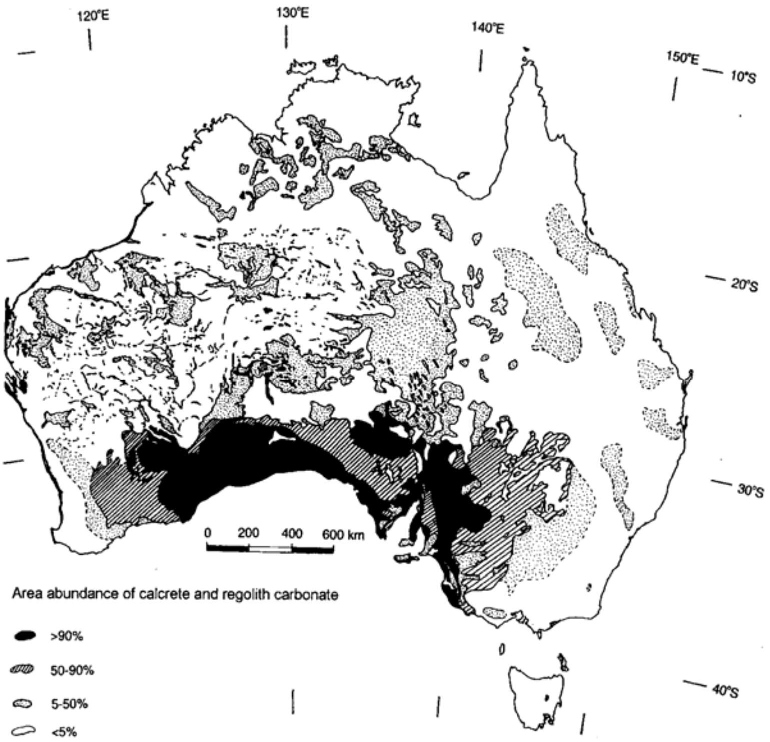


Figure 1.1 Distribution of calcrete in southern Australia (Chen et al., 2002)

Much of southern Australia is also dominated by mallee shrublands which occur on a range of calcareous soils (Parsons, 1994). This plant form is the common semi-arid eucalypt among the eucalypt-dominated communities of temperate Australia (Australian Surveying Land Information Group, 1990). Mallee eucalypt root systems reach depths of tens of metres and are extremely efficient in extracting water (Parsons, 1994).

Most biogeochemical research within Australia has been focused on the eastern part of the continent with studies in other areas being more limited (Lintern et al., 1997a; Arne et al., 1999). There is no previous reconnaissance-scale multi-element

biogeochemical research for southern Australia and where malleeform eucalypt is widespread.

Multi-element analyses are of major interest to describe the inter-element relations and to substantiate that soil-vegetation relationships are understood and taken into consideration when interpreting analytical results. Trace metal concentrations have been studied in some plant species, but data on their concentrations in the different parts of the plants are sparse, especially for malleeform eucalypts (Lintern et al., 1997a; Thomas, 2004).

However, only such data sets allow assessment of the influence of regional factors on the trace-element chemistry of vegetation. Reconnaissance studies are also needed to establish reliable background concentrations of the elements in plants growing on different bedrock substrates. Baseline bio- and pedogeochemical surveys have been conducted for many developed countries, but not yet for Australia. Specifically, this sort of research in the semi-arid area of southern Australia where there is very limited stream drainage can provide cost-effective, internally consistent and quality-controlled data on the inorganic chemical composition of soils and vegetation.

1.2 Location of the study areas

The broader study area (Figures 1.2 and 1.3) encompasses an area of 2300 km (east-west) by 300 km (north-south) between latitudes 30°S and 36°S. The study areas encompass four principal sub-regions corresponding to parts of three significant geological provinces. From east to west (geologically youngest to oldest) they represent parts of the Murray Basin, Gawler Craton (including northern Yorke and Eyre Peninsulas) and Yilgarn Craton (the Eastern Goldfields).

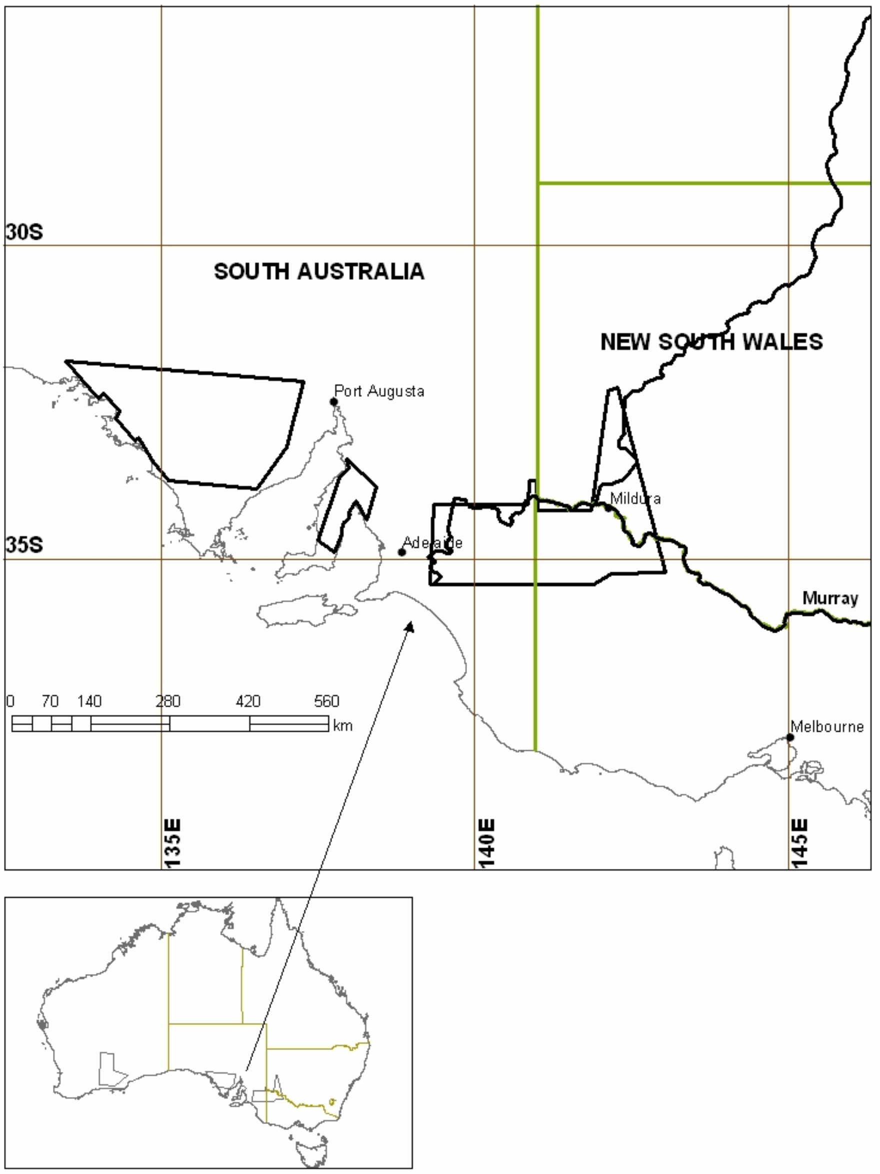


Figure 1.2 Location of the study areas in New South Wales, Victoria and South Australia

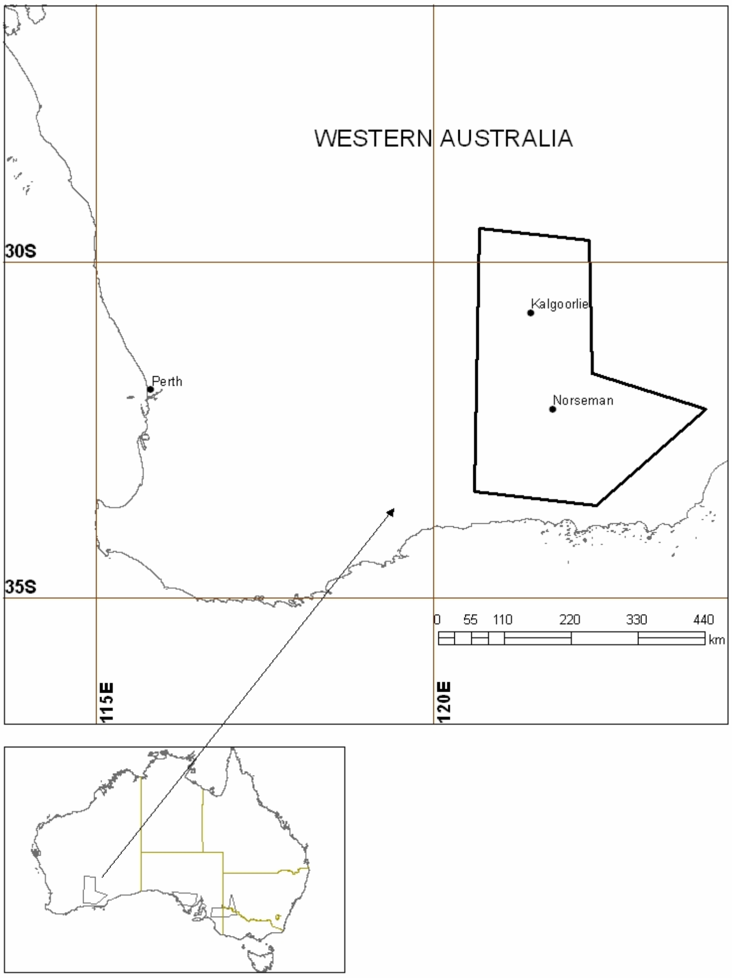


Figure 1.3 Location of the study area in Western Australia

1.3 Previous research in the study area

Existing biogeochemical investigations from within the study areas are sparse. Geobotanical and biogeochemical studies in the sclerophyllous woodland and shrub associations of the Eastern Goldfields area of Western Australia have been made with particular reference to the role of *Hybanthus floribundus* (Lindl.) F.Muell as a nickel indicator and accumulator plant (Cole, 1973). Exploration for base metals in the Stuart shelf, northeastern of the Gawler Craton, SA, has involved plant sampling (Rattigan et al., 1977). The latter study suggests that biogeochemistry has a useful application in specific geological situations. Lintern et al. (1997a) have focused on gold

concentrations in vegetation and soils in three case studies from the gold-fields of southern Western Australia.

Biogeochemistry of the Ballarat East Goldfield which is located within the western Lachlan Fold Belt of central Victoria has been studied as a potential prospecting tool (Arne et al., 1999).

1.4 Objectives

The main objectives of this research are to develop a biogeochemical methodology incorporating major- and minor-element chemistry of plants and soils in order to achieve models for secondary dispersion patterns of elements at a reconnaissance-scale for both media and to enable interpretation of the influence of various lithologies (and mineralization) on the chemical composition of vegetation in the study area. The several sites in Australia, namely parts of the Murray Basin, Gawler Craton in South Australia and part of Yilgarn Craton in Western Australia, contribute to a broad study of mallee, commonly developed on soil carbonate in southern Australia.

The results obtained add to the volume of data needed to understand the biogeochemical patterns in the area and the systematics governing soil-plant relationships. This research complements earlier local studies in southern Australia for mineral exploration and environmental appraisal and provides more detailed multi-element biogeochemical data which will assist with future research.

The five specific aims of this thesis are:

1) To investigate chemical differentiation (or response) among different plant organs (i.e. bark, twigs and leaves).

2) To evaluate the influence of different underlying bedrock lithologies and the degree of soil carbonate development, on plant biogeochemistry on a reconnaissance scale.

3) To elucidate the relationship between element abundances in plants and their concentration in the substrate.

4) To determine the secondary dispersion patterns of trace elements in the soils and vegetation within the study areas.

5) To describe the biogeochemical response patterns over a known mineralized site, namely the Zn-Pb mineralization at Menninnie Dam, Gawler Craton, South Australia.

1.5 Structure of the thesis

This research is presented in eight chapters. This first chapter provides a general introduction to the research, provides a brief literature review, introduces the research sites, explains the previous studies and defines the research objectives.

Chapter two introduces the plant chemistry and the mechanisms of element uptake by plants and provides the physiogeographic patterns of vegetation in the study sites. The general geology of the research areas is also described in this chapter.

Chapter three deals with the biogeochemical methods used in the research and explains soil and plant sampling procedures and the chemical methods used to analyse the soil and biosamples. Statistical procedures including single and multivariate methods for data analysis of vegetation and soils samples are provided in chapters four and five, respectively. Also these chapters establish secondary dispersion models of trace elements in the soil and plants in the study areas. Reconnaissance bio-and pedogeochemical maps which indicate potential areas for mineral prospectivity, are

presented in these chapters. The relationships between trace-element uptake by vegetation and their concentration in the soil are also dealt with in chapter five.

The multivariate analyses of the bio- and soil geochemistry datasets are examined in chapter six which allow us to consider simultaneous variations in several properties. Chapter seven describes the bio- and pedogeochemical patterns at Menninnie Dam mineral prospect, South Australia. The conclusions of this project are summarised in chapter eight.

Chapter 2 : GENERAL GEOLOGY AND PHYTOGEOGRAPHY OF THE STUDY AREAS

2.1 Introduction

The study areas encompass four sub-regions corresponding to parts of three significant geological provinces, which from east to west (geologically youngest to oldest) are the Murray Basin, Gawler Craton (including Yorke and Eyre Peninsulas) and Yilgarn Craton (Figure 2.1).

2.1.1 Murray Basin

The Murray Basin is one of the largest (450,000 km^2) Cenozoic basins along the southern margin of Australia. Partly circumscribed by the Eastern Highlands and the Mount Lofty Ranges, this shallow intracratonic basin developed during the rifting of Australia from Antarctica in the Mid- to Late Cretaceous (Veevers, 1991). The western half of the basin was a wide (≈520 × 410 km), shallow marine gulf of epeiric sea character and extent throughout the early Neogene. The thin (<150 m), generally flat-lying limestones accumulated in the western part of the basin during a period of tectonic quiescence and are only gently warped and locally faulted by post-Miocene tectonism. The rocks accumulated approximately 200-500 km inboard of the continental shelf edge.

The margins of the gulf were rimmed to the north and east by a wide (≈100 km) belt of lagoonal and supratidal, non-evaporitic mud flats (Geera Clay) that trapped terrigenous sediments nearshore (Paine, 2005).

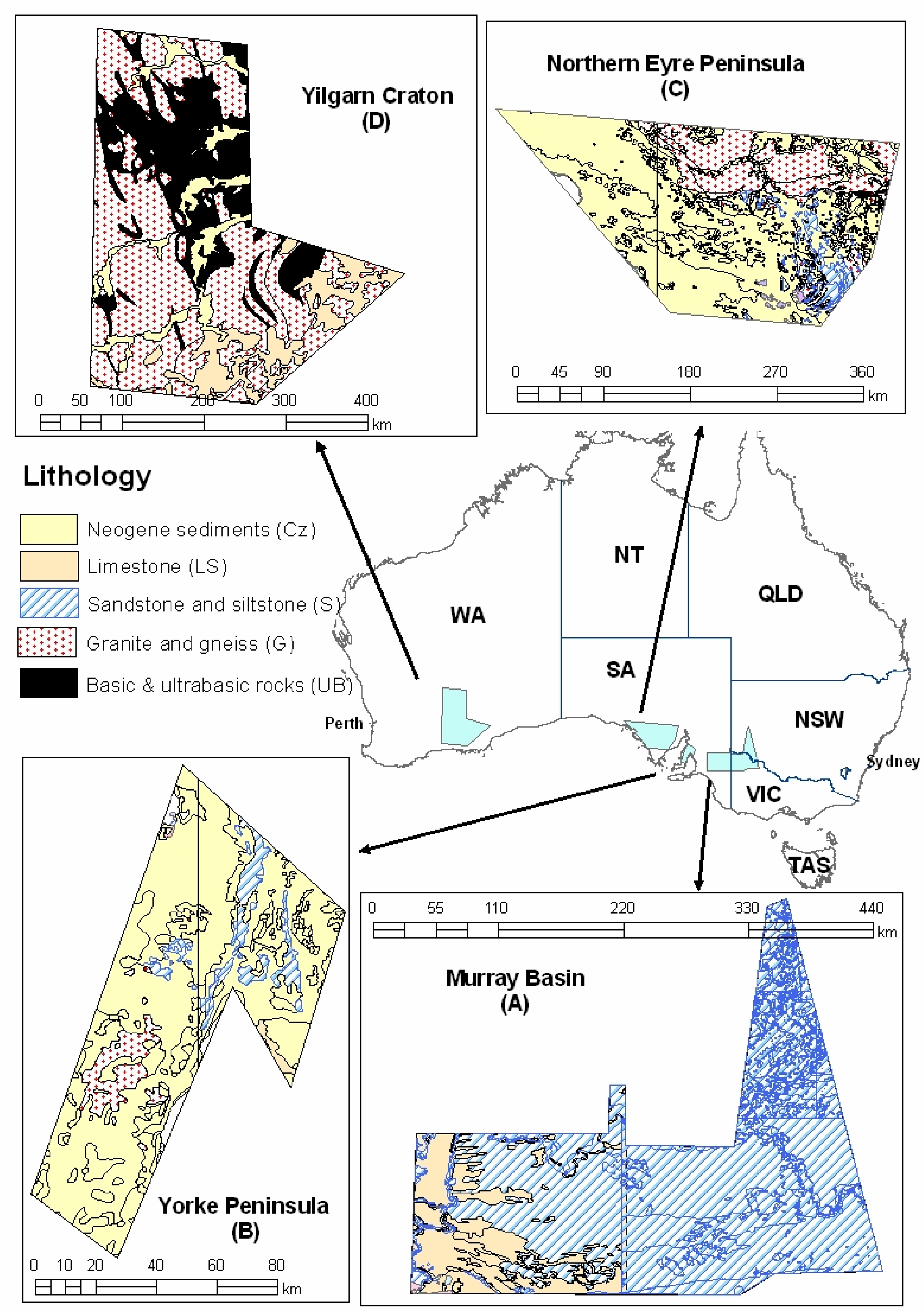


Figure 2.1 Simplified geological/lithological maps of the four main study areas. The simplified four-fold lithological division is used to compare soil and vegetation chemistry to that of the underlying bedrock.

There were three major depositional sequences in the Tertiary correlating with periods of sea level rise and fall. Deposition of the earliest Tertiary sequence commenced in the Paleocene and continued throughout the Eocene to the Lower Oligocene. During the Paleocene to Eocene, the Warina Sand of the Renmark Group was deposited in the central western depocentre. Later in the Eocene, carbonaceous silt, sand and clay were deposited in fluviolacustrine environments forming the Olney Formation of the Renmark Group (Stephenson and Brown, 1989)

The second sequence of Tertiary deposition ranged from the Oligocene to mid-Miocene. This resulted from a major marine transgression which partly flooded the western area of the Murray Basin. An epicontinental sea deposited marl and limestone of the Murray Group, with clay being deposited in the shallow-marginal marine environments. The sea level fell during the Mid Miocene, causing the Olney Formation, Geera Clay and Winnambool Formation to locally prograde back over the limestones of the Murray Group. This sea level decline was followed by a short period of erosion, and most authors suggest that the sea entirely retreated from the Murray Basin (Kingham, 1998).

The third depositional sequence took place in the Late Miocene to Pliocene and involved a series of marine transgressions and regressions. The initial transgression deposited clay and marl in a shallow marine environment, while at the same time the coarse-grained sandy Calivil Formation was deposited in fluvial and fluvio-lacustrine environments in the eastern half of the Murray Basin. A marine regression during the Early Pliocene led to the deposition of the fluvial and strand plain Loxton-Parilla Sands (Stephenson and Brown, 1989). Uplift along the western margin of the Murray Basin during the early Pleistocene led to the tectonic damming of the Murray River which

formed Lake Bungunnia, resulting in the deposition of the Blanchetown Clay (An et al., 1986).

2.1.2. Gawler Craton

The Gawler Craton (Figure 2.2) comprises a Late Archaean to Early Palaeoproterozoic basement that is surrounded by Palaeoproterozoic to Mesoproterozoic orogenic belts (Betts et al., 2003). The craton records a protracted history involving several cycles of magmatism, sedimentation and orogenesis (Glaessner and Parkin, 1958). The Archaean nucleus of the Gawler Craton is composed of highly deformed supracrustal successions of the Sleaford and Mulgathing Complexes. These rocks record a *ca* 2640–2300 Ma orogenic event (Sleafordian Orogeny). During the Palaeoproterozoic, clastic and chemical sediments of the Hutchison Group were deposited along the eastern and northern margin of the craton. The Hutchison Group was subsequently intruded by several magmatic suites collectively termed the Lincoln Complex (*ca* 1850– 1730 Ma). These rocks were then deformed during the *ca* 1740–1700 Ma Kimban Orogeny (Vassallo and Wilson, 2001). It has been proposed that the Kimban Orogeny occurred as the Gawler Craton collided with the North Australian Craton (Betts et al., 2003).

The Gawler Craton records a large magmatic event (Hiltaba magmatic event) in which voluminous *ca* 1600– 1590 Ma bimodal Gawler Range Volcanics were emplaced in the central Gawler Craton. This was followed by voluminous emplacement of granitic magmas in the western, northern, central and eastern parts of the craton between *ca* 1590 and 1575 Ma and, at the same time, intrusion of minor picritic dykes

in the eastern parts of the craton (Flottmann and Cockshell, 1996).

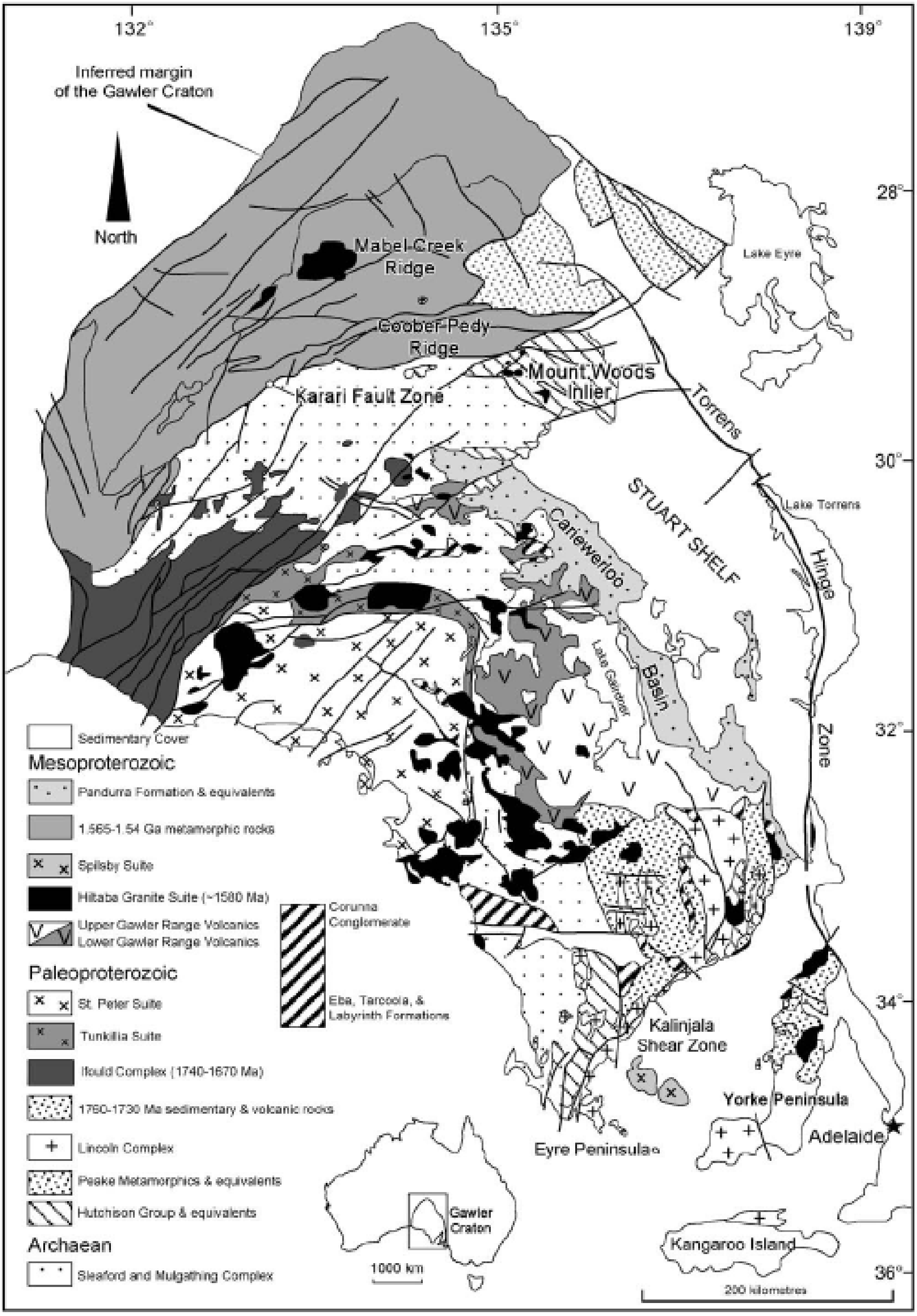


Figure 2.2 Regional geology of the central Gawler Craton showing major lithological packages and structures (adapted from Daly et al., 1998; Ferris et al., 2002).

It has been suggested that the arrival of a mantle plume was the major cause of the Hiltaba magmatic event, although recent studies have shown that the Hiltaba magmatic event was coincident with the *ca* 1600–1590 Ma Olarian Orogeny in the Curnamona Province, and that movement along major shear zones accompanied emplacement of Hiltaba Suite granite plutons (McLean and Betts, 2003).

In the Yorke Peninsula part of the Gawler Craton, the oldest rock unit is the middle Palaeoproterzoic Corny Point Paragneiss, a layered migmatite containing a Hutchison Group equivalent protolith (1920-1860 Ma), which was metamorphosed to granulite facies at nearly 1845 Ma (Zang and Hore, 2003). Several felsic and mafic plutonic suites (mainly Gleesons Landing Granite) intruded the paragneiss on the southern Yorke Peninsula.

2.1.3. Yilgarn Craton

The Yilgarn Craton comprises an area of approximately 660 000 km^2 and forms one of the largest intact segments of Archaean crust on Earth. The Craton is situated in the central part of the Precambrian Shield of Western Australia, which comprises Archaean granitoids and greenstones of the Yilgarn and Pilbara Cratons, metamorphosed Archaean and Proterozoic granitoids, gneisses and volcanic rocks of the Paterson and Gascoyne Provinces and the Albany–Fraser Province (Geological Survey of Western Australia, 1974). The shield also includes Proterozoic sedimentary rocks of the Nabberu, Bangemall and Hamersley Basins. Much of the Yilgarn Craton is a granite–greenstone terrain characterised by arcuate belts of metamorphosed sedimentary and volcanic rocks (greenstone belts) that lie between large areas of granitoid. The bulk of the craton is thought to have formed between 3000 Ma and 2600 Ma, with some gneissic terrains exceeding 3000 Ma in age (Myers, 1993). The rocks and structures

that comprise the craton are superficially similar over large parts of the craton and in detail can be subdivided into various terranes on the basis of pre-metamorphic lithological associations, geochronology and styles of tectonism and metamorphism (Griffin et al., 2004).

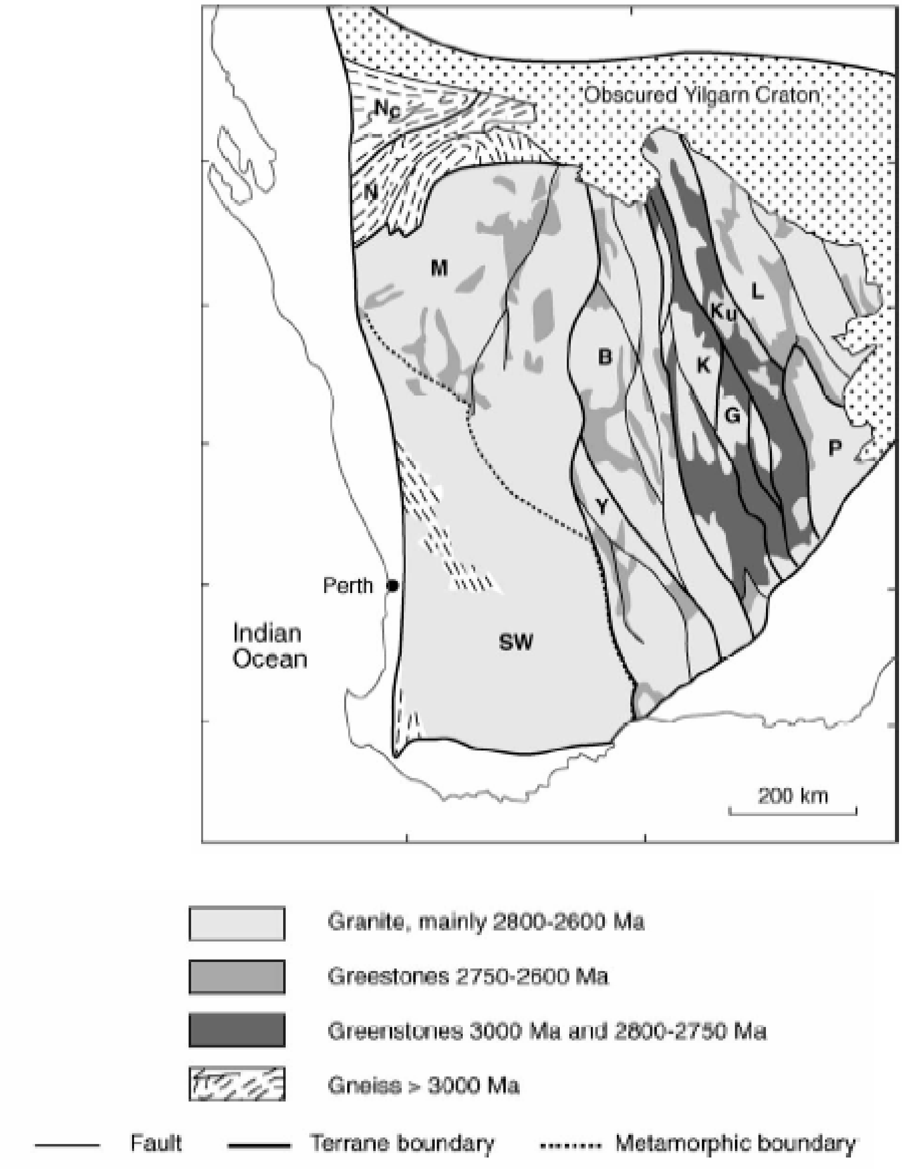


Figure 2.3 Terrane structure of the Yilgarn Craton, after Griffin et al. (2004). B, Barlee; K, Kalgoorlie; M, Murchison; N, Narryer; Nc, Narryer terrane affected by the Capricorn Orogeny; SW, southwest Yilgarn composite terrane; Y, Yellowdine; Ku, Kurnalpi; G, Gindalbie; L, Laverton; P, Pinjin.

These terranes (Figure 2.3), which include the Barlee, Gindalbie, Kalgoorlie, Kurnalpi, Laverton, Murchison, Narryer, Pinjin, Yellowdine and Southwestern composite terranes are thought to have undergone intense tectonic, volcanic, plutonic and metamorphic activity between 2780 Ma and 2630 Ma. This is interpreted as a period of major plate-tectonic activity that swept together and amalgamated a number of diverse crustal fragments, including volcanic arcs, backarc basins and microcontinents, to form the Yilgarn Craton.

The Southwestern composite terrane is characterized by a relatively high-grade (granulite to upper amphibolite facies) granite–greenstone complex and numerous dolerite dykes have intruded the predominantly granitic rocks of the area. The dykes are vertical or subvertical and range in thickness from less than 1m to over 200 m, averaging approximately 10 m.

The greenstones are characterised by ultramafic and mafic volcanic rocks formed as extensive submarine lava plains, and volcanic centres of felsic and mafic volcanic rocks developed more locally. Sedimentary rocks are mainly derived from felsic volcanics and banded iron-formation and form a prominent greenstone component. They appear to have formed in broad basins during tectonic and volcanic quiescence. Layered gabbroic sills are another major greenstone component. Widespread granite intrusion throughout the craton is thought to have occurred between 2700 Ma and 2600 Ma (Myers, 1993). The granites were emplaced as sheets into the pre-existing greenstone sequences.

-Phytogeography of the study areas

2.2 Vegetation

A plant is a living entity. From its environment it takes raw materials and makes them into organic chemicals suitable for its own use (Fitter and Hay, 1987). With these chemicals the plant makes more of its own living substance, makes and uses its own food, carries on digestion and assimilation, and grows and reproduces, according to the pattern laid down by its inheritance (Northern, 1968).

2.2.1 Root system

Roots are organs that enable plants to mine the soil for essential nutrients. The intimate contact with the soil mass that roots require for normal function is the reason for plants being sessile during most life stages. Functions such as photosynthesis and nitrogen fixation do not preclude freedom of motion, but the primary acquisition of mineral nutrients from soil does.

2.2.2. Leaf system

A leaf generally has an expanded blade and a stalk, known as a petiole, which bears at the base two small appendages called stipules. Carbon dioxide enters the leaf through minute pores called stomata, and water is distributed to the leaf cells by veins. Only a small portion of the water reaching the leaf cells is used in photosynthesis. A greater amount is evaporated from cells within the stomata as water vapour (Douce and Day, 1985).

2.2.3. Plant nutrition

Plant nutrition has unique importance in the realm of life on Earth and in the affairs of humankind. All living things consist of atoms of chemical elements. The ultimate

reservoirs of these elements on Earth are the rocks, the oceans, and the atmosphere. Not all living things, however, participate in this primary mining of the raw materials of life. Only green plants and certain microorganisms are able to extract simple inorganic compounds previously synthesized by other living organisms.

Soil is the primary medium for the mineral nutrition of terrestrial plants. Minerals in the soil water are generally immobile. The distances that they travel from their points of release from soil particles to the sites of absorption on roots are commonly measured in micrometres (10^{-6} m) or occasionally up to a few metres. The volume of soil adjacent to plant root and most intimately engaged in the exchange of materials with them (rhizosphere), is the least explored ecosystem, because of its inaccessibility and sensitivity to experimental manipulation.

Soil has five major components: mineral matter, water containing solutes (i.e., the soil solution), gases, living organisms, and organic matter. The fraction of soil volume that each of these components occupies varies greatly with the particular soil and prevailing conditions. Immediately after rainfall, for example, water may occupy all the pore space or voids; afterwards the water will drain into deeper layers of soil and subsoil, drawing air into the interstices among the solid particles.

Soils continuously release minerals from the solid phase to the soil solution through the dissolution of salts that are sparingly soluble and through the exchange of ions (predominantly cations) bound to soil particles with ions in the soil solution. The strength of cation binding to soil particles increases in the following order: sodium, ammonium, potassium, magnesium and calcium. The proportions of each cation, however, vary greatly in different soils. Usually, the principal cations in solutions are potassium, calcium and magnesium. Sodium ions may predominate in semi-arid regions. The soil solution is the most important source of nutrients for terrestrial plants.

This is a dilute solution, one that would soon be depleted if soil particles did not constantly release minerals from the solid phase or if soil microorganisms did not rapidly catabolize organic matter.

2.2.4 Macronutrients in plants

If an element is known to be an integral component of a structure, compound, or metabolite of plants, its essentiality is obvious. Seven mineral elements, nitrogen, phosphorus, sulfur, potassium, calcium, magnesium and iron (and also carbon from the atmosphere) together with those from water, mean that ten elements are recognized as essential elements or nutrients (Epstein and Bloom, 2005). With the exception of iron, these elements are needed in relatively large amounts; they are thus referred to as macronutrient elements or simply macronutrients.

Tissue analyses from a wide variety of plants found Si concentrations in those plants range from 0.2% to 10% of dry weight depending on plant species. This concentration range is equivalent to those (in tissue) of Ca, Mg, P and S, four of the included essential elements. Despite the prominence of Si found within a plant's physical makeup, Si has not been considered as an essential element, and has not been included in any standard formulation of nutrient solutions and fertilizers (Kabata-Pendias, 2001). However, continuing evidence suggests that Si does enhance the growth of a wide range of crops, from rice, sugarcane and wheat, to citrus, strawberry, cucumber, tomato and rose.

2.2.5 Trace elements in plants

Plants can accumulate trace elements, especially heavy metals, in or on their tissues due to their great ability to adapt to variable chemical properties of the environment:

thus plants are intermediate reservoirs through which trace elements from soils, and partly from waters and air, move to man and animals (Baker, 1983).

The response of plants to the chemistry of the environment is controlled by several external and biochemical factors. Nevertheless, the chemical analysis of plants is a promising tool to study chemical properties and changes in the lithosphere (Kabata-Pendias, 2001). Three general uptake characteristics can be distinguished in plants: accumulation, indication, and exclusion. To a large extent, this depends on the specific ability of plants. The metabolic fate and role of each trace element in plants can be characterized in relation to some basic processes such as: uptake (absorption), and transport within a plant; enzymatic processes; concentration and forms of occurrence; deficiency and toxicity and ion competition and interaction (Anderson and Scarf, 1983).

The reaction of plants to chemical stresses that are caused by both deficiencies and excesses of trace elements cannot be defined exactly because plants have developed during their evolution and course of life. Therefore, plant responses to trace elements in the soil and ambient air should always be investigated for the particular soil-plant system (Kabata-Pendias, 2001).

The chemical composition of plants reflects, in general, the elemental composition of the growth media. The common concentration of trace elements in plants growing on various, but non-polluted soils show quite a large variation for each element. A large variety of possible ligands for metals exist in plants, especially in xylem and phloem. Thus, metal ions form complexes with small and macromolecular substances, mainly organic (Phipps, 1981).

2.2.6 Root uptake

The absorption of trace elements by roots can be both passive (nonmetabolic) and active (metabolic). Passive uptake is the diffusion of ions from the external solution into the root endodermis. Active uptake requires metabolic energy and takes place against a chemical gradient (Thurman, 1981). Mechanisms of uptake differ, depending on the given element. Pb and Ni are preferably absorbed passively, while Cu, Mo, and Zn are preferably absorbed actively. When biological and structural properties of root cells are altered, however, all elements are taken up passively. This is the case when concentrations of elements pass over a threshold value for a physiological barrier (Gobran et al., 2001).

2.2.7 Essential trace elements for plants

The trace elements essential for plants are those which cannot be substituted by others in their specific biochemical roles and that have a direct influence on the organism so that it can neither grow nor complete some metabolic cycle (Osteras and Greger, 2003) . Trace metals of the transition metal group are known to activate enzymes (Table 2.1) or to be incorporated into metalloenzymes as electron transfer systems (Cu, Fe, Mn, and Zn) and also to catalyze valence changes in the substrate (Cu, Co, Fe, and Mo). Some particular roles of several trace elements (Al, Cu, Co, Mo, Mn, and Zn) which seem to be involved in protection mechanisms of frost-hardy and drought-resistant plant varieties are also reported (Krauss et al., 2002).

Table 2.1 Forms and principal functions of some trace elements in plants

Element	Constituent of	Involved in
As	Phospholipid (in algae)	Metabolism of carbohydrates in algae and fungi
B	Phosphogluconates	Metabolism and transport of carbohydrates, flavonoid synthesis, nucleic acid synthesis
Co	Cobamide coenzyme	Symbiotic N_2 fixation
Cu	Various oxidases, plastocyanins, and ceniloplasmin	Oxidation, photosynthesis, protein and carbohydrate metabolism
F	Fluoracetate (in a few species)	Citrate conversions
Fe	Hemo-proteins and nonheme iron proteins	Photosynthesis, N_2 fixation, and valence changes
Mn	Many enzyme systems	Photoproduction of oxygen in chloroplasts
Zn	Anhydrases, dehydrogenases	Carbohydrate, nucleic acid and lipid metabolism

Although many papers have been published on the behaviour of trace elements in soil and plants, their chemistry is inadequately known. Accordingly, a better understanding of the behaviour of trace elements in the soil-plant system seems to be much needed (Kabata-Pendias, 2001).

2.3 Plants in the study areas

2.3.1 Introduction

Australia is a continental mass lying south of the Equator between latitudes 11° S and 44° S. The climate varies markedly with geographical position: summer rainfall predominates in the north, winter rainfall is characteristic of the south, and the eastern seaboard shows a more general distribution of rainfall throughout the year. A marked climatic gradient, from humid coastal fringe to arid inland, is found in the south, east and north of the continent (Specht and Specht, 1999). The structure of the vegetation varies along these climatic gradients: dense rainforests in parts of eastern Australia; tall

eucalypt forests of the south-east and south-west; eucalypt forests/woodlands, with either grassy or heathy understorey, distributed throughout the continent; heathlands and grasslands in tropical to temperate climes; mallee eucalypt vegetation on the calcareous soils of the south; and a variety of other vegetation types in the vast arid zone and in the alpine, coastal, and wetland landscapes of the continent.

The Australian vegetation has many unique features, both in composition and structure. In composition, it is unique in the sense that a very high proportion of its species are endemic to the continent. It is also unusual in that two large tree and shrub groups, the eucalyptus and the phyllodinous acacias, between them dominate almost all the plant associations of the continent, whilst having very limited natural occurrence outside Australia (Barlow, 1994). In structure, it includes vegetation types, such as sclerophyll forest, mallee woodland and hummock grassland, which do not fit easily into global vegetation classifications (Read, 1987).

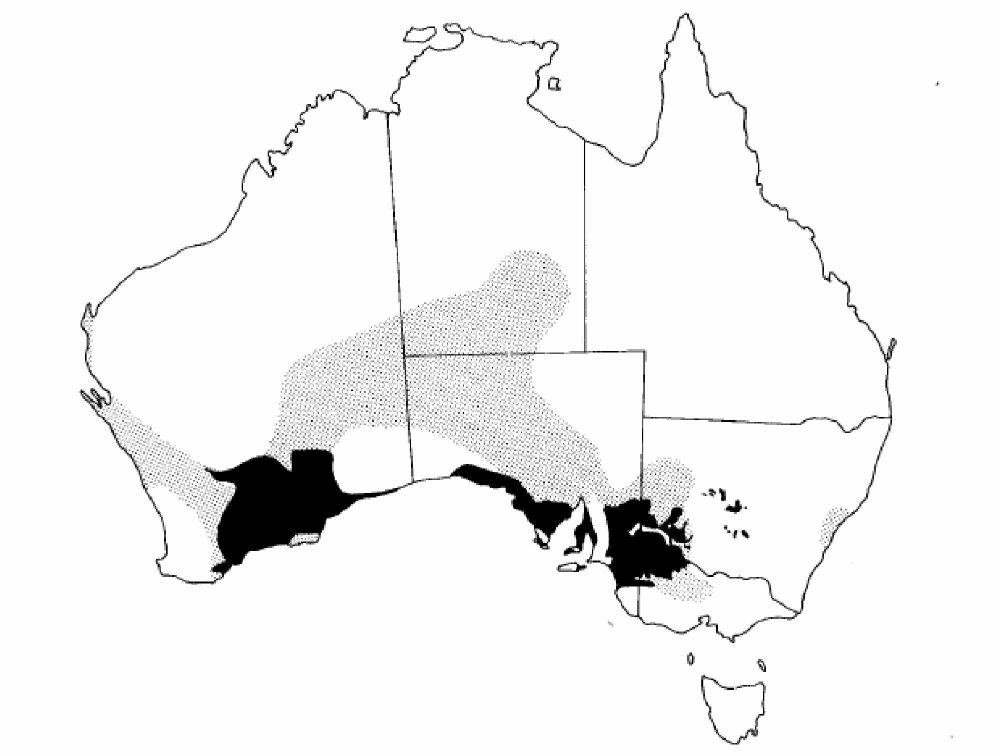
The vegetation of today comprises those taxa that were able to survive as the evaporative climate became drier. On the nutrient-poor soils, especially low in phosphorus, which have persisted on much of the continent for the last 50 million years, the flora has remained distinct. The attributes that enabled some of the Gondwanan flora to survive over this long period of time also facilitate their rapid regeneration from underground organs and epicormic buds, whenever a disturbance such as fire occurs.

2.3.2 Description of mallee eucalypts

2.3.2.1 Mallee communities

The major portion of eucalyptus scrub and shrublands is dominated by eucalyptus having many stems arising from a large, underground, woody swelling composed of

stem tissue called a lignotuber. Eucalyptus with this growth habit are commonly called mallees (Parsons, 1994). Mallee communities extend across southern Australia from Western Australia (longitude 117˚ E) to New South Wales (longitude 147˚ E) with a latitudinal range of from 22˚ to 37˚ S (Figure 2.4).



■ Predominantly mallee areas ▒ areas where mallee is significant but not predominant

Figure 2.4 Distribution of mallee in Australia (after Hill, 1989)

The ‘mallee region’ is a general term, which has evolved, for the zone of calcareous aeolian soils in eastern South Australia, southwestern New South Wales and western Victoria where the vegetation is dominated by mallee communities (Hill, 1990). In this main area of mallee occurrence, climate is broadly of Mediterranean-type with predominantly winter rainfall. Coastal mallee areas, such as at Ceduna, South Australia, can have frosts on average 18 nights per year, whilst for inland stations, e.g. Kalgoorlie in Western Australia, the figure rises to 27. The same term has also been applied to the

southern region of Western Australia, but has not attained general acceptance (Hill, 1989), while as many as three-quarters of the eucalypts of southern Western Australia are mallees. Overall, mallee can be regarded as the common semi-arid eucalypt among the eucalypt-dominated communities of temperate Australia.

2.3.2.2 The mallee growth habit

Mallees are usually 3 to 9 m tall, but can exceptionally reach heights up to 18m (e.g. some stands of *E.diversifolia* on Kangaroo Island, South Australia). The lignotubers arise as swellings in the axils of the cotyledons and first few leaves. They become large, woody, convoluted swellings commonly 0.3-0.6 m in diameter and rarely up to 1.5 m (Parsons, 1994). Lignotubers have the same anatomical characteristics as normal stems but with greatly contorted xylem elements. Lignotuber wood can have almost twice the proportion of storage tissue as stem wood and thus a larger potential for starch storage. Lignotubers also contain a very large number of concealed dormant buds.

The frequent fires which occur in mallee areas rarely damage the largely buried lignotuber. Mallee lignotubers may carry up to 70 shoots six months after fire; this can diminish to about 20-30 seven years later and to less than ten by 100 years. The stems of mallee usually branch sparingly and bear leaves only at the end of the branches so that the canopy resulting from many plants is often very narrow, even and horizontal, giving typical mallee communities a very distinctive appearance. Isotopic data from investigations at two study sites, Murbko (near Blanchetown) and Borrika (near Karoonda) in the southwest Murray Basin of South Australia suggests that mallee vegetation may be able to extract water from water tables at least 30m deep (Leaney et al., 2001).

2.3.3 Biogeographic patterns of mallee in southern Australia

Continental biogeographers regard the belt of mallee vegetation across southern Australia as an ecotone between the maritime temperate sclerophyllous woodlands and the large inland expanse of semi-desert steppe (Tivy, 1995). Mallee vegetation is part of one large continuum where the most important influencing factor is soil water relations. In the rainfall zone from 250 to 400 mm, mallee is predominant on a range of calcareous soils; it is this combination which traditionally has been regarded in Australia as constituting the typical mallee country.

2.3.3.1 Biogeographic patterns of mallee in the eastern part of southern Australia

The major areas are on Quaternary aeolian deposits. Soil texture is very variable and topsoil texture ranges from sand to clay. Although the soils are predominantly calcareous, some of the deep sands like the Berrook sands can have siliceous surface horizons. The ecologically best-known area is northwestern Victoria and adjoining parts of South Australia and New South Wales (Harden, 1991). The literature commonly refers to the marked differences in mallee eucalypt size between communities reflected in the use of terms like big mallee and small mallee. Big mallee usually has three to four stems per plant, stem diameters more than 150 mm at maturity, and height over 6 m; mallee has many thinner stems per plant and height about 3.5-6 m; while small mallee has a height less than 3.5 m at maturity.

In this region, soil texture is usually the most important single factor affecting the distribution of native plants. This is related both to increasing levels of macronutrients with increasing clay content and to the inverse texture effect, whereby soil water supply to plants decreases with increasing clay content. In some areas like north-western

Victoria, big mallee can occur on clays in the wetter part of the area, but in the driest parts, grassland commonly occupies these soils (Parsons, 1994). Big mallee is particularly prominent in these dry areas; however, on these soils, the height of mallee eucalypts increases with decreasing rainfall and this change can occur even when soil fertility stays approximately constant. The fine degree of control operated by texture-related factors is illustrated by the very closely related species *Eucalyptus socialis* and *E. oleosa*. Sandy soils on crests and slopes of small dunes carry *E. socialis*, but this species gives way completely to *E. oleosa* with only slight increases in clay content on the intervening flats.

2.3.3.2 Biogeographic patterns of mallee in South Australia

Eucalyptus species of the mallee habit form a broad, somewhat irregular, belt across southern South Australia. Although there is scant information available, soil moisture conditions (especially during periods of water deficiency) would seem to be the major environmental factor controlling the distribution of mallee ecosystems (Figure 2.5). Thus, there is a general relationship between mallee distribution and average annual rainfall: the mallee belt corresponds approximately with areas between the 250 mm and 450 mm isohyets (Sparrow, 1989). The mallee belt has considerable environmental and conservational importance in South Australia as it occupies about half of the southern temperature regions of the state.

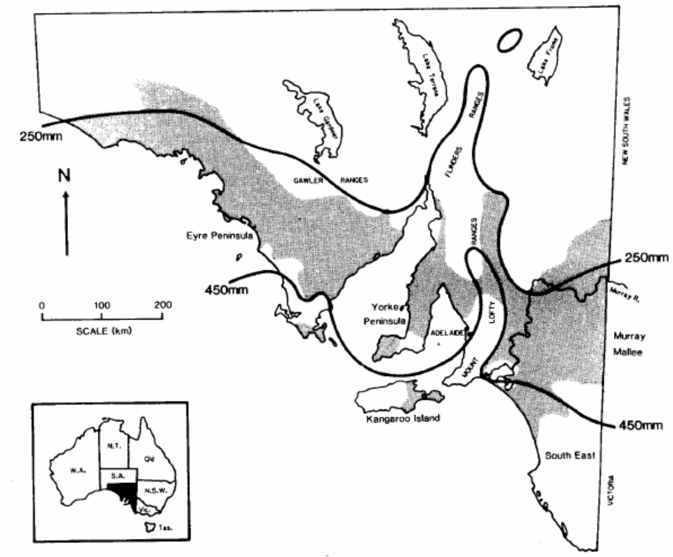


Figure 2.5 Distribution of major mallee ecosystems in South Australia in relation to average annual rainfall (after Sparrow, 1989).

In South Australia, clearance of mallee vegetation has proceeded chronologically from the agriculturally most desirable areas to the least useful areas. The mallee vegetation is now conserved in a number of National Parks and Wildlife Service reserves throughout their respective distributional ranges (Figure 2.6). There are a number of conservation parks containing *Eucalyptus oleosa-gracilis* mallee types. These parks include Danggali Conservation Park in the Murray Basin, and Lake Gilles Conservation Park and Yumbarra Conservation Park on northern Eyre Peninsula. The first two of these three parks contain excellent interfaces between mallees and chenopod shrub associations, showing the mosaic nature of such interfaces due to topographic and edaphic variation (Sparrow, 1989).

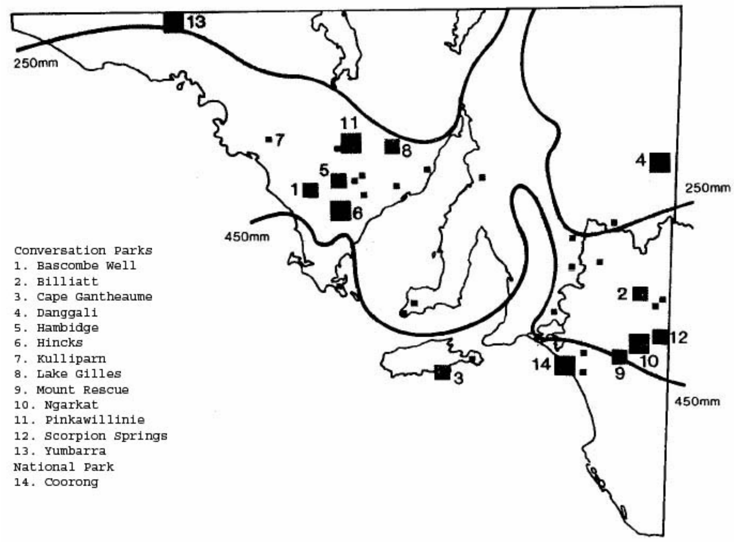


Figure 2.6 The location of Conservation and National Parks in South Australia. The different symbol sizes represent three categories of reserve area: less than 20,000 ha, between 20,000 and 50,000 ha and greater than 50,000 ha (after Sparrow, 1989).

2.3.3.3 Biogeographic patterns of plants in Western Australia

The ecology of much of the Western Australia mallee is poorly understood. Mallee dominated by eucalypts including *Eucalyptus redunca* and *E. eremophila* is mapped as widespread on areas of brown calcareous earths north of Esperance (Beard, 1975). Proceeding north on these soils into drier areas, where annual rainfall drops below about 300 mm, this vegetation is replaced by various communities dominated by appreciably taller eucalypts (more than 10 m tall), which are thus mapped as woodlands. One common type is *E. oleosa-E. flocktoniae* woodland up to 18 m tall (Parsons, 1994). There is continuous variation from this to typical mallee shrubland, *E. oleosa* varying greatly in size and occurring in both structural types (Beard, 1990). Similar woodlands occur in the same climatic region on other loamy soils, for example, the *E. transcontinenalis-E. flocktoniae* community commonly 12-18 m tall, where the dominant eucalypts are single-stemmed. The lowest of these woodlands tend to have the highest eucalypt density and the tallest, the lowest density. These woodlands and

similar ones make up the very large Goldfields area of Western Australia mapped as woodland at 1:5,000,000 by the Atlas of Australian Resources (1990).

2.3.4 Mallee species of the study sites

Six mallee species have been collected across the study sites: *Eucalyptus diversifolia*, *E. oleosa*, *E. gracilis*, *E. socialis*, *E. eremophila* and *E. transcontinentalis*, of which the last two species are endemic to Western Australia (Appendix A). Identification of species is mostly based on field examination of the flower, fruit, bark and leaves using illustrated field guides (e.g. Brooker and Kleinig (2001) which was mostly used in the following section) and Euclid (Eucalyptus identification) software (Brooker et al., 2000).

2.3.4.1 Identification of mallee species

A number of characters are commonly used in identifying the species. These include the habit, bark type, foliage, inflorescence, buds and fruit.

- Habit

The first assessment of a eucalypt will be made on approach to a tree or forest. The whole process of identification begins in the field with broad external assessment and ends with further examination of the voucher specimens in the laboratory. Considerable height and more or less erect form will place the species in the forest or woodland tree category; many stems define the mallee habit. These are the obvious features that initially confront the viewer.

- Bark

After taking into account the habit features, the next important character to assess in eucalypts is the type of bark. Each year there is an increment of living bark that results in the continually expanding girth of the tree. In all species the outermost layer dies each year. In about half of the species this dead layer completely sheds, exposing a new layer of living bark, and the process continues year after year. This group is known as the smooth barks. The dead bark may be shed from these trees in large slabs, in ribbons (Figure 2.7), or in small flakes. Invariably the newly exposed living bark is relatively smooth and brightly coloured but this fades with weathering. Commonly the dead bark comes off in pieces at various times of the year such that the trunk is mottled depending on the amount of time the newly revealed patches of bark are exposed to weathering (Brooker and Kleinig, 2001).

a) Smooth: the dead bark is shed annually, either mostly in one season or in several phases throughout the year.

b) Tessellated: the dead bark is retained and is short-fibred; it breaks into small plates.

c) Rough and compact: a few species have persistent bark, which remains dense and compacted with narrow fissues, often commonly kino impregnated.

d) Box: the dead bark is retained and is short-fibred, moderately thin, firm or hard, with narrow longitudinal fissures.

e) Ribbony: the bark comes off the branches in long ribbons which do not detach completely and remain hanging from the crown.

Figure 2.7 Ribbony bark (Brooker and Kleinig, 2001)

- Pith

Once sampled, a very handy and accessible feature is the pith of the branchlets. About half of the dry country mallees have a line of brown oil glands in the pith usually visible to the naked eye, while the remainder has a white or uniformly coloured, undifferentiated pith. This character is easily assessed in the field by pulling a side branchlet away from the main axis. Pith glands, if present, will be most conspicuous at the nodes so this is where the character should be sought for its presence or absence.

Figure 2.8 Pith glands (Brooker and Kleinig, 2001)

- Leaf

Most eucalypt species have adult leaves that are more or less the same colour on both sides. But if an adult leaf is distinctly discolorous (the upper face is darker and greener

than the lower) this is a fairly powerful tool in the discrimination of species. The discoloured appearance of the leaf is a factor of internal structure, as the green photosynthetic tissue (cells with chlorophyll-bearing chloroplasts) is near the upper surface of the leaf and is lacking towards the lower surface in this type of leaf (Harden and Williams, 1980). Another protected character is the leaf venation (arrangement of a system of veins, as in a leaf blade) and this can be characteristic of certain groups. The midrib of a leaf is the primary vein; the side veins are the secondary veins. When these are the only veins apparently present or visible, there is no reticulation, which is a strong character in assessing leaves for identification. Some characteristics of individual leaves are:

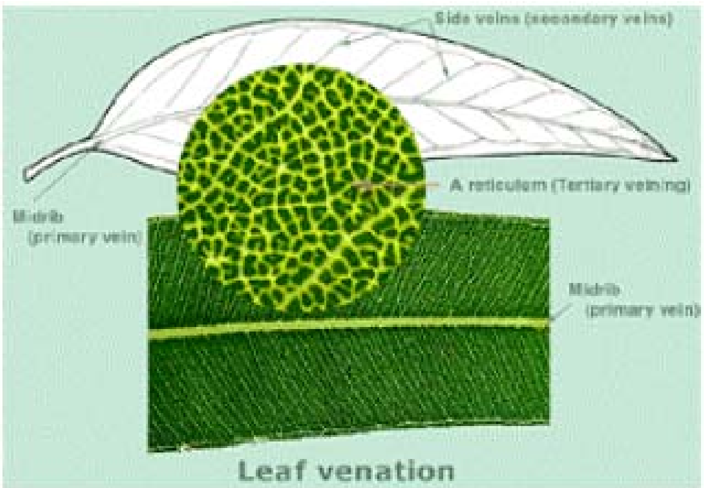


Figure 2.9 Leaf venation (Brooker and Kleinig, 2001)

a) Petiolate/sessile: with/without a leaf stalk

b) Ovate: broader below the middle, pointed at the end

c) Oblique: the two halves of the leaf blade meet at different points on the petiole

d) Glossy (dull): the leaf surface is (not) shiny

e) Glaucous: the leaf is covered with a white wax causing the leaf to look whitish, bluish, or blue-grey.

Most eucalypts in southern Australia have oil glands in the leaves, which can be seen by holding the fresh leaf up and observing the blade with oblique transmitted sunlight using a 10 × lens. There are four categories of reticulation and gland pattern (Figure 2.10):

A) The glands appear within the areoles, the smallest non-reticulated area, island glands

B) The glands appear to be at the intersections of the veinlets, intersectional glands

C) There are no observable glands

D) The glands are indistinct, usually in a thick leaf where there is a large amount of inner leaf content that impedes the transmission of the light.

The first two categories are strong aids to identification, as related species will always have similar patterns.

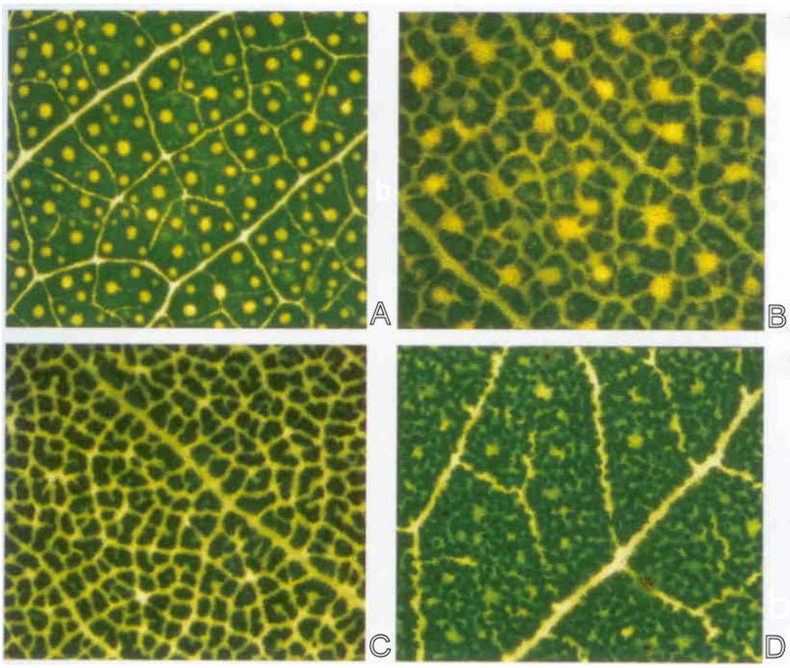


Figure 2.10 Oil gland patterns in leaves (Brooker and Kleinig, 1999)

- Inflorescences

Looking beyond the leaves, it is advisable to seek the floral structures. These are traditionally the defining aspects of species. There are numerous characters associated with them. Basically there are two contrasting forms of floral architecture, the individual flower buds or flowers, and then their arrangement on the branchlets.

a) Simple and axillary: the bud cluster occurs on a simple axillary stalk, the peduncle (the peduncle is the common stalk of an individual flower bud cluster). In cross section the peduncles may be round, elliptic or flattened with sharp edges. These characteristics may be distinct while the inflorescence is immature, and they may be obscured when in fruit.

b) Compound and axillary: the bud clusters occur decussately in several separate peduncle groups on an elongated axillary axis.

c) Compound and terminal: several to many bud clusters occur in a branched arrangement usually at the leafless ends of the branchlets and with none or few in the axils of individual leaves.

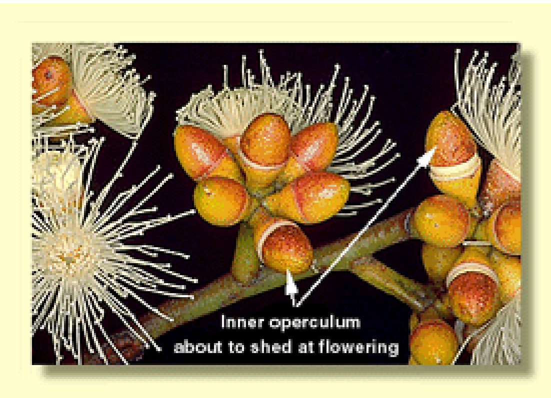


Figure 2.11 Inner opercula (Brooker et al., 2000)

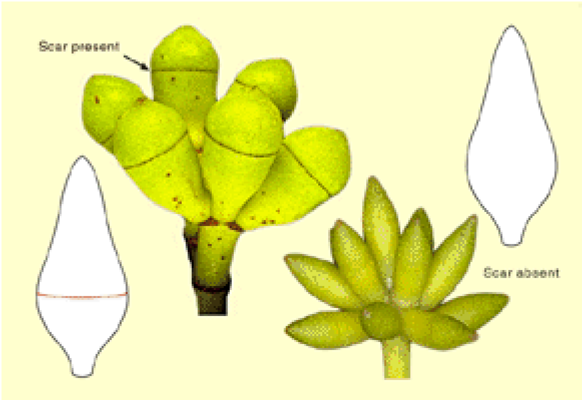


Figure 2.12 Operculum scars (Brooker and Kleinig, 2001)

The eucalypt flower lacks showy petals. The petals are in fact united very early in bud development to form a cap or a cone-shaped structure that covers the stamens and ovary during their development. This is the inner operculum, which sheds just before flowering when the stamens expand and are almost ready to shed their pollen (Figure 2.11). There is a delay in pollen ripening and dispersal to lessen the chance of self-fertilisation and consequent inbreeding.

The outer whorl of the floral parts are the sepals, which, likewise, unite to form an operculum. In the majority of species the outer operculum sheds early in bud development. In so doing, the tissue around the approximate middle of the bud, that is, where the operculum attaches to the base of the bud, dies and results in the detachment of the operculum. This leaves a scar around the middle of the bud, which is seen with the naked eye or with a lens (Figure 2.12). A few species, the monocalypts, have lost the outer operculum altogether in the evolution of the group. Therefore, throughout the development of the bud in these species there is no scar, and the side of the bud is smooth (Orchard and Thompson, 1999).

- Fruit

After fertilization, the flower enlarges, dries and develops into a woody fruit. The fruits of eucalypts, commonly called the gumnuts, are a compound structure of supporting tissue, the hypanthium, and the ovary. In bud, the ovary is sunk into the invaginated top of the pedicel (individual bud stalk) known as the hypanthium. Following fertilisation, the stamens fall from the flower, the style surmounting the ovary usually sheds, and the remaining structure becomes woody and matures into the fruit. The rim of the fruit comprises the scar or circular "platform" where the operculum was attached, then on the inner side, the narrow or broad ring of tissue that bore the stamens, and finally a band of tissue that links the rim with the ovary roof. This last tissue is the disc (Figure 2.13). The mature woody ovary may be deeply sunk in the fruit and not actually be visible below the rim, be more or less level with the rim, or in other species, the roof of the ovary may be raised above the rim (Figure 2.14).

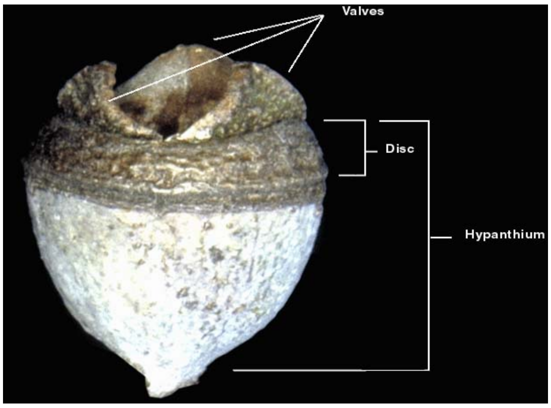


Figure 2.13 Disc and valves of the fruit of eucalypts (Brooker and Kleinig, 2001)

Of considerable value in identification are the valves. Their number and exsertion can be characteristic of species and species groups, e.g. the red gums in which the ovary splits into 3 or 4 valves, which are usually strongly exserted.

Figure 2.14 Level with rim (Brooker and Kleinig, 2001)

-Distribution of the six species of mallee in southern Australia

1- *Eucalyptus diversifolia* (Soap mallee)

Habit: Mallee to 6 m tall. Bark: smooth cream, pink, grey, yellow or brown. Juvenile: stem rounded in cross-section; juvenile leaves opposite for many pairs, sessile, amplexicaul, elliptic to ovate or oblong, to 60 mm long and 50 mm wide, becoming alternate, petiolate, lanceolate, green. Adult: leaves alternate, petiole 8-20 mm long, lanceolate to falcate (sometimes), 55-120 mm long, 8-23 mm wide, base tapering to petiole, concolorous, glossy or dull, green to blue-green

Distribution: *Eucalyptus diversifolia* is distributed widely along the coast and subcoastal plains of South Australia occurring inland in the upper South-East, particularly on leached, white sands; also a very localised occurrence at Cape Nelson in far western Victoria (Figure 2.15) and along the shore of the Great Australian Bight and inland to about Madura. The broad scale distribution of the *Eucalyptus diversifolia* correlates closely with geology and rainfall, occurring almost exclusively on the Bridgewater Formation (a Pleistocene aeolianite limestone with strong calcrete development) in areas receiving greater than 400 mm annual rainfall.

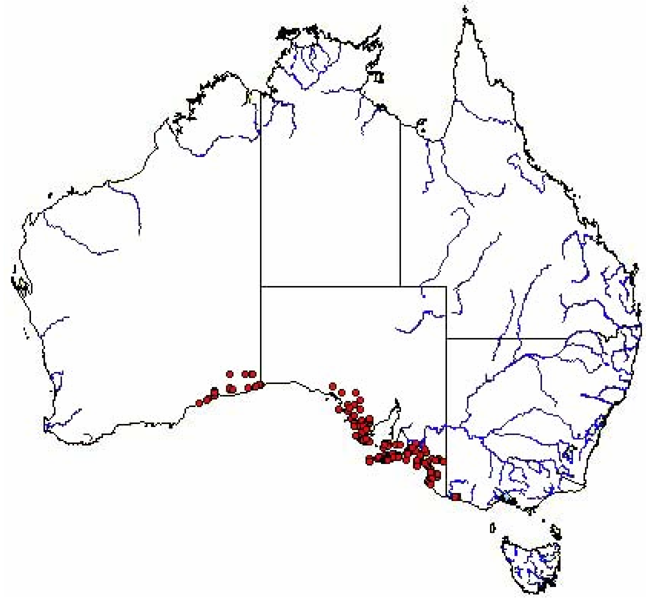


Figure 2.15 Distribution of *E.diversifolia* in southern Australia (Brooker, et al., 2000)

2- *Eucalyptus gracilis* (Yorrell, White mallee)

Habit: Mallee or tree to 7 m tall. Bark: usually rough on lower stems (rarely smooth throughout), tessellated box-type, flaky or fibrous, grey or brown; smooth bark white, pink, brown or grey, in some cases powdery. Juvenile: stem rounded in cross-section; juvenile leaves always shortly petiolate, opposite for 6 or 7 nodes, then alternate, ovate to narrowly lanceolate, 45-90 mm long, 9-18 mm wide, dull, grey-green. Adult: leaves alternate, petiole 5-15 mm long, narrowly lanceolate to linear to slightly falcate, 45-110 mm long, 4-17 mm wide, usually tapering to petiole, rarely oblique, concolorous, glossy, green.

Distribution: Widespread in the typical mallee scrubs from Western Australia through South Australia and Victoria to western New South Wales (Figure 2.16).

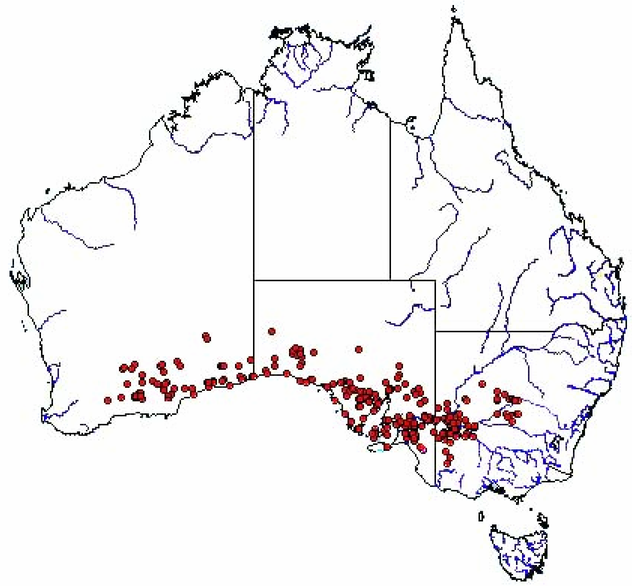


Figure 2.16 Distribution of *E.gracilis* in southern Australia (Brooker, et al., 2000)

3- *Eucalyptus oleosa* (Red mallee, Glossy-leaved red mallee)

Habit: Mallee, or rarely a tree, to 10 m tall. Bark: rough on lower stems, flaky or fibrous, usually loose grey to grey-brown, in some cases extending to large branches; smooth bark cream, grey-yellow, pink, brown or coppery, at times with short ribbons of decorticated bark in the upper branches. Juvenile: stems more or less round in cross-section, rarely slightly glaucous; juvenile leaves spirally arranged at first, later leaves decussate and finally alternate, shortly petiolate, lanceolate to linear, 22-80m cm long, 6-13 mm wide, bluish green. Adult: leaves alternate, petiole 7-17 mm long, narrowly lanceolate to linear to falcate, 55-110 mm long, 5-20 mm wide, base tapering to petiole, concolorous, glossy, green, penniveined, densely to very densely reticulate.

Distribution: *Eucalyptus oleosa* is widespread across southern Australia from Coolgardie in Western Australia east through southern South Australia, north-western Victoria and south-western New South Wales (Figure 2.17).

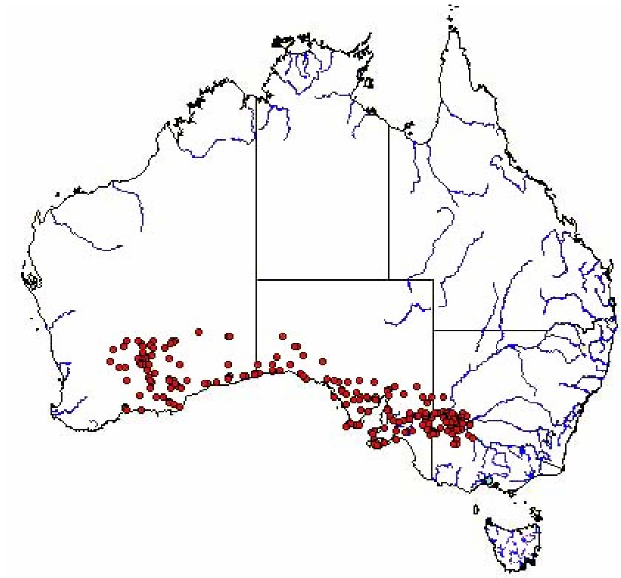


Figure 2.17 Distribution of *E.oleosa* in southern Australia (Brooker, et al., 2000)

4- *Eucalyptus socialis* (Red mallee)

Habit: Mallee to 10 m tall. Bark smooth throughout or with persistent fibrous, flaky bark on lower trunks; smooth bark white to light grey or pale coppery brown, often with ribbons of decorticated bark in the upper branches. Juvenile stem usually square in cross-section, in some cases glaucous; juvenile leaves sessile to shortly petiolate, some slightly decurrent, opposite for few to many pairs becoming subopposite then alternate (in some cases reverting for a few nodes), ovate to lanceolate or elliptical, 25-80 mm long, 8-42 mm wide, dull, green to grey-green or glaucous. Adult leaves alternate, petiole 10-30 mm long, lanceolate to falcate, 50-110 mm long, 10-25 mm wide, usually tapering to petiole, concolorous, dull green or grey-green, or glossy green in southern forms, penniveined, densely reticulate, intramarginal vein parallel to and just within margin, oil glands island and intersectional.

Distribution: Widespread in the drier parts of southern and central Australia from the south-east in the typical mallee scrubs of South Australia, Victoria and New South

Wales as far north as Wilcannia and Coolabah, extending into the desert country and occurs as far as the Pilbara in central northern Western Australia (Figure 2.18).

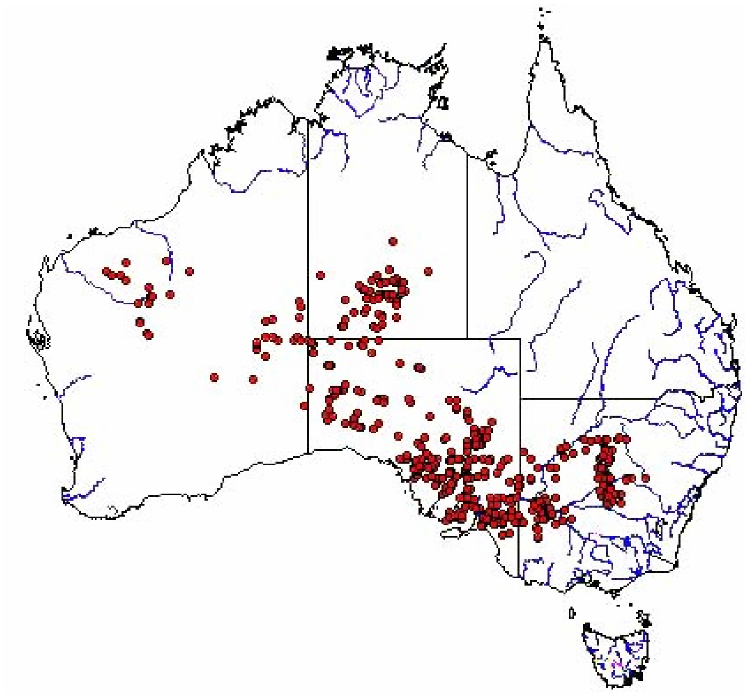


Figure 2.18 Distribution of *E. socialis* in southern Australia (Brooker, et al., 2000)

5- *Eucalyptus eremophila* (Sand mallee)

Habit: Mallee. Bark: smooth, grey-white over salmon pink to brilliant coppery. Pith of branchlets glandular. Juvenile leaves petiolate, alternating, ovate, to 110 × 40 mm, dull, blue-green. Adult leaves petiolate, alternating, narrow-lanceolate, held erect, 50-120 × 6-15 mm, concolorous, glossy, obscured by very numberous, round, island oil glands.

Distribution: widespread in the wheatbelt and goldfields of the south-west, extending to east of Zanthus and south to the coastal plains; endemic to Western Australia (no accurate distribution map available) (Brooker and Kleinig, 2001).

6- *Eucalyptus transcontinentalis* (Redwood)

Habit: small to medium-sized tree or mallee; Bark: rough, grey over most of stems or trunk. Branchlets, glauceous. Juvenile leaves: sessile, opposite and decurrent for many pairs, ovate, 30-120 × 15-45 mm, concolorous, green, blue-green or glaucous. Adult leaves petiolate, alternating, lanceolate, 60-150 × 7-22 mm, concolorous, dull, light green to grey-green; side veins numerous to sparse, regular; reticulation dense, obscure, with numerous, round island and intersectional oil glands.

Distribution: widespread from the northern wheatbelt eastward to the goldfields; endemic to Western Australia (no accurate distribution map available).

2.4. Climate

The climate of Australia is predominantly continental but the insular nature of the land mass is significant in producing some modification of the continental pattern. The pattern of climate is affected by the relative position of land and ocean surfaces. Generally, as water warms up more slowly than land because of its greater specific heat, in summer the littoral is cooler than the interior. In winter, anticyclones mostly travel along the latitude of central Australia whilst depressions (mid-latitude cyclones) travel eastwards just south of the continent bringing rain to most of its southern half. Thus southern Australia receives some reliable rain from the west only in winter when the northernmost path of the depressions is closer (Gentilli, 1972).

Australia's rainfall is thus due to several factors, such as monsoonal low pressure and winds in the north, cyclonic low pressure, winds and fronts in the south, convectional thunderstorms in the interior, and trade winds and other factors on the north-eastern coast. Years of drought in southern Australia occur when the whole belt of higher pressure and travelling anticyclones follows more southerly paths than in wet years. In

summer the interior of Australia commonly comes under the influence of northerly winds, originally of monsoonal origin but almost dry because they have lost much moisture further north. In winter this large area is under the influence of the trade winds, which here are very dry, or of the larger anticyclones; occasionally rain from a very extensive westerly front will reach this far inland.

The southern tip of the Eyre Peninsula extends far enough south to be exposed to westerly streams of oceanic air relatively free from continental influences and receives over 500 mm of rain a year with a hygric growing season of over six months. The west coast of Eyre Peninsula has the same orientation as the fronts which bring most of the rain. The isohyets, although locally affected by the hilly topography, tend to remain parallel to the west coast. In general, the east coast gets 75 mm less rain a year than the west coast at the same latitude, and the growing season is correspondingly shortened by five or six weeks. In the northern part of the Eyre Peninsula the rainfall decreases to 250 or 300 mm per year, and the hygric growing season lasts less than four months (The Commonwealth Bureau of Meteorology, 2003).

In Yorke Peninsula, 160 km long and 32 to 53 km wide, there is little climatic differentiation. Temperatures are moderate on the average, the mean maximum for February decreasing from 31°C at Kadina to 29°C at Maitland. The rainfall is favourably affected by topography. The two areas with more than 500 mm a year rainfall are near Maitland and west of Warooka, whilst the east coast, sheltered by the Maitland Plateau, gets only 300 mm per year (French et al., 1968).

The Murray Lowlands lie in the lee of the Mt Lofty Range and, in general, continentally prevails, except for times when a cool change or a marked sea breeze sweeps inland. At Berri the highest temperature recorded is 47°C, in January, but temperatures above 38°C may occur between October and March. The annual rainfall

in the north is about 250 mm, in the south-east 400 mm, with a maximum in the winter or the spring, a minor peak in February due to tropical cyclones or thunderstorms and, occasionally and locally, a very minor peak in October. Only a few months get more than 25 mm of rain, or in the south, more than 50 mm (The Commonwealth Bureau of Meteorology, 2003).

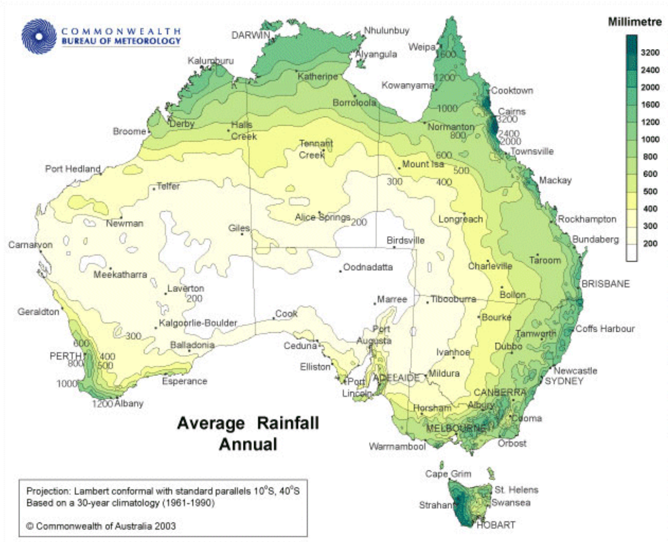


Figure 2.19Average annual rainfall map of Australia (The Commonwealth Bureau of Meteorology, 2003)

The Yilgarn Craton has a semi-arid to Mediterranean climate with wide ranges in annual rainfall from 150mm to 1400 mm and an annual evaporation potential of 2500–4100 mm (The Commonwealth Bureau of Meteorology, 2003). Rainfall may vary widely between different years and droughts and floods are features of the semi-arid region. From the southwest to the northeast margin, there is a generally consistent and marked decrease in rainfall and an increase in temperature and potential evaporation. The reliability of the rainfall decreases progressively to the north, where summer cyclonic rains contribute significantly to the major rainfall and these storms can move south, causing irregular heavy falls.

Chapter 3 : BIOGEOCHEMICAL SURVEYS: DESIGN, SAMPLING PROCEDURES AND ANALYTICAL METHODS

3.1 Introduction

Low-density geochemical surveys provide a cost-effective means to assess the composition of near-surface materials over large areas. An aim of the current research is to develop the application of this methodology to mallee eucalypt-dominated areas of southern Australia. Most procedures, including sample collection, preparation and chemical analyses (except Instrumental Neutron Activation Analysis (INAA) which was conducted by the Becquerel Laboratories, NSW Australia) were performed by the author.

Soil and plant samples were collected during two comprehensive fieldtrips during the autumn of 2004 across the study areas (Figure 3.1). Each of the 94 sites (Appendix A) was chosen to represent regionally significant geological units and not selected on the basis of an equi-spaced or statistical grid, but rather chosen by making the best use of existing knowledge (e.g. earlier calcrete studies, geology, vegetation and soil maps). The average sampling density is 1 sample per 300 km^2, but it was considerably increased (to about 1 per 100 km^2) in areas where a steep gradient in changing lithology could be expected, and decreased (to about 1 per 600 km^2) in areas with nearly homogeneous bedrock.

3.2 Sampling procedures

Soil

Soil forms the upper layer of the regolith containing living matter and supporting or capable of supporting, plant life. Knowledge of soil chemistry is an essential

prerequisite for the proper understanding of biogeochemical patterns. This is because vegetation and soils are closely interconnected and interdependent. The relationship between the soil and its vegetation is so close as to be considered an integral part of the biogeochemical technique (Kovalevsky, 1987; Palmer, 1995).

Soil sampling therefore will be considered as an adjunct to prospecting methods involving plant analysis; that is, for determining BAC (biological absorption coefficient) values (Chapter 5) or for comparing the relative performance of the two sample types in detecting dispersion patterns.

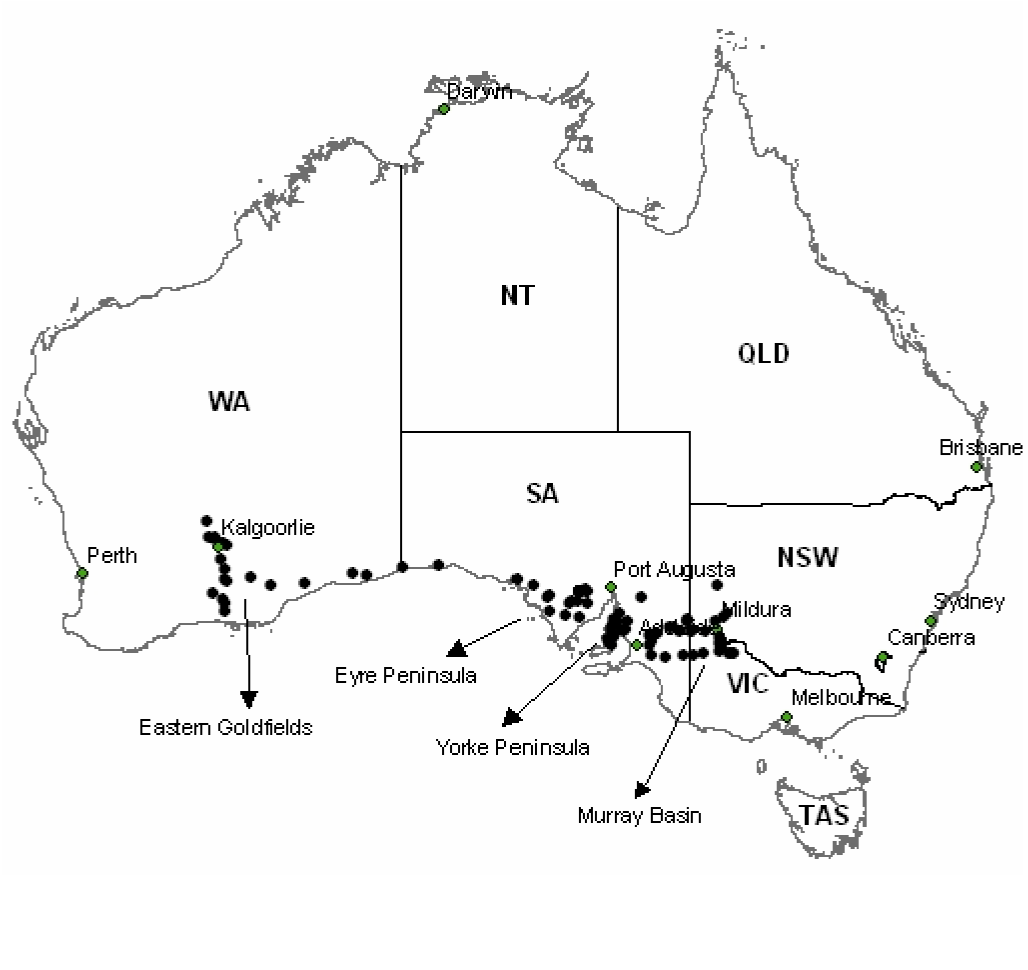


Figure 3.1 Distribution of the 94 sampling sites across southern Australia.
NSW: New South Wales, NT: Northern Territory, QLD: Queensland, SA: South Australia, TAS: Tasmania, VIC: Victoria, WA: Western Australia

Soils were sampled from 100–200 mm depth to avoid recent transported material. Each individual sample weighed approximately 500 g, sufficient to yield 30 g to 50 g of

representative sample powder to use during the analytical studies (Rose et al., 1979; Thornton, 1983). The samples were collected using a hand auger (a stainless steel screw) to approach the target depth, excavated with a plastic spade, and placed in nylon bags.

Air drying is the most accepted procedure for soil sample preservation as this may reduce the rate of possible post-collection changes (Tan, 1996). The temperature must not exceed 35 °C because drying at elevated temperatures may cause changes in the physical and chemical characteristics of the soil sample (Patnaik, 1997).

The samples were therefore, air-dried, passed through a 355 μm stainless steel sieve to separate the fine fraction from the sand fraction and the finer fraction used for INAA. The samples needed further preparation prior to chemical analysis by ICP-MS which is discussed later.

Vegetation

The value of plant analysis for detecting trace element status of plants hinges largely on the care that is taken in collecting, handling and analysing the gathered plant material (Reuter and Robinson, 1997). Unreliable and misleading interpretations will occur unless proper steps are taken to minimize errors in each of the above tasks. Procedures for sampling and handling plants should be standardized to ensure that the tests can be interpreted with confidence.

Vegetative material was sampled at each sampling site across the study area. The sampling procedure was developed from a number of other methods that have been cited throughout this chapter (e.g. Dunn, 1995). As explained in the previous chapter, the selection of plants was limited to those that were readily identified, dominant and widespread in southern Australia. Individuals were of similar size, age and health so that results were comparable. In addition, each plant organ has a different capacity to

store nutrients and metals and, therefore, valid conclusions may only be drawn by comparing the same plant tissues (Dunn, 1995; Ernst, 1996).

For this research, mallee bark, twigs and leaves were sampled, with above-ground vegetative material providing results that should adequately reflect the elemental abundances of the entire plant (Reuter and Robinson, 1997). Plant organs with obvious deformities and desiccation were avoided. Also, nutrient levels have been reported to vary between sun and shade leaves (Salisbury and Ross, 1978; Brooks et al., 1995). To minimize these problems, it was necessary to sample from different orientations around the plant to gain an estimate of whole-plant chemistry (Appendix S).

The amount of sample taken needed to be sufficient for analysis and to be representative of the individual chemistry (Dunn, 1995). A sample of between 100-200g was collected. Whole upper branches were collected, and later separated into twigs and leaves. The outer bark was collected, as it is commonly more informative and has higher trace element concentrations (Kovalevsky, 1987). Once collected, samples were stored in cloth bags to avoid mould development.

In biogeochemical studies in the high-latitude northern hemisphere, sampling is typically undertaken in spring, when plants are most physiologically active (Mohr and Schopfer, 1995). However, in semi-arid areas of southern Australia, there is no distinct growing season. Plant sampling was therefore conducted during autumn, when the plants are experiencing a high rate of physiological activity.

The sample preparation procedure involved the washing, drying and grinding of samples. However, there are no consistently reported clearly defined protocols for cleaning vegetation samples. Washing with water (tap, deionised, distilled or ultrasonic bath), detergents and dilute acids are the most commonly used methods of cleaning.

In this study, plant samples were thoroughly rinsed in deionised water and then placed in an ultrasonic bath with deionised water for ten minutes to remove soil particles. This stage was repeated three times, and plant material was finally rinsed with deionised water. One portion of some selected leaf samples was left unwashed to assess possible environmental issues (airborne pollution).

The plant samples were dried at 60°C for 24–48 hours to constant weight. High temperature (above 70°C) drying for long periods (more than 48 hours) was avoided, as it causes significant losses in total weight, in volatiles or leads to charring. Conversely, temperatures below 70°C will not halt metabolic activity and mould development that can alter element abundances, particularly if the samples are initially damp (Bargali et al., 1993; MacNaeidhe, 1995). The vegetative materials were then placed in a food blender and macerated to less than 2 mm size. The blender was cleaned between samples with compressed air and washed with deionised water and dried with compressed air.

The pulverized samples were considered representative of each sample site. For each sample, 10-15 g, depending on the tissue type, of macerated plant material were packed into labelled and sealed polyethylene containers for INAA. Dried vegetation subsamples were also digested using a microwave method and analysed by ICP-MS as explained later in this chapter.

3.3 Analytical methods

This section briefly explains the two important analytical methods applied in this research, namely Instrumental Neutron Activation Analysis (INAA) and Inductively Coupled Plasma-Mass Spectrometry (ICP-MS).

3.3.1 Instrumental Neutron Activation Analysis (INAA)

The 1980s saw significant developments in commercial analytical packages based on INAA and its sensitive, interference-free capabilities in the determination of Au. Features such as the unrivalled simplicity of INAA, its flexibility to handle a range of sample weights (e.g. 1-20g) and its ability for direct analysis without sample decomposition has encouraged its application. Moreover, it is a largely non-destructive technique so that once the sample has cooled down, it can be used for other analyses or archived (Hall, 1995).

It is particularly suitable for vegetation as this matrix is highly concentrated in such elements as C, N, H and O which create a very low background spectrum and hence relatively few interferences compared to, for example, rocks or sediments. Furthermore, ashing can be avoided and hence potential losses due to volatilization or contamination by elements introduced during sample decomposition negated.

Table 3.1 lists the detection limits by INAA for vegetation in the dried form and for soil. In this research, in the generation of the gold + 31 elements package, a flux monitor was attached to each sample and all samples were activated for 10 to 30 min in a thermal neutron flux of 2 to 4×10^{12} n cm^{-2} s^{-1}. An initial count was done after 7 days, with each sample counted for 60 min. A second count was done after a further 7–14 days decay, with each sample counted for 120 min for this later count. The gamma ray spectra were measured using hyperpure Ge coaxial detectors linked to multichannel analyzers as part of an integrated counting control and data handling system. Spectral data were analyzed using in-house programs developed by Becquerel Laboratories at the Lucas Heights Research Laboratories (Sydney).

Table 3.1 Typical detection limits for dried plant and soil by INAA in this research

	Plant		Soil	
Element	Unit	DL	Unit	DL
Ag	ppm	0.2	ppm	2
As	ppm	0.1	ppm	0.5
Au	ppb	0.5	ppb	3
Ba	ppm	5	ppm	50
Br	ppm	0.1	ppm	0.5
Ca	ppm	200	%	0.1
Ce	ppm	0.3	ppm	1
Co	ppm	0.1	ppm	0.5
Cr	ppm	0.2	ppm	2
Cs	ppm	0.02	ppm	0.5
Eu	ppm	0.02	ppm	0.2
Fe	ppm	20	%	0.01
Hf	ppm	0.01	ppm	0.2
Ir	ppb	1	ppb	10
K	ppm	500	%	0.1
La	ppm	0.02	ppm	0.2
Lu	ppb	5	ppm	0.1
Mo	ppm	1	ppm	2
Na	ppm	10	%	0.005
Rb	ppm	0.5	ppm	5
Sb	ppm	0.02	ppm	0.1
Sc	ppb	5	ppm	0.05
Se	ppm	0.2	ppm	2
Sm	ppm	0.01	ppm	0.1
Ta	ppm	0.05	ppm	0.5
Te	ppm	0.2	ppm	2
Th	ppm	0.01	ppm	0.2
U	ppm	0.2	ppm	0.5
W	ppm	0.2	ppm	1
Yb	ppm	0.02	ppm	0.3
Zn	ppm	1	ppm	20
Zr	ppm	10	ppm	200

3.3.2 Inductively Coupled Plasma-Mass Spectrometry (ICP-MS)

The development of Inductively Coupled Plasma-Mass Spectrometry (ICP-MS) is one of the most significant analytical advances to occur in the past 20 years, as it allows multi-element analysis of solutions and solids at subnanogram concentrations.

3.3.2.1 Experimental procedures

- Instrumentation

The ICP-MS instrument used was the Agilent 7500ce (Agilent Technologies, Inc., Japan) equipped with an integrated autosampler (Agilent Inc., Germany). Details of the operating conditions and measuring parameters are summarized in Table 3.2. A microwave (MW) digestion unit (ETHOS SEL Microwave Solvent Extraction System, Milestone Srl, Bergamo, Italy) equipped with MPR- 600/12S Rotor with TFM Teflon vessels (maximum operating temperature and pressure 260ºC and 500 psi respectively) was used for sample dissolution.

Table 3.2 ICP–MS operating conditions and measurement parameters

Plasma gas flow rate	16 L/min
Carrier gas flow rate	0.74 L/min
Make-up flow	0.4 L/min
RF power	1550 W
Nebulizer Microflow	100 μL/min (Agilent)
Spray chamber	Glass double pass
Spray chamber temperature	Cooled to 2 °C
ICP torch injector	2.4 mm
Sample tubing	0.89 mm i.d.
Instrument peristaltic pump	0.1 rps
Sample/skimmer cones	Nickel
Rotary pumps	2
Autosampler	I-AS (Germany)

- Chemicals and reagents

All calibration standard solutions used were prepared by serially diluting multi-element standard solutions (ICP multi-element standard solution VI, Merck). Indium

and yttrium (all from Merck, Darmstadt, Germany) were used as internal standards and were added to all solutions at about 15 µg/L concentration.

Nitric acid 65 % Suprapure (Merck, Darmstadt, Germany) was used for microwave-assisted digestion and analysis process.

High-purity Milli-Q+Element water (Millipore, Bedford, USA) was used for dilution of the standards, for preparing samples and for final rinsing of the acid-cleaned vessels.

The following certified reference materials were analyzed: NIST SRM 1575a Pine needles and NIST SRM 2709 San Joaquin soil (both from the National Institute of Standards and Technology, Gaithersburg, MD, USA).

- Soil sample digestion procedure

Of the soil sample pulverized by agate mortar and pestle, 0.2-0.3 g was weighed into a 100ml TFM Teflon digestion vessel to which 8 ml of HNO_3 was added. For this research, each digestion batch (12 vessels) underwent a two-step microwave heating program (Table 3.3). Following the digestion, the digested samples were brought to a volume of 100 ml with Milli-Q+Element water in volumetric flasks. For the final analysis, this was further diluted with Milli-Q+Element water.

Table 3.3 Microwave program for digestion procedure of soil

Step	Time (min.)	Temperature (ºC)	Power (Watt)
1	7	Up to 185	Up to 1000
2	8	185	1000

- Plant sample digestion procedure

The plant material (0.2-0.3 g) was digested with the addition of 8 ml of HNO_3. The heating program similar to soil samples was applied (Table 3.4). After cooling to room temperature, the digests were diluted about 10-fold using Milli-Q+Element water and

further diluted resulting in a dilution factor of approximately 1000 prior to ICP-MS analysis.

Table 3.4 Microwave program for digestion procedure of vegetation

Step	Time (min.)	Temperature (ºC)	Power (Watt)
1	10	Up to 170	Up to 900
2	10	170	900

- ICP-MS Analysis

The digested samples, quality controls, blanks, and standards were injected into the ICP-MS torch, where argon gas plasma was used to ionize the injected sample. The resulting ions passed though a two-stage interface (sample and skimmer cones) designed to enable the transition of the ions from atmospheric pressure to the vacuum chamber of the ICP-MS system.

Prior to measurement, the ICP-MS was optimised for oxide formation by means of the ratio CeO^{+}/Ce^{+}, and for the formation of double-charged ions by means of the Ce^{2+}/Ce^{+} couple. External calibration was performed with multi-element standard solutions. Internal standards (In, Y) were added to samples, blank and multi-element standard solutions before introducing the solutions to the plasma. Each sample was measured in triplicate to generate a measurement average with standard deviation.

Samples were analysed in sequences containing synthetic blanks (2% HNO_3), preparation blanks, samples and standards. For external calibration, different sets of standards were used: 0, 5, 20 and 100 ppb for plant and 0, 5, 20, 100 and 500 ppb for soil for 12 trace elements (B, Be, Cd, Cu, Ga, Li, Mn, Ni, Pb, Sr, Tl and V).

3.4 Results

Of the 32 elements analyzed by INAA, the following were not detected (Table 3.1) in vegetation; Ir, Mo, Ag, U and Zr. The elements Sb, Lu, Se, Ta and W were detected in only a few biosamples and therefore, were not considered in data analysis in this research. Also, Ir, Se, Ag, Te and Mo were not detected in soils and so were eliminated from the further analysis.

Most elements analysed by ICP-MS were detected in vegetation except Be and Cd which were detected in only a few biosamples. For the soil samples, ICP-MS detected all analysed elements, except for B which was found in 53% of samples (Appendix I).

Table 3.5 Multi-element concentration ranges for plant tissues (Appendix E), across all study areas

			bark		twig		leaf	
Element	Method	Unit	Min.	Max.	Min.	Max.	Min.	Max.
As	INAA	ppm	<0.1	0.44	<0.1	0.53	<0.1	0.95
Au	INAA	ppb	<0.5	4.2	<0.5	2.47	<0.5	1.71
B	ICP-MS	ppm	1.67	23.2	3.9	23.8	11.24	167.9
Ba	INAA	ppm	<5	16.6	<5	14.9	<5	14.2
Be	ICP-MS	ppb	<0.004	20.3	<0.004	71.2	<0.004	152
Br	INAA	ppm	2.23	14	2.54	24.2	14.4	78
Ca	INAA	ppm	1840	31800	4390	25600	2700	18000
Cd	ICP-MS	ppb	<0.005	159.5	<0.005	497.2	<0.005	134.3
Ce	INAA	ppm	<0.3	1.06	<0.3	1.6	<0.3	1.09
Co	INAA	ppm	<0.1	0.32	<0.1	0.19	<0.1	0.49
Cr	INAA	ppm	<0.2	1.67	<0.2	5.21	<0.2	1.27
Cs	INAA	ppm	<0.02	0.066	<0.02	0.061	<0.02	0.043
Cu	ICP-MS	ppm	0.3	3.96	1.07	10.15	0.73	10.2
Eu	INAA	ppm	<0.02	0.03	<0.02	0.063	<0.02	0.028
Fe	INAA	ppm	<20	403	<20	88.5	25.6	200
Ga	ICP-MS	ppm	<0.0001	0.64	<0.0001	0.93	<0.0001	0.67
Hf	INAA	ppm	<0.01	0.087	<0.01	0.017	<0.01	0.027
K	INAA	ppm	<500	2830	<500	5550	<500	8520
La	INAA	ppm	<0.02	0.52	<0.02	0.525	<0.02	0.474
Li	ICP-MS	ppm	<0.0001	0.72	<0.0001	1.37	<0.0001	6.5
Mn	ICP-MS	ppm	1.57	57.3	1.7	299.5	2.41	95.8
Na	INAA	ppm	318	3180	512	3770	1760	7650
Ni	ICP-MS	ppm	<0.0001	1.69	0.16	7.06	0.09	5.39
Pb	ICP-MS	ppm	<0.0001	0.6	0.02	0.85	<0.0001	0.34
Rb	INAA	ppm	<0.5	1.46	<0.5	1.6	<0.5	2.98
Sb	INAA	ppm	—	—	—	—	0.026	0.034
Sc	INAA	ppm	<0.005	0.146	<0.005	0.033	<0.005	0.065
Sm	INAA	ppm	<0.01	0.1	<0.01	0.21	0.2	0.34
Sr	ICP-MS	ppm	15.3	345.7	37.1	428.9	6.8	506.2
Te	INAA	ppm	<0.2	0.39	<0.2	0.37	<0.2	0.29
Th	INAA	ppm	<0.01	0.194	<0.01	0.036	<0.01	0.08
Tl	ICP-MS	ppb	<0.0005	104.7	1	14	1.3	60.4
V	ICP-MS	ppm	0.02	0.51	0.02	0.24	0.02	0.31
W	INAA	ppm	<0.2	0.24	—	—	<0.2	0.4
Yb	INAA	ppm	<0.02	0.05	<0.02	0.03	<0.02	0.03
Zn	INAA	ppm	<1	50.5	<1	43	<1	24

Table 3.6 Multi-element concentration ranges for soil samples (Appendix I), across all study areas

Element	Method	Unit	Min.	Max.
As	INAA	ppm	<0.5	59.4
Au	INAA	ppb	<3	85.9
B	ICP-MS	ppm	<0.001	21.8
Ba	INAA	ppm	<50	529
Be	ICP-MS	ppm	0.08	0.48
Br	INAA	ppm	0.71	64.8
Ca	INAA	%	<0.1	19.1
Cd	ICP-MS	ppm	0.01	0.56
Ce	INAA	ppm	5.42	78.4
Co	INAA	ppm	0.74	38.5
Cr	INAA	ppm	7.6	1790
Cs	INAA	ppm	<0.5	3.5
Cu	ICP-MS	ppm	0.4	39.3
Eu	INAA	ppm	<0.2	1.41
Fe	INAA	%	0.28	7.72
Ga	ICP-MS	ppm	1.2	8.3
Hf	INAA	ppm	1.76	11
K	INAA	%	0.12	2.07
La	INAA	ppm	2.55	41.7
Li	ICP-MS	ppm	2	15.6
Lu	INAA	ppm	<0.1	0.44
Mn	ICP-MS	ppm	8.1	332.3
Na	INAA	%	0.02	1.53
Ni	ICP-MS	ppm	1.4	151.2
Pb	ICP-MS	ppm	1.1	79.1
Rb	INAA	ppm	<5	109
Sb	INAA	ppm	<0.1	3.9
Sc	INAA	ppm	1.02	33.1
Sm	INAA	ppm	0.5	5.63
Sr	ICP-MS	ppm	4.4	432.8
Ta	INAA	ppm	<0.5	1.79
Th	INAA	ppm	1.32	17.5
Tl	ICP-MS	ppm	0.02	1.28
U	INAA	ppm	<0.5	2.59
V	ICP-MS	ppm	3.4	63.6
W	INAA	ppm	<1	4.25
Yb	INAA	ppm	0.35	3.14
Zn	INAA	ppm	<20	156
Zr	INAA	ppm	<200	540

- Precision of the analytical methods

The quality control procedures consisted of inserting analytical duplicates of some leaf samples at a rate of 1 in 10 samples. The results were then tested against a precision chart with the target of 10% precision at 95% confidence level (Figure 3.2 using Br as an example; and Appendix B).

In this chart, the lines D_{90} and D_{99} are respectively the 90^{th} and 99^{th} percentiles of the absolute difference between duplicates as a function of concentration, assuming a normal distribution of error. If the duplicate data comply with the specification, on average 90% of the points will fall below the D_{90} line and 99% points below the D_{99} line. If the precision is better, a higher proportion of the points will tend to fall below the lines and if worse, the opposite situation will tend to occur (Thompson and Howarth, 1978). Excellent precision was obtained, with the average difference between the concentrations obtained for duplicate samples falling between 19% (Fe) and 1% (Br).

A similar procedure was applied for the quality control of the ICP-MS analyses (Appendix B). The average difference between the values obtained for the duplicates varies from 2% (for Cd and Cu) to 18% (Sr).

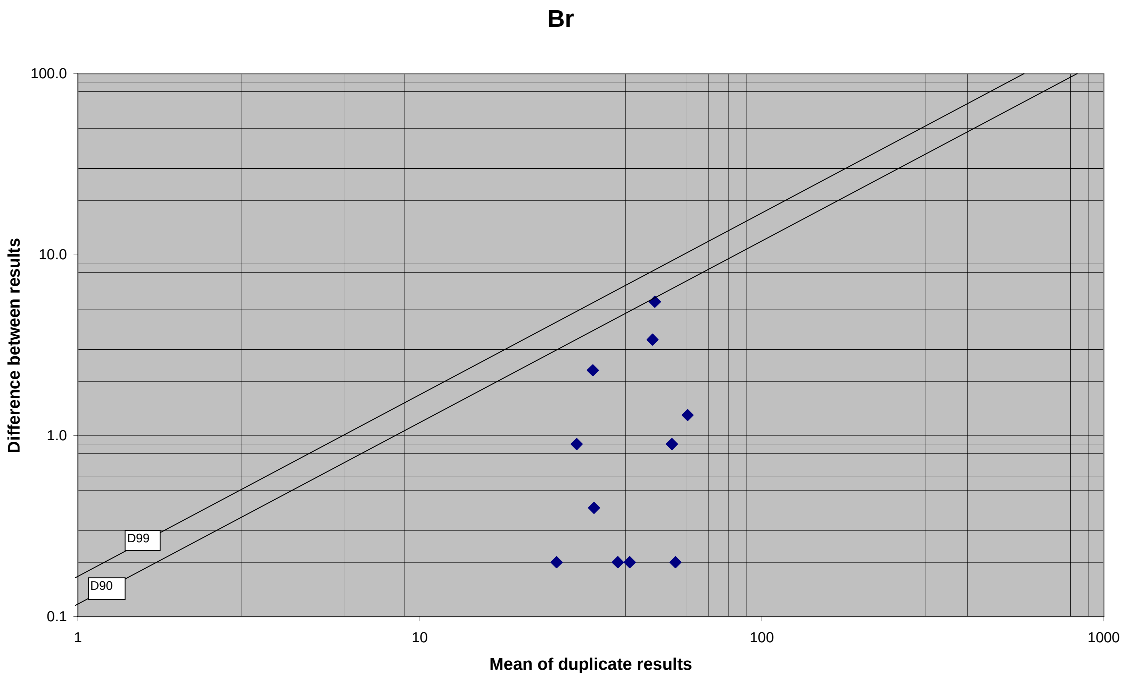


Figure 3.2 Precision Control chart for the determination of Br in biosamples (leaf) by INAA.

Chapter 4 : BIOGEOCHEMICAL DISPERSION PATTERNS WITHIN MALLEE PLANTS

4.1 Introduction

The value of reconnaissance geochemical surveys that involve the collection of lake or stream sediments or soils has been extensively tested and documented. By contrast, this research involves, in part, a reconnaissance biogeochemical survey using mallee plants across southern Australia. Accordingly, this presents a special opportunity to study the response and tolerance of trace element abundances and distributions among a little-studied but abundant medium (mallee eucalypts).

4.2 Statistical procedures

A sound statistical interpretation of the data is important within most biogeochemical investigations, especially where the contrast between typically low values (weak anomalies) in vegetation are close to background (Brooks et al., 1995). The first criterion applied for data clustering was a consideration of the proportion of data displaying element concentrations above the detection limit of the analytical methods.

The procedures for handling censored data depend on the technical application involved. The best method to use generally depends on the amount of data below the detection limit and the size of the data set. In general, the performance of the substitution methods deteriorates when the percentage of '< DL' values exceeds 30% (Farnham et al., 2002). Depending on the trace element data set that is evaluated, the percentage of values below the detection limit may exceed this amount. For these cases, it may be preferred to use the uncensored data where available (Aruga, 1997). Use of

uncensored data can commonly be useful for evaluation of the trace element chemistry when the biogeochemical data from different locations and sites vary substantially. For instance, the concentration of certain trace elements from one region may be quite low (i.e., $< DL$) but may be substantially higher in another region (HDL). These trace elements would therefore be quite useful in distinguishing anomalies from these different regions. On the other hand, the concentrations of these trace elements may be quite low in the entire study area and including them in the evaluations may just add substantial noise to the analysis. In these situations, robust techniques such as Exploratory Data Analysis (EDA) are commonly required to accurately infer the distributional properties from these data sets (Wellmer, 1998).

As a result, the mallee biogeochemical data sets were divided into two categories, based on the amount of uncensored results. The first category included trace elements in each plant organs with more than 70% of data above the detection limit of the analytical method and the second group comprised the elements with less than 70% of data above the limit of detection. The classification of the latter data set was treated by EDA, while cumulative frequency curves was applied for the first category.

4.3 Analysis of variance of biogeochemical data

To evaluate any possible chemical differentiation among different plant organs, the first data set was used. The values were log-transformed to approximate normal distributions and to make the variance independent of the mean and to avoid the effect of greater means = greater variances (Sokal and Rohlf, 1995). A probability of 0.05 or lower was considered as significant. Table (4.1) shows the list of elements for each organ considered for analysis of variance (ANOVA).

Table 4.1 selected elements considered for ANOVA

Bark	Twig	Leaf
B	B	B
Br	Br	Br
Ca	Ca	Ca
Cd	Cd	Cu
Cu	Cu	Fe
Fe	Fe	Ga
Ga	Ga	K
K	K	La
La	La	Li
Li	Li	Mn
Mn	Mn	Na
Na	Na	Ni
Ni	Ni	Pb
Pb	Pb	Rb
Sc	Rb	Sc
Sm	Sc	Sm
Sr	Sm	Sr
Tl	Sr	Tl
V	Tl	V
Zn	V	Zn
	Zn	

Table 4.2a Summary statistics of elemental concentrations (ppm) for bark samples

	ADL*	Min	Max.	Mean	SD
B	94	1.67	23.19	8.93	4.13
Br	94	2.23	14	7.46	2.73
Ca	94	1840	31800	9035	6696
Cu	94	0.3	3.96	1.12	0.54
Fe	89	<20	403	63	53
Ga	84	<0.01	0.64	0.12	0.1
K	60	<500	2830	1089	528
La	88	<0.02	0.52	0.08	0.07
Li	90	<0.01	0.72	0.13	0.12
Mn	94	1.57	57.35	7.78	8.93
Na	94	318	3180	1225	454
Ni	92	<0.01	1.69	0.29	0.25
Pb	84	<0.009	0.60	0.13	0.11
Sc	91	<0.005	0.15	0.02	0.02
Sm	89	<0.01	0.1	0.02	0.01
Sr	94	15.3	345.7	72.6	55.2
Tl	86	<0.0005	104.72	4.34	11.2
V	94	0.02	0.51	0.1	0.09
Zn	83	<1	50.5	4.65	6.72

*ADL: number of data which are above the detection limit (maximum is 94, being the number of samples sites)

Table 4.2b: Summary statistics of elemental concentrations (ppm) for twig samples

	ADL	Min	Max.	Mean	SD
B	94	3.90	23.8	9.61	3.81
Br	94	2.54	24.2	8.86	4.04
Ca	94	4390	25600	11743	4382
Cu	94	1.07	10.15	2.94	1.63
Fe	89	<20	89	42	15
Ga	89	<0.01	0.93	0.22	0.16
K	94	884	5550	2456	781
La	89	<0.02	0.53	0.1	0.1
Li	87	<0.01	1.37	0.19	0.22
Mn	94	1.70	299.5	33.14	41.96
Na	94	512	3770	1636	698
Ni	94	0.16	7.06	0.76	0.84
Pb	94	0.02	0.85	0.14	0.13
Sc	93	<0.005	0.03	0.01	0.01
Sm	93	<0.01	0.24	0.03	0.03
Sr	94	37.1	428.9	114.2	63.1
Tl	94	1	14	5.39	2.74
V	94	0.02	0.24	0.1	0.05
Zn	94	2.24	43	9.45	7.03

Table 4.2c: Summary statistics of elemental concentrations (ppm) for leaf samples

	ADL	Min	Max.	Mean	SD
B	94	11.24	167.9	54.51	33.53
Br	94	14.4	78	41.82	12.44
Ca	94	2700	18000	6405	2584
Cu	94	0.73	10.2	3.12	1.44
Fe	94	26	200	81	38
Ga	91	<0.01	0.67	0.18	0.13
K	94	2710	8520	4941	1366
La	69	<0.02	0.47	0.08	0.07
Li	92	<0.01	6.5	0.87	0.94
Mn	94	2.41	95.79	30.54	20.71
Na	94	1760	7650	3874	1145
Ni	94	0.09	5.39	1.04	0.94
Pb	86	<0.009	0.34	0.11	0.06
Sc	93	<0.005	0.07	0.02	0.01
Sm	94	0.01	0.09	0.03	0.01
Sr	94	6.8	506.2	51.6	57.1
Tl	94	1.3	60.4	18.38	15.42
V	94	0.02	0.31	0.1	0.06
Zn	94	4.46	24	9.8	3.86

4.3.1 Comparison of multi-elemental responses in different plant organs

The summary statistics of elemental concentrations of bark, twig and leaf samples are summarized in Table 4.2. A preliminary investigation of plant composition from the

study area indicates differences in elemental concentrations among the three sample media, where the mean concentrations of 12 of 19 elements in the leaf samples are higher than in the other tissues (bark, twigs).

The statistical significance was computed by ANOVA followed by multiple comparison of means by the one of the post-hoc tests, Tamhane's T2 tests which do not assume equal variances (Hoaglin et al., 1983).

Robust ANOVA for unbalanced data was performed to see whether the apparent differences in the averages computed for the plant organs are significantly different. The post hoc multiple comparison tests are performed for each element separately.

ANOVA of fifteen (B, Br, Ca, Cu, Fe, Ga, K, Li, Mn, Na, Ni, Sc, Sr, Tl and Zn) of the 19 elements investigated displayed significant concentration differences between organs whereas mean contents of La, Pb, Sm and V showed no significant differences between plant tissues, which are discussed later in this chapter.

4.3.2 Plant chemistry responses to plant species and lithological variation

Compiled geological maps and field observations of bedrock types were used to evaluate the spatial association between bedrock lithology and biogeochemistry. This was achieved by a spatial overlay of the geological maps, which were simplified to five lithotypes (unconsolidated Neogene sediments (Cz), limestone (LS), sandstone and siltstone (S), granitic rocks (G), basic and ultrabasic rocks (UB)), using a Geographical Information System (GIS). To examine of the effect of plant species and lithological variation in each sample a two-way ANOVA produced models for estimation of these possible variations.

Table 4.3 Summary of two-way ANOVA of the biogeochemical survey

	Bark		Twig		Leaf	
	Plant species	Bedrock	Plant species	Bedrock	Plant species	Bedrock
B	-	-	-	-	-	-
Br	*	*	-	*	-	-
Ca	*	-	*	*	-	-
Cd	*	-	*	-	-	-
Cu	-	-	-	-	-	-
Fe	-	-	*	*	*	*
Ga	-	*	*	*	-	*
K	*	*	*	-	-	*
La	-	-	-	-	-	-
Li	-	-	-	-	*	-
Mn	-	*	-	*	-	*
Na	*	*	*	*	-	-
Ni	-	*	-	*	-	*
Pb	-	-	-	*	-	-
Rb	-	-	-	-	-	-
Sc	-	-	*	*	*	*
Sm	-	-	*	-	-	-
Sr	-	*	-	*	-	*
Th	-	-	-	-	-	-
Tl	-	-	-	-	-	*
V	-	-	-	*	-	-
Zn	-	-	-	-	-	*

* Significant difference

Br, Ca, Cd, K and Na in bark, Ca, Cd, Fe, Ga, K, Na, Sc and Sm in twigs, and Fe, Li and Sc in leaves show significant differences between mallee species (Table 4.3 and Appendix C). For instance in twigs, there is a significant difference between Sm contents in *E. oleosa* and *E. eremophila*, whereas for the other plant tissues, no significant differences are distinguishable. Also, *E. Gracilis* and *E. Socialis* showed different responses in Na uptake in bark and twigs, whereas Sc and Fe in twigs and leaves show difference concentrations between mallee species. Ga in twigs showed significant differences between *E. eremophila* and other mallee species sampled in this study (Figure 4.1).

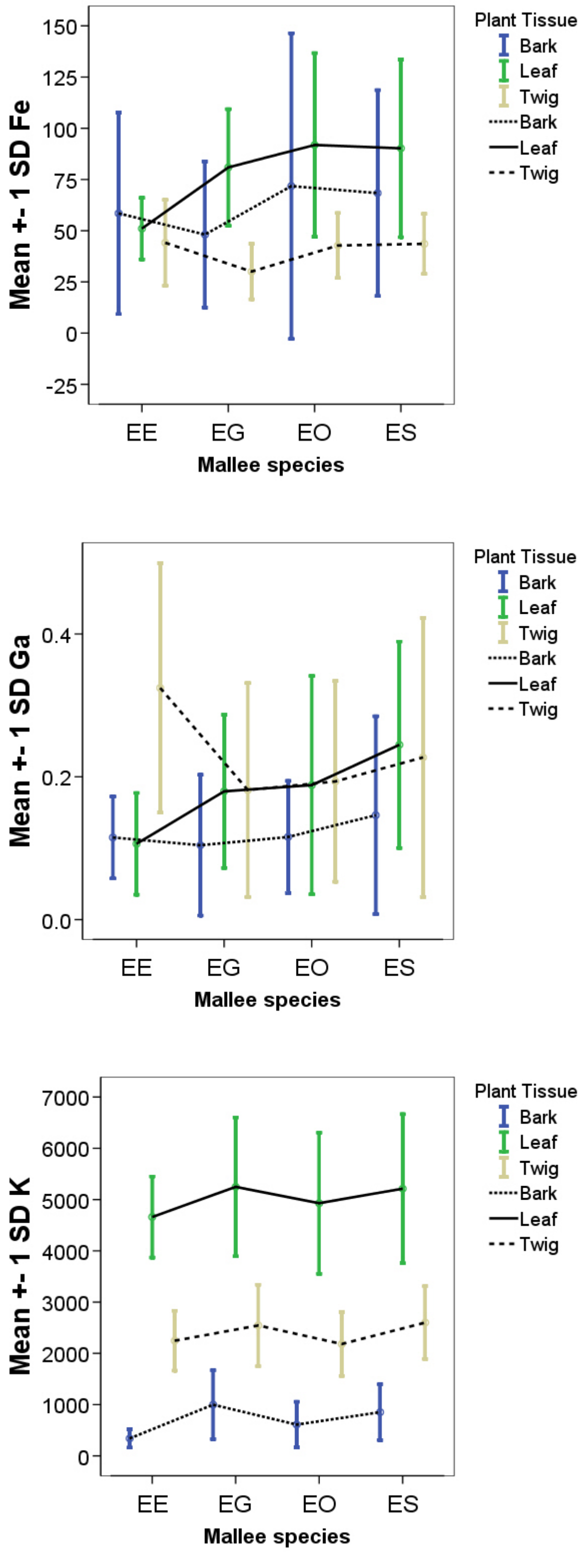


Figure 4.1 The comparison of elemental concentration (ppm) for some elements among different species of malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean. EE: *E. eremophila*, EG: *E. gracilis*, EO: *E. oleosa*, ES: *E. Socialis*

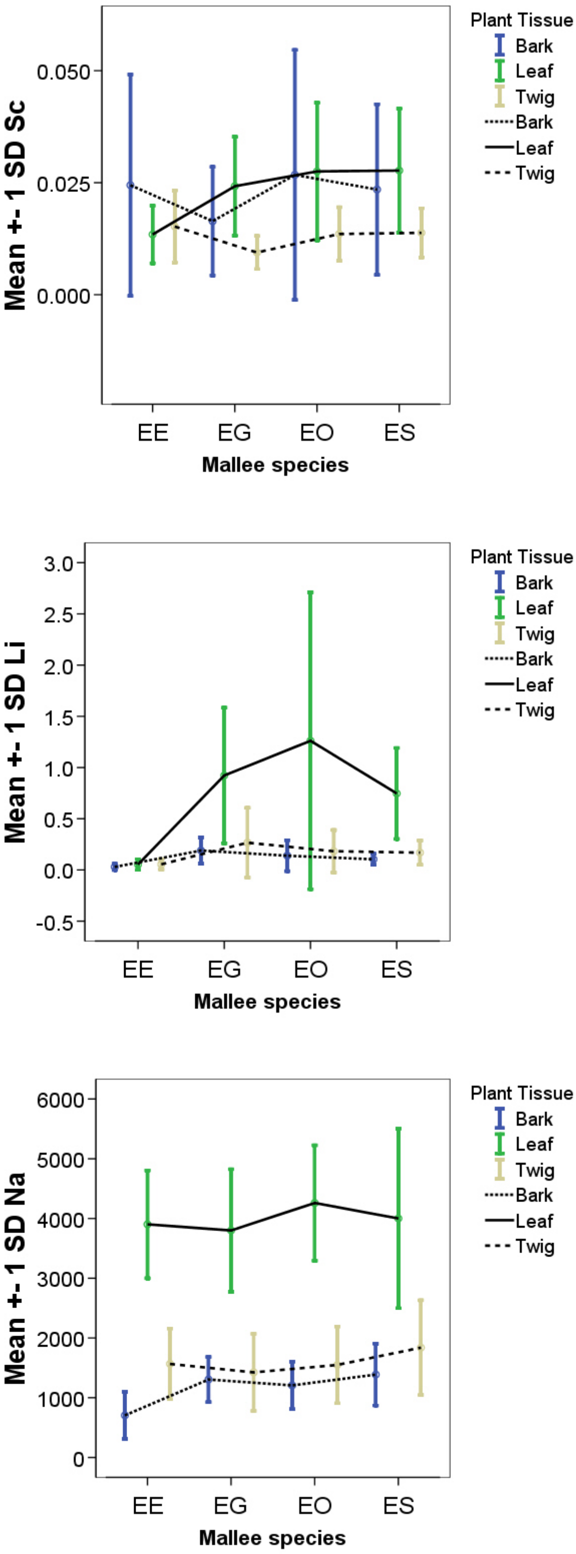


Figure 4.1The comparison of elemental concentration (ppm) for some elements among different species of malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean. EE: *E. eremophila*, EG: *E. gracilis*, EO: *E. oleosa*, ES: *E. Socialis*

Br, Ga, K, Mn, Na, Ni and Sr in bark, Br, Ca, Fe, Ga, Mn, Na, Ni, Pb, Sc, Sr and V in twigs, Fe, Ga, K, Mn, Ni, Sc, Sr, Tl and Zn in leaves display a response to lithology, whereas there are no significant differences between mean concentrations of the other elements. The ANOVA tables can be found in Appendix C. These results will be applied in the following section to classify elemental concentrations and discussed in detail later.

4.4 Evaluation of statistical parameters for elements determined in each ANOVA model

-Elements that exhibit significant differences between plant species and lithologies

It was necessary to standardise the data for each specific population in which the ANOVA model showed significant variation between plant species and lithologies. This statistical treatment was made so that the data for different populations was independent of individual statistical distributions. This resulted in a new data set for the elements that not only have zero mean but are measured in units of standard deviations. This was done by subtracting the mean of the distribution from each site and dividing by the standard deviation of the distribution. The new variable, Z_i, can be defined by the following equation:

$Z_i = (x_i - \mu)/\sigma$, where, μ and σ are the mean and standard deviation of data set.

Now, the frequency curves of different bedrocks (or plant species) for a given element, are identical. Table 4.4 shows the elements standardized in each plant organ.

Table 4.4 List of elements considered for standardization process in each plant tissue

	Between plant species	Between lithologies
Bark	Br	Br
	K	Mn
	Na	Na
		Ni
Twig	Ca	Br
	Na	Fe
		Mn
		Na
		Ni
		Pb
		Sc
		Sr
		V
Leaf	Li	Ga
		K
		Sc
		Sr
		Tl

As can be seen in Table 4.4, in bark samples, standardization for Br and Na has been made in two stages. In the first stage, the data set was standardized by plant species, and in the second stage, both elements have been standardized by lithologies. In some elements, such as Ca in bark and twig, and Fe and Sc in leaf, a subset of data included one site, and therefore, it was combined with another subset and in these cases, standardization was not applicable.

-Elements with no statistically significant mean variations between different subsets of data

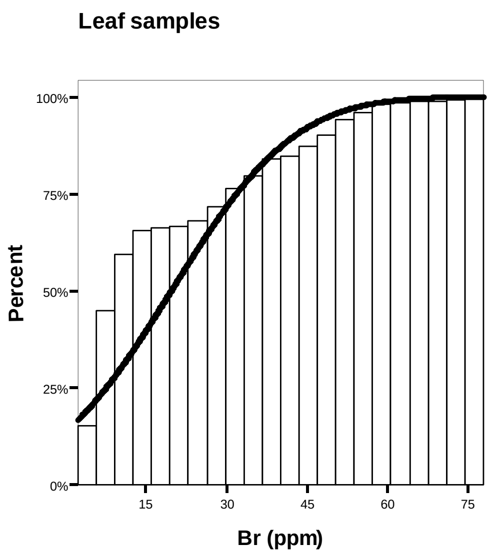
Based on an ANOVA model, the result of the following elements (Table 4.5) in each plant tissue (bark, twig and leaf) were converted to logarithms. Log-transforming the values results in a nearly straight-line graph on a cumulative probability plot (Figure 4.2 using Br as an example). In these cases, it can be seen that their distributions

become nearly normal, or at least much more symmetrical. In addition to converting a skewed variable into a more symmetric form, logarithmic transformation may also be useful in stabilizing the variance (Reyment and Savazzi, 1999).

Table 4.5 List of elements considered for log-transformation in each plant tissue

Bark	Twig	Leaf
B	B	B
Ca	Cd	Br
Cd	Cu	Ca
Cu	Ga	Cu
Fe	K	Fe
Ga	La	La
La	Li	Mn
Li	Rb	Na
Pb	Sm	Ni
Sc	Th	Pb
Sm	Tl	Rb
Sr	Zn	Sm
Th		Th
Tl		V
V		Zn
Zn		

(a)



(b)

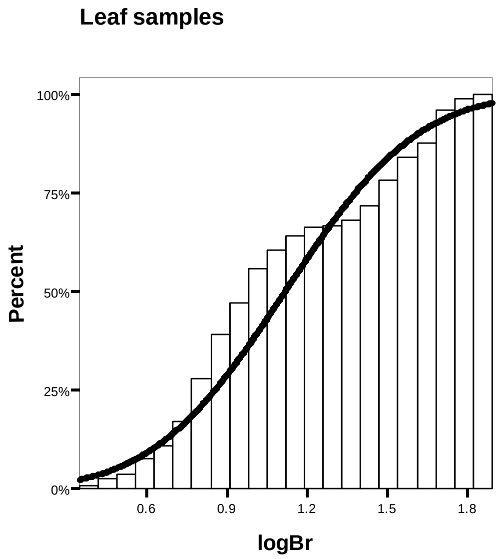


Figure 4.2 Comparison of cumulative frequency graphs for Br in leaf

Six elements, B, Cu, La, Sm, Th and Zn are log-transformed in three plant organs, whereas Fe, Ca, Pb and V in bark and leaf and Li and Rb in twig and leaf are the elements whose concentrations were converted to logarithms. Sc, K and Br are converted only in bark, twig and leaf samples, respectively.

4.5 Exploratory data analysis

As explained earlier, exploratory data analysis (EDA) was applied for the second data set in which there was limited number of results and a majority of data is at or below the detection limit of the analytical methods used (INAA and ICP-MS).

Previous research (Kurzl, 1988; de Caritat et al., 2001; Reimann et al., 2001a) give an introduction to the advantages of using EDA methods when dealing with geochemical data. The boxplot and five-number summary display the characteristics of the empirical distribution for single elements at a glimpse: location, spread, skewness, tail lengths and outliers (‘‘wild’’ values) (Tukey, 1977; Hoaglin et al., 1983).

To generate this plot, a box is drawn between the upper and lower hinges comprising 50% of the data. The median, which lies within the box, is represented by a horizontal bar, and its position depicts the symmetry or skewness of the data. The box describes the inner spread of the empirical distribution, which is called hinge spread. Peripheral data behaviour is symbolized by "whiskers", each representing 25% of data between the hinges and extremes (Figure 4.3).

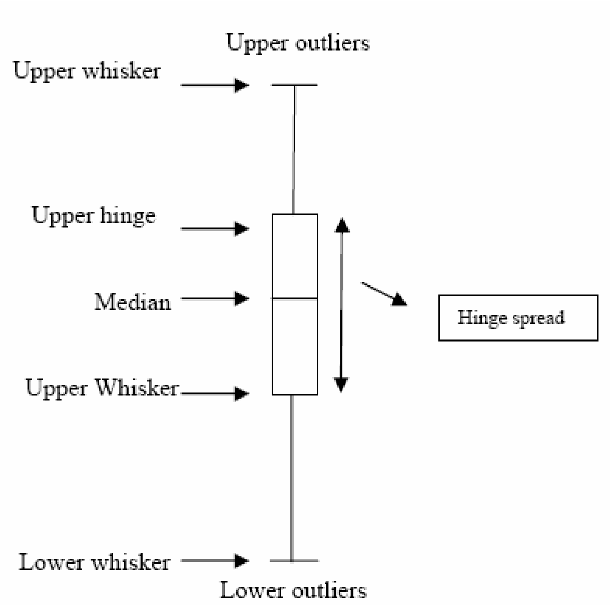


Figure 4.3 Definition of the boxplot characteristics

4.6 Classification procedure

In order to separate different classes of samples, a number of methods can be used, depending on the amount of data, purpose of the study and knowledge of the area surveyed (Reimann and Garrett, 2005). As described in earlier sections, the biogeochemical data were divided into two parts; one division with more than 70% above the detection limit (DL) and the second one with less than 30% above DL. In the following each part will be treated separately to determine the data set classes for the biochemistry of different plant tissues.

4.6.1 Cumulative frequency curves

A combination of cumulative frequency plot, Lepeltier method (Matschullat et al., 2000) and useful property of (log) normal distribution which is that area under the curve, within any specific range, can be calculated and expressed in terms of standard deviations from the mean (Davis, 2002), were applied. This approach resulted in a classification as follows:

Class 1: $x < \bar{x} + s$

Class 2: $\bar{x} + s \leq x < \bar{x} + 2s$

Class 3: $x \geq \bar{x} + 2s$

This technique requires curves of the individual elements to display the relative cumulative frequency linearly. The background value is defined by considering 75% percentiles extracted from cumulative frequency curves which are equivalent to $\bar{x} + s$ in a normal distribution.

The quantification of a geochemical background, mainly for trace components, is necessary for both applied and theoretical geochemical questions and models (Reimann et al., 2001a). This project provided this opportunity to assess, for the first time, regional background values of mallee vegetation for southern Australia.

4.6.2 Box plot

For the data set treated by EDA analysis, the box plot was used as a graphical display for classification of results. An outlier cutoff was introduced and attached to the plot. In this research, the following classes/groups were considered on which was based their corresponding biogeochemical maps:

Class 1: upper hinge

Class 2: upper hinge to upper whisker,

Class 3: outliers

Values below detection were set to one half the detection limits for the purpose of graphical data analysis and for computing some ratios.

4.7 GIS-based mapping of results

Although GIS is used by thousands of different organizations and hundred of thousands of individuals to access and manage fantastically varied sets of geographically-related information (Voss et al., 2004; Portoghese et al., 2005), the current study seems to be the first biogeochemical reconnaissance study in southern Australia utilizing GIS technology. GIS was used in several stages of the project; as a mapping and analysis tool and in the context of research. Finally, this result will be able to apply for a multi-user system to serve an organization's ongoing needs for regional assessment in both environmental monitoring and mineral exploration aspects.

In this project, a variety of tasks have been grouped into three steps. The first step was to compile all information, such as geological maps, the field observations notes, (bio) geochemical results and other necessary information for a broad area from New South Wales to Western Australia which covered four states of Australia. A GIS-based simplified bedrock geology map was compiled for southern Australia using GIS databases held by the Geological Surveys of these four states.

The next step was to create a database that contains all the geographic and (bio)geochemical data required for the study areas. This involved obtaining and translating electronic data from a variety of sources and formats, making sure the layers are of adequate quality for the project, and making sure the layers are in the same coordinate system and will overlay correctly, and adding items to the data set to track analysis result values.

The second step was to analyse the data. This commonly involved overlaying several data types, querying attributes and feature locations for interpretation. The final step in this project-based analysis was to communicate the results of the analysis by producing (bio) geochemical maps.

The three ArcGIS Desktop applications including ArcCatalog, ArcMap and ArcToolbox (Environmental Systems Research Institute Inc, 2004) were used to do the analysis. ArcCatalog is the application for managing the spatial data holdings and databases designs and for recording the metadata. ArcCatalog was used for all mapping, as well as for map-based analysis. ArcToolbox was used for data conversion and geoprocessing.

In each map, layers were set which define how the geographic features including sample site locations, (bio) geochemical results, geological units, urban areas, state boundaries, etc. will be drawn when they are added to a map.

4.8 Assessment of the biogeochemical reconnaissance maps

In this section, biogeochemical dispersions patterns in plant chemistry for each plant tissue are described. Each map exhibits element concentrations in different symbols and sizes proportional to the relative concentration of elements.

The results and biogeochemical patterns for plant tissues are represented in the form of point-based maps for most macro- and micronutrients elements (Appendix D). The chemical composition of the plant tissues for the most abundant and widespread mallee vegetation within the southern Australia is included in Appendix E. The results are described for each plant tissue and are listed for 28 elements in alphabetical order according to elemental symbol, except for rare earth elements (REE) which are considered as a single group. The Ag, Ir, Mo, Sb (except two sites for leaf), U and Zr

concentrations in all samples were below the detection limits for the analytical methods used (INAA and ICP-MS). Statistical graphs and plots including cumulative frequency graphs and boxplots for appropriate elements in each tissue can be found in Appendix F.

- Elemental variability in mallee plant tissues

4.8.1 Arsenic (As)

Arsenic is renowned for its toxicity, yet plants can accumulate amounts without exhibiting any visible harmful affects (Burlo et al., 1999). Arsenic is an essential element for the metabolism of carbohydrates in fungi and algae (Adriano, 1992).

The As content within the mallee tissues is limited and most of the data were recorded below the detection limit (0.10 ppm) except five bark samples, nine twigs samples and eleven leaf samples . The As concentration is lower in the twigs (median of 0.15 ppm) than in the bark and leaves (median of 0.28 ppm and 0.19 ppm). The highest arsenic contents in the bark, twigs and leaves occur on the Yilgarn Craton where all the detectable values for bark were recorded. Arsenic shows positive correlations with Au in twigs and leaves (Appendix G).

4.8.2 Gold (Au)

Gold is not known to be essential for plant growth and health. Consequently, patterns of Au distribution may reflect zones of relative gold enrichment in soils, groundwater and bedrock (Dunn et al., 1991; McInnes et al., 1996).

A few mallee samples record Au content above the detection limit for the method used (INAA). Specifically, seven bark samples (maximum of 4.2 ppb), nine twig samples (maximum of 2.47ppb) and six leaf samples (maximum value of 1.71 ppb) had detectable Au. For all of these samples the Au concentrations of the bark is higher than

other plant organs. The samples with the highest Au contents are recorded in the far west of the study area. Also, one site in Yorke Peninsula recorded detectable gold in both bark and leaf samples. Tellurium (Te), which is a mobile element in the surficial environment and a pathfinder element for Au, shows some similar biogeochemical patterns with Au values, so that in five sites, Te was recorded where Au was also detectable in plant organs (Table 4.6).

Table 4.6 The coincidence of Te and Au in mallee vegetation

Sample site	Province	Te (ppm) in tissue	Au (ppb) in tissue
T-142	Yilgarn Craton	twig (0.21)	all plant organs (0.61, 2.17, 1.58)*
T-217	Yilgarn Craton	twig (0.23)	bark (0.52)
B-216	Yilgarn Craton	bark (0.21)	twig (0.55)
B-53	Murray Basin	bark (0.21)	twig (0.51)
B-98	Gawler Craton	bark (0.28)	bark (0.73)

* In bark, twig and leaf, respectively.

4.8.3 Boron (B)

Boron is important in plants metabolically, and it is believed to play a significant role in the translocation of sugars (Adriano, 1992). B is relatively immobile in plants; but because it is translocated mainly through the xylem, it is largely accumulated in leaves. In this research, the mallee leaves (median of 45.4 ppm) are significantly enriched in boron in comparison to bark and twigs (median of 8.7 ppm and 9.2 ppm, respectively).

4.8.4 Beryllium (Be)

Be concentration in plants under natural conditions is reported to range from 0.001 to 0.4 ppm in dried plant matter. Most Be taken up by plants remains in the roots and only a very small proportion of absorbed Be is translocated to above-ground plant organs. Be absorption mechanisms of plants seem to be similar to those involved in the uptake of Ca. However, these elements have antagonistic interactions. The correlation

analysis of mallee biosamples shows no significant correlation between these elements, except a weak negative correlation in leaves (Appendix G).

Most mallee samples recorded Be contents below the detection limit (0.004 ppb) for the chemical analysis used (ICP-MS), except in 20, 24 and 52 samples of bark, twigs and leaves, respectively. The map of Be distribution clearly shows the relative enrichment in the eastern part of the study area, mostly in Yorke Peninsula and part of the Murray Basin (Appendix D).

4.8.5 Barium (Ba)

Although Ba is reported to be commonly present in plants, it apparently is not an essential component of plant tissues (Adriano, 1992). The Ba content ranges from less than the INAA detection limit of 5 ppm to 16.6 ppm, being the highest in mallee bark. For all plant tissue results that were above the detection limit, the median concentration of barium in leaves (7.6 ppm) is marginally higher than that in bark (6.7 ppm) and twigs (6.5 ppm). The highest Ba values in bark, twig and leaf samples are recorded in the volcanics of the Gawler Craton.

4.8.6 Bromine (Br)

Bromine is a volatile element, present in most, if not all terrestrial plants, but it is not known to be an essential element (Dobrovolsky, 1994). The bromine contents within the mallee leaves are significantly higher than other tissues in the study area, so that the Br median content in leaf samples is greater than five times those in bark and twigs (medians of 7.3 ppm, 7.9 ppm and 40.1 ppm in bark, twig and leaf, respectively). It was expected that Br enrichment would occur in shoreline sites, due to the influence of Br-bearing salt spray from the ocean. In particular, this happened for twig and leaf

samples, so that high contents of Br have been distributed in coastal areas of the Eyre and Yorke Peninsulas. Also, there is a positive correlation between Br and Na in twigs and leaves. However, some high concentrations of Br occur as isolated anomalies inland. It is likely that the zones of Br enrichment are related to local chemistry and physiochemical conditions.

4.8.7 Calcium (Ca)

Calcium is a macronutrient element, essential for the rigidity of cell walls in most plants (Epstein and Bloom, 2005). Bowen (1979) cited Ca in land plants to be within the range of 3000-14000 ppm.

The Ca background values in biological material in the mallee study area vary between 7943 ppm in leaf tissues to 14125 ppm in twig samples. Mallee twigs (median of 11000 ppm) are significantly higher in calcium compared to bark and leaves (median of 6560 ppm and 6020 ppm, respectively), although the highest Ca concentration recorded was from a sample of bark tissue (31800 ppm). The minimum concentrations of Ca for plant tissues were 1840 ppm, 4390 ppm and 2700 ppm in bark, twig and leaf samples, respectively.

4.8.8 Cadmium (Cd)

Although Cd is considered to be a nonessential element for metabolic processes, it is effectively absorbed by the root system. For all mallee organs with detectable Cd (limit of detection is 0.005 ppb), the median concentration in twigs (13.1 ppb) is higher than those of bark (6.2 ppb) and leaves (5.9 ppb). Specifically, the highest phyllode (75.7 ppb), bark (61 ppb) and twig (268 ppb) contents are from samples across the

Yilgarn Craton area. Only in bark samples, did Cd which is a secondary component of some gold deposits, show a positive correlation with Au.

4.8.9 Cobalt (Co)

The essentiality of Co for both blue-green algae and micro-organisms in fixing N is well established. It is not clear, however, whether Co is essential for higher plants, although there is some evidence of a favourable effect of Co on plant growth (Kabata-Pendias, 2004).

Within the survey area, Co contents in the twig samples were below the detection limit (0.10 ppm), except at two sites. Also, eight sites have been recorded for Co assays above detection limit in bark. All plant tissues have shown their highest concentration of Co in one site over basic substrate, and which are 0.32 ppm, 0.19 ppm and 0.49 ppm for bark, twig and leaf, respectively. The map of the spatial distribution of Co within leaf tissue shows some enrichment of Co in the eastern part of the study area (Appendix D).

4.8.10 Chromium (Cr)

There is no evidence yet of an essential role of Cr in plant metabolism. The Cr content in plants is controlled mainly by the Cr content of the soil. There is not much literature on Cr in plants. Common levels of Cr found in plant material are usually on the order of 0.02 ppm to 0.2 ppm (DW) and concentrations of Cr in plants vary widely for kinds of tissues and stages of growth (Kabata-Pendias, 2001).

Median concentrations of Cr within the mallee plant parts are marginally higher in the twig tissue (0.39 ppm) than in the bark and leaf tissue (0.35 ppm and 0.29 ppm

respectively). The highest Cr assays from the mallee bark (1.67 ppm) and leaf (1.27 ppm) are found in samples from the part of study area overlying mafic lithologies of the Yilgarn Craton.

4.8.11 Cesium (Cs)

This alkali metal is apparently not an essential component of plant tissues, and is usually present at less than 60 ppb in mallee tissues. It is reported that Cs is relatively easily taken up by plants, although its absorption by roots appears not to parallel K absorption (Kabata-Pendias, 2001).

The Cs contents of the plant bark (median of 29 ppb) are generally higher than in twig (median of 28 ppb) and leaf (median of 25 ppb) tissues.

4.8.12 Copper (Cu)

Concentrations of Cu within mallee plant tissues are generally higher in the leaves (median of 3.09 ppm) rather than in the twigs and bark tissue (median of 2.74 ppm and 1.01 ppm, respectively). The highest Cu assays from the mallee tissues are found in a leaf sample from over granitic substrate in the central part of the survey area.

4.8.13 Iron (Fe)

The content of Fe in plants is essential both for the health of plant and for the nutrient supply to man and animal. The variation among plants in their ability to absorb Fe is not always consistent and is affected by changing conditions of soil and climate and by the stages of plant growth (Epstein and Bloom, 2005). The natural Fe content of fodder plants ranges from 18 ppm to about 1000 ppm (Adriano, 1992).

Iron contents within the mallee plant tissues vary markedly with the highest bark, twig and leaf values of 403 ppm, 88.5 ppm and 200 ppm and minimum values below the detection limit (20 ppm) for bark and twig and 25.6 ppm for leaf.

Statistical analysis of many biogeochemical data sets has suggested the presence of an 'iron factor' (Dunn et al., 1996), represented by a close association among Fe, Hf, Sc, Th and the rare earth elements. There are similarities in the distribution patterns of these elements in the study area, but there is a strong overprint of the elements that occur with Fe in areas of the Eyre Peninsula and Yilgarn Craton. The biochemical patterns of plant organs are fairly similar in the study area and Fe distribution closely parallels that of Cr and, to a lesser extent Co, suggesting a mafic rock association.

4.8.14 Hafnium (Hf)

Hafnium is a non-essential element for which precise INAA data are obtained at low ppm levels. Hafnium is uniformly distributed through the biosamples, with similar concentrations in the bark (median 18 ppb), twigs (median 14 ppb) and leaves (median 15 ppb). Hafnium levels are higher where Fe concentrations are high because the two elements are commonly associated in plants (Appendix G and Dunn et al., 1995). The maximum concentration of Hf in mallee vegetation occurs in bark (87 ppb) over granitic substrate.

4.8.15 Potassium (K)

Potassium is a macronutrient that is required in high concentrations. It plays essential roles in the growth of all plants. Potassium uptake is vital for plant health and in the overall metabolism of vegetation (Hopkins, 1999).

The K contents of mallee plant organs vary with the highest bark, twig and leaf concentrations of 2830 ppm, 5550 ppm and 8520 ppm respectively and the lowest values being below detection limit (500 ppm), 1030 ppm and 2710 ppm, respectively. The lowest K assay results are typically located in the western section of the study area, because of the low K content of the basic substrate.

4.8.16 Manganese (Mn)

Manganese is an essential element which is readily taken up and translocated within plants. It is reported at lower concentrations in phloem exudate than in leaf tissue and it has been concluded that weak transport of Mn through the phloem vessels is responsible for the low concentration of Mn in fruits and storage roots (Kabata-Pendias, 2001).

The Mn response from the mallee twig and leaf are relatively similar (median of 18.5 ppm and 25.6 ppm, respectively) compared to bark Mn contents which has a low median value of 5 ppm. The highest Mn values from biological material are in the twig tissues (maximum of 157 ppm) which are mainly located in the western part of the study area.

4.8.17 Sodium (Na)

Mallee eucalypts contain relatively high Na concentrations with significantly higher values for the leaf tissues (median of 3810 ppm) than for bark and twigs (medians of 1240 ppm and 1460 ppm). The highest Na contents in leaf samples are recorded from the Eyre and Yorke Peninsulas and SE of Adelaide (i.e. in proximity to the ocean). The minimum Na content in the sampled plant organs are 318 ppm, 512 ppm and 1760 ppm for bark, twig and leaf, respectively.

4.8.18 Nickel (Ni)

There is no evidence of an essential role of Ni in plant metabolism, although the reported beneficial effects of Ni on plant growth have stimulated speculation that this metal may have some function in plants (Wang et al., 1997). Although median values for the leaf samples (0.83 ppm) is higher than for twigs and bark (median of 0.56 ppm and 0.25 ppm, respectively), the highest Ni concentrations are found in the twig tissue (maximum of 7.06 ppm).

Within the study area, the lowest tissue assays are from the central part of the area including Eyre Peninsula and the Nullarbor Plain, whereas the effect of a mafic to ultramafic substrate within the Yilgarn Craton is seen in the vegetation with the highest Ni content in all tissues (1.69 ppm, 7.06 ppm and 5.39 ppm in bark, twig and leaf, respectively).

4.8.19 Lead (Pb)

Despite the known toxic effects of Pb, it occurs naturally in all plants. It is taken up mainly by root hairs and stored as a pyrophosphate in cell walls. The translocation of Pb from roots to tops is greatly limited, and only 3% of the Pb in the root is translocated to the shoot (Madejon et al., 2002).

Median values for Pb among the mallee tissues are similar (median of 0.08 ppm, 0.09 ppm and 0.10 ppm for bark, twig and leaf, respectively); however, the highest Pb concentrations are found in the twig organ (maximum of 0.85 ppm). The map of Pb distribution (Appendix D) presents some enrichment areas which occur mainly in part of Gawler Craton in Yorke Peninsula, whereas there are no sites with unusually high concentrations of Pb in the central and western part of the study area, except for a few twig samples.

4.8.20 Rubidium (Rb)

Rubidium apparently is taken up by plants, as are other monovalent cations. It may partly substitute for K sites in plants, as their properties are similar, but cannot substitute for K metabolism roles; therefore, in high concentrations, it is rather toxic to plants (Adriano, 1992). Rubidium concentrations in leaf and twig samples are positively correlated with K in the study area, with no association between these elements in bark (with a few data above detection limit for Rb (0.50 ppm) in bark). The Rb content in the mallee bark and twig (median of 0.78 ppm and 0.75 ppm respectively) are lower than in leaf tissue (median 1.08 ppm). The maximum Rb values in all plant organs are recorded on granitic substrates in the study area (1.46 ppm, 1.60 ppm and 2.98 ppm in bark, twig and leaf respectively).

4.8.21 Antimony (Sb)

Antimony is an important pathfinder trace element in mineral exploration, but is not recognized as having nutritional significance in plants. All plant material, except leaf tissue in two sites (values of 0.34 ppm and 0.26 ppm) recorded values below the detection limit (0.02 ppm); therefore, no biogeochemical maps for vegetation assays are presented in this research (except for leaves).

4.8.22 Scandium (Sc)

There is a lack of data on Sc distribution in plants. Kabata-Pendias (2001) found 5 ppb Sc in vegetables and 0.07 ppm in grass. Bowen (1979) reported the range of Sc in lichens and bryophytes to be from 0.3 ppm to 0.7 ppm (DW). If required, Sc is needed only in ultra-trace amounts, and therefore its presence in plant parts is controlled essentially by the chemistry of the substrate and by the distribution of other elements.

There is a high correlation between Sc and Fe in all media (correlation coefficients of 0.98, 0.90 and 0.97 in bark, twig and leaf plant tissue respectively). Background concentrations in mallee eucalypts vary between 10 ppb in twigs and 43 ppb in leaves.

4.8.23 Selenium (Se)

Although Se in plants has been investigated in many studies (Wang and Gao, 2001; Hartikainen, 2005), its physiological role and essentiality in plant nutrition is not known. There are some opinions stating that Se may be involved in certain metabolic processes (Anderson and Scarf, 1983).

Very few mallee samples record Se contents above detection limit (0.2 ppm) for the method used (INAA). Two leaf samples (values of 0.29 ppm and 0.34 ppm), and one twig sample (0.21 ppm) had detectable Se. All bark samples record Se below detection limit for the analysis used (INAA).

4.8.24 Strontium (Sr)

The Sr concentration in plants is highly variable and is reported to range from <1 to 10000 ppm in dried plants. Typical values, calculated as the mean for different food and feed plants, range from about 10 to 1500 ppm. It is reported that Sr is not very readily transported from roots to shoots; however, the highest concentrations of Sr are often reported for the tops of plants (Kabata-Pendias, 2001). In this research, the median content of Sr in the mallee twig (101 ppm) is significantly higher than for other plant organs (55.8 ppm and 42.6 ppm for bark and leaves, respectively). Sr commonly performs a function similar to Ca, and may be incorporated into their structural components. Within the study area, there is a broad similarity between the distribution

patterns of the two elements which is reflected in a positive correlation between Sr and Ca, especially in bark and leaves (Appendix G).

4.8.25 Tellurium (Te)

The biological cycling of Te is known to resemble that of Se, and the microbial metabolism of Te also seems to be similar to that of Se. Apparently, tellurium occurs in plant tissues at concentrations lower than those of Se. Bowen (1979) cited high Te accumulations, from 2 ppm to 25 ppm (DW), in a few plants from Te-rich soils. Kabata-Pendias (2004) gave the range in Te content of vegetables as less that 0.013 ppm to 0.3 ppm. Tellurium is an associated element for Au and Ag, which belong in the shallow zone of mineralization. Tellurium anomalies appear to mark a zone many hundreds of metres above some productive deposits (Rose et al., 1979).

Only sixteen biological materials provided Te contents above the detection limit (0.2 ppm) for the method used (INAA). Specifically, five bark samples (maximum of 0.39 ppm), eight twig plant tissues (maximum of 0.37 ppm) and three leaf samples (maximum of 0.29 ppm) had detectable Te. As mentioned before, at five sites, the presence of Te in the sampled plant tissues coincides with detectable gold values in vegetation.

4.8.26 Thorium (Th)

Thorium has a low mobility, which is reflected in its concentration in resistate minerals and is not essential for plant growth. Brooks (1983) mentioned 3 ppb (DW) for elemental abundance for Th in vegetation.

In the study area, thorium is uniformly distributed through the plant tissues, with similar concentrations in bark (median of 21 ppb), twigs (median of 16 ppb) and leaves (median of 24 ppb). The Th response in all media is comparable in the Eyre Peninsula, which may reflect the high Th concentrations typical of those growing on felsic igneous rocks.

4.8.27 Tungsten (W)

Tungsten is an important pathfinder trace element in mineral exploration, but is not recognized as having nutritional significance in plants. All plant material, except leaf tissue in two sites, recorded values below the detection limit (0.2 ppm; INAA) and, therefore, no biogeochemical map for bark and twigs assays is presented in this research. The mallee leaf samples with a tungsten value above the detection limit are from Eyre Peninsula with a granitic substrate (value of 0.40 ppm) and one site from the Yilgarn Craton (value of 0.22 ppm).

4.8.28 Zinc (Zn)

Zinc is an essential micronutrient in plants, necessary for carbohydrate and protein metabolism in biota. Most plant samples (all twig and leaf plant tissues and 88% of bark samples) had Zn concentrations above the detection limit (1 ppm). Twig and leaf biological material recorded the highest median (7.31 ppm and 8.64 ppm respectively), which were significantly higher than dead plant part (2.15 ppm). The maximum concentrations of zinc in the sampled plant organs are 14.4 ppm, 43 ppm and 24 ppm for bark, twig and leaf respectively.

4.8.29 Rare earth elements (REE)

Because of their similar chemical properties, these elements are considered as a single group. Included in standard INAA multi-element packages are determinations for lanthanum (La), cerium (Ce), samarium (Sm), europium (Eu), ytterbium (Yb) and lutetium (Lu). Lutetium consistently yields concentrations below the detection limit (5 ppb) and therefore no biogeochemical map of Lu is included.

Also, very few mallee samples record Yb contents above the detection limit (20 ppb; INAA). Specifically, two bark and twig samples (maximum values of 50 ppb and 30 ppb respectively) and four leaf samples (maximum of 30 ppb) had detectable Yb. The highest Yb value in the sampled plant organs (50 ppb for bark) is recorded from the Eyre Peninsula over a granitic lithology.

The Sm concentrations within the plants are relatively evenly distributed, with a median value of 21 ppb for bark samples and 20 ppb for twig and leaf tissues. The highest Sm values are recorded for the eastern half of the study area, with the maximum Sm assay of 100 ppb, 242 ppb and 90 ppb for bark, twig and leaf respectively.

Most of the mallee organs record Eu contents equal to or below the detection limit (20 ppb; INAA), except nine bark samples (maximum value of 30 ppb), two twig samples (maximum value of 63 ppb) and four leaf samples (maximum value of 28 ppb).

The elemental distribution for La and Ce are typically similar to Sm. The highest La and Ce values are recorded for twig samples (maximum values of 0.52 ppm and 1.60 ppm respectively). The overall concentrations of the REE are quite low for mallee tissues, although there are broad similarities in their distribution patterns, the REE show some differences. In particular, the light rare earth elements (LREE: La, Ce and Sm) are more enriched in the central and eastern part of the area than in the western part. There is commonly a close association between the REE and Fe in tree tissues,

especially in bark and leaf, and comparison of biogeochemical maps of REE elements with the map of Fe distribution in vegetation show broad similarities.

4.9 Discussion

Different responses of plant organs

Sampling and trace element analysis of mallee vegetation over extensive areas of southern Australia was conducted to establish models for secondary dispersion patterns of trace elements in the plant organs.

Figure 4.4 shows the comparison of elemental concentrations for four elements, of which two (K and Ca) are macronutrients. For all elements, the means of the three sample media are significantly different showing, at probabilities of 0.05 or less, that they represent subsets of the same population **(**Appendix C). Potassium and Na in leaves are concentrated more than in the other plant organs, so that relation of bark<twig<leaf in elemental contents of both exist. This may be related to the geochemical association of these elements and an expression of their geochemical characteristics. The greater enrichment of these elements in leaves than in other tissues may reflect foliar uptake from aerial sources (e.g. salt spray from the ocean) which can be translocated to other plant tissues in a lesser extent (Kabta-Pendias, 2001).

The biochemical response of mallee eucalypts to bromine concentration has delineated three subsets. The highest and lowest contents of Br were in leaves and bark, respectively (Figure 4.5). According to previous studies (Kabata-Pendias, 2001, 2004), Br reveals a significant positive correlation with exchangeable calcium and organic carbon in calcareous soils. In some cases, the source of the large amount of Br in topsoils is apparently related to atmospheric inputs either from sea-spray areosols or

from human activities (Jobbagy and Jackson, 2001). These studies found that Br was usually higher in leaves than in other tissues.

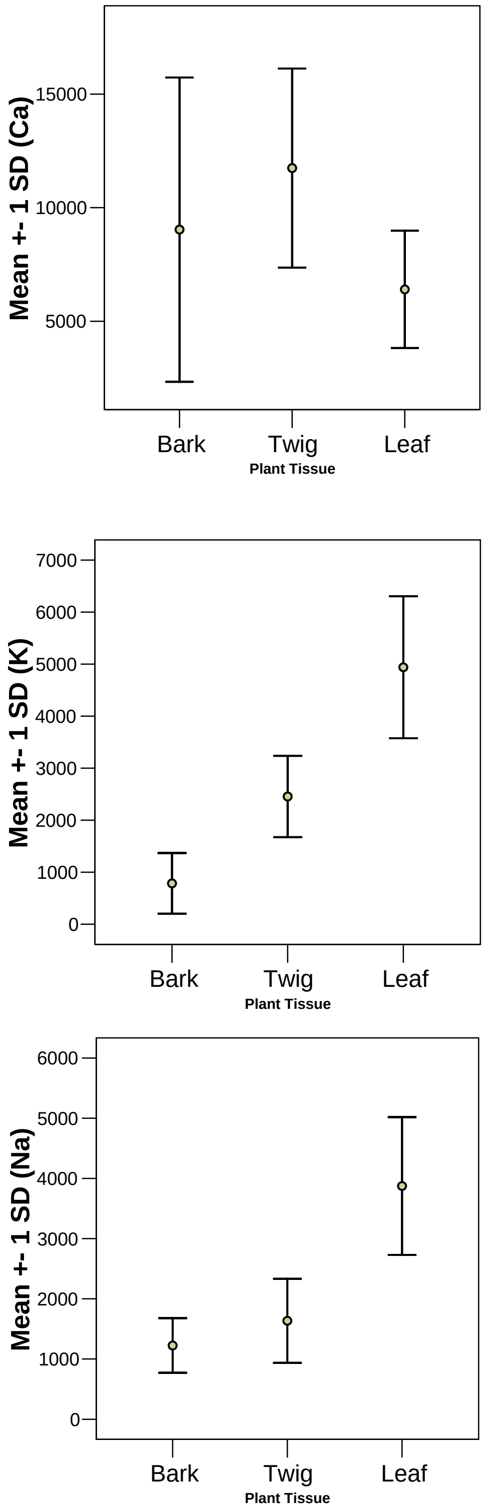


Figure 4.4 Comparison of elemental concentration (ppm) for some essential nutrient and trace elements in malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean.

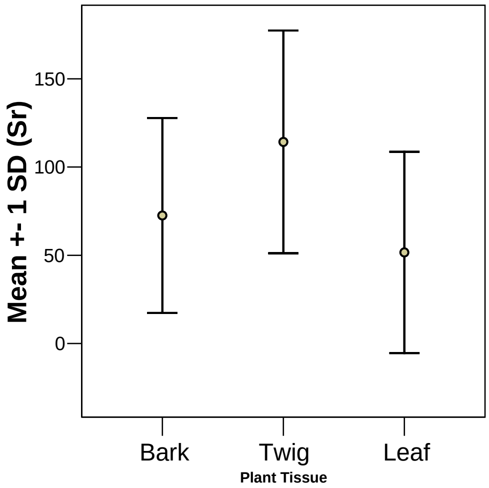


Figure 4.4 Comparison of elemental concentration (ppm) for some essential nutrient and trace elements in malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean.

In plant tissues, mobile Fe has been identified as citrates and soluble ferredoxins. Fe is readily transported in plant tissues, and therefore its deficiency appears first in younger plant parts. Usually, the more Fe deficient, the great the ability of plant roots to extract Fe from minerals and from chelating agents (Krauss et al., 2002).

In this study, iron is enriched more in leaf samples than in other plant parts (Figure 4.5). A comparison between Fe and Ca contents variation among plant organs (Figures 4.4 and 4.5) reveals that there was a reversed pattern between these two elements, so that a relation of twig<bark<leaf for Fe and leaf<bark<twig for Ca confirm earlier studies concerning absorption and transport of iron by plants (Taiz and Zeiger, 2002). This may imply that the translocation process of iron in plants occurs more readily than for calcium and that foliage is able to uptake more iron than woody parts. The other possible explanation of this relation may be the antagonistic effect of Ca (macronutrient) on Fe (trace element) which is dependent on both growth media and intracellular metabolism. In contrast, Sr response in different plant organs shows a comparable pattern to Ca, as the two elements have similar geochemical and biochemical characteristics, and thus, Sr is commonly associated with Ca. This

association can be observed to some extent in correlation coefficients between Ca and Sr in biological material (0.73, 0.20 and 0.25 for bark, twig and leaf, respectively).

The distribution of scandium (Sc) between the three sample media is similar to Fe (Figure 4.5). This can be due to biochemical similarity between these two metals. Sc is known to occur in natural environments as Sc^{3+} which can substitute for Al^{3+}, Fe^{3+}, Y^{3+} and also Ti^{4+} ; thus, the element is mainly associated with ferromagnesian minerals (Adriano, 1992).

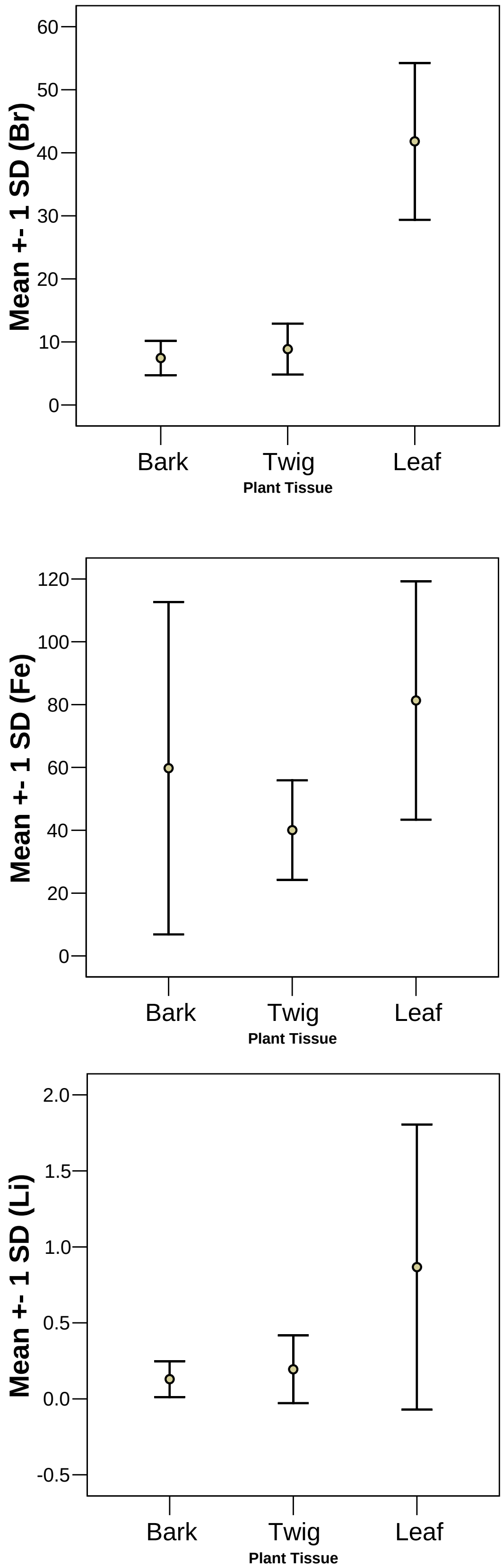


Figure 4.5 The comparison of elemental concentration (ppm) for some trace elements in malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean.

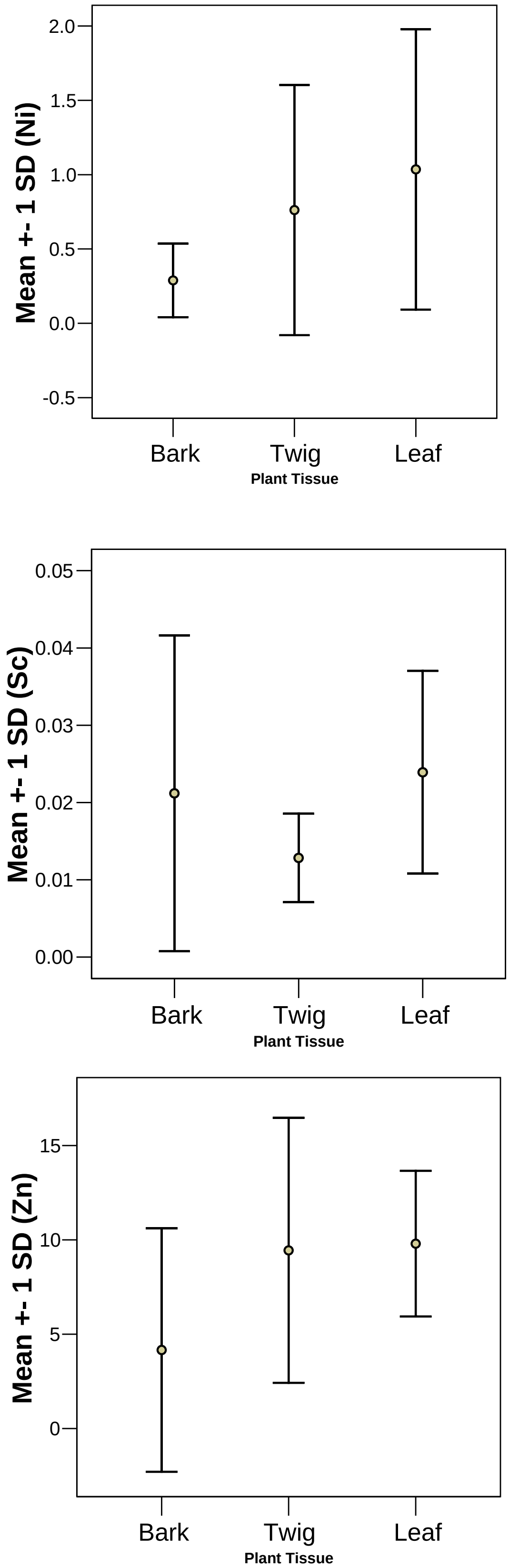


Figure 4.5 The comparison of elemental concentration (ppm) for some trace elements in malleeform eucalypts from southern Australia. The bar shows one standard deviation on each side of mean.

Figure 4.5 illustrates the relationships of the means for some trace elements considered to be non-essential for plant growth (except for Fe and Zn) and likely to reflect the underlying bedrock chemistry (Kovalevsky, 1987, 1995). Iron and Sc mean contents exhibit a similar order between plant organs, twig<bark<leaf, whereas those of Br, Li, Ni and Zn are bark<twig<leaf. The elemental concentrations for other elements, La and Sm, which both are rare earth elements (REE), between tissues are statistically indistinguishable (Appendix C). The uptake rate of REEs from soil to root is higher than the translocation rate from root to plant tops (Tyler, 2004) which may explain their behaviour among tissues. It is concluded that most of macro and trace elements have concentrated more in leaves than other tissues. The observed pattern is most likely related to the biological behaviour of different organs with respect to elemental concentrations and mobility.

Plant chemistry responses to morphological variation of regolith carbonates

Regolith carbonates (calcrete) have a wide distribution in southern Australia, especially in regions with transported overburden (Chen et al., 2002). Pedogenic calcrete forms from the relative accumulation of carbonate in the soil moisture zone, by movement of percolated rain water and/or soil water, such as eluviation/illuviation or as a product of biological activity such as a root respiration. The ultimate source of Ca in southern Australian calcretes is from marine carbonate (aerosols and dust), whereas the carbon is sourced from vegetation and microbial activity (Quade et al., 1995; Lintern et al., 2006).

The calcrete profiles of this study vary from simple profiles consisting of mainly one morphological type of calcrete, to complex profiles with several types of calcrete

either mixed or separated in a vertical sequence. The possible chemical responses of plant organs to these morphological variations which are essentially a subdivision of the intensity of calcrete development were investigated, Based on field observations (including surface examination and existing quarries), the calcretes were divided into three types. Type I, powdery (or soft) calcrete; Type II, nodular calcrete; and Type III hardpan (or massive) calcrete. These categories effectively represent increasing abundance of carbonate.

The results demonstrate that all mallee plant organs have quite higher mean contents of Fe, Mn, Ni and Zn where calcrete in the substrate is mainly powdery calcrete (Figure 4.6). Where calcrete is least intensely developed as powdery accumulations or grain coatings, the bedrock influence appears to be strongest and this is, in turn, reflected in higher responses in plant composition. Previous studies on the chemistry and mineralogy of Australian calcretes show that considerable compositional variability in southern Australia calcretes is related to both calcrete morphology and underlying lithology (Hutton and Dixon, 1981; Dixon, 1994).

Dixon (1994) examined six calcrete profiles down a toposequence in the St. Vincent Basin and found that there was a systematic decrease in Ca from top to bottom of the toposequence and an accompanying increase in Mg, as well as systematic decrease in Ca with depth. The study also showed that as the degree of induration of calcretes increases, so does their chemical purity, with hardpan calcretes being the most calcareous, and powdery calcretes the least (Dixon, 1994). It was also noted that calcrete composition varied depending on the underlying lithology, so that calcrete bulk chemistry developed on norite in the Murray Basin at Black Hill strongly reflected the weathering of this rock type (Dixon, 1994).

In contrast, there is a higher range of concentration for Ca and Sr in plant organs growing on substrates with hardpan and nodular calcretes (Figure 4.6). The virtually identical contents of K and Na of plant organs on all calcrete occurrences (Figure 4.7) may show that a biological mechanism of exclusion-accumulation controls the uptake of these elements. The similarity of these results to outcomes of one-way ANOVA may imply that plants supply themselves with the major nutrients, even given the relatively different fertility of soils and development of calcrete throughout the area.

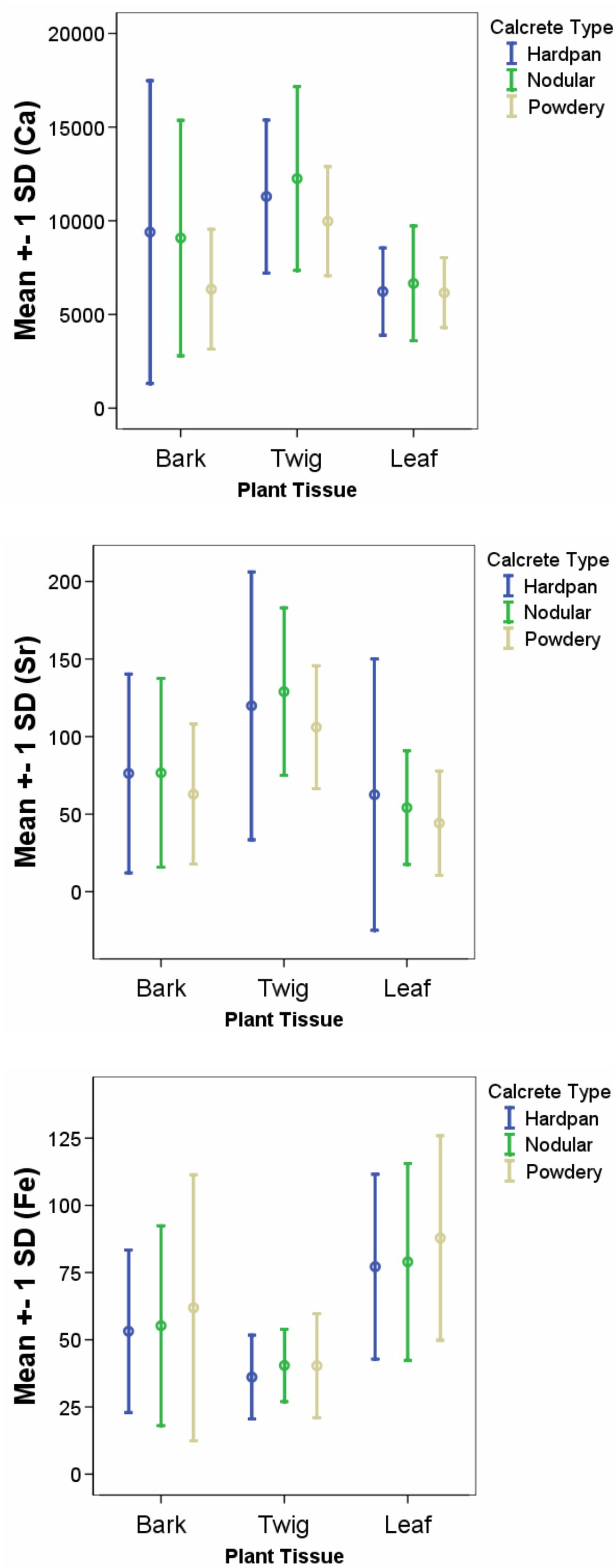


Figure 4.6 Variation of some selected elements (ppm) in mallee plant organs based on the regolith carbonate type in the substrate. The bar shows one standard deviation on each side of mean.

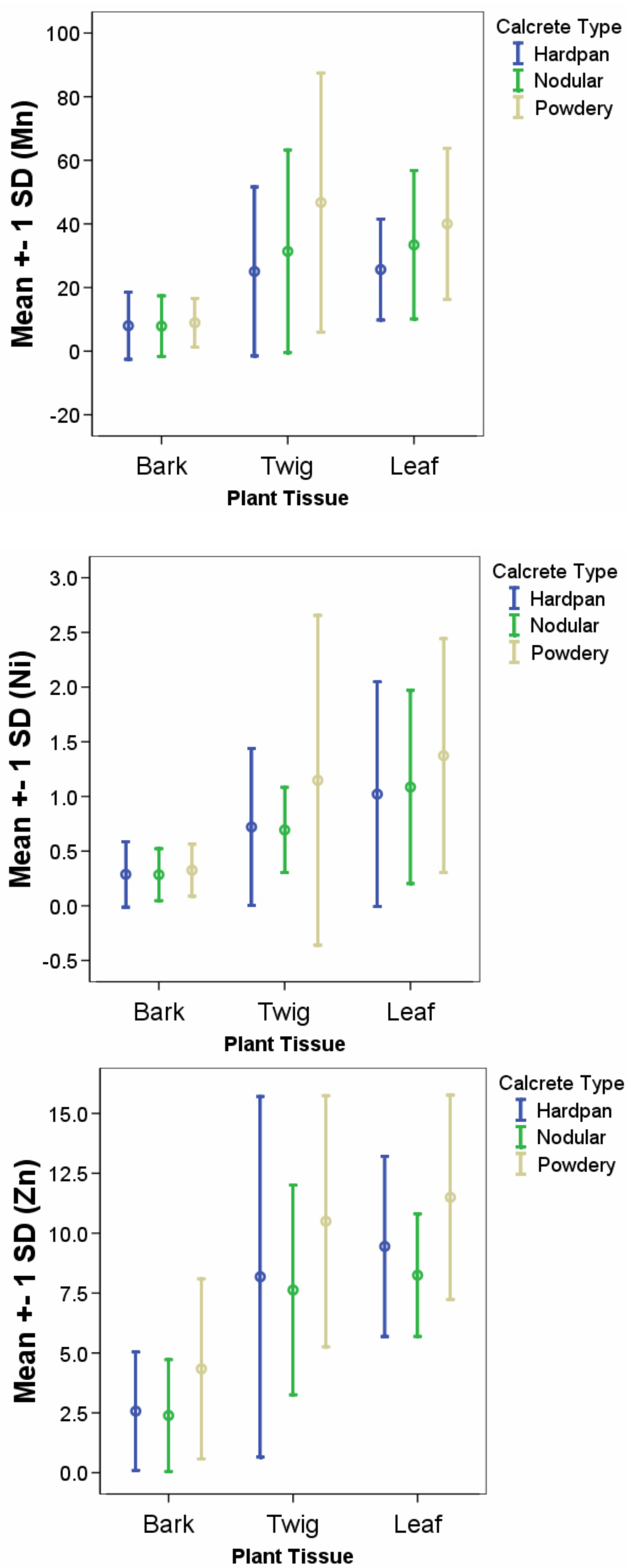


Figure 4.6 Variation of some selected elements (ppm) in mallee plant organs based on the regolith carbonate type in the substrate. The bar shows one standard deviation on each side of mean.

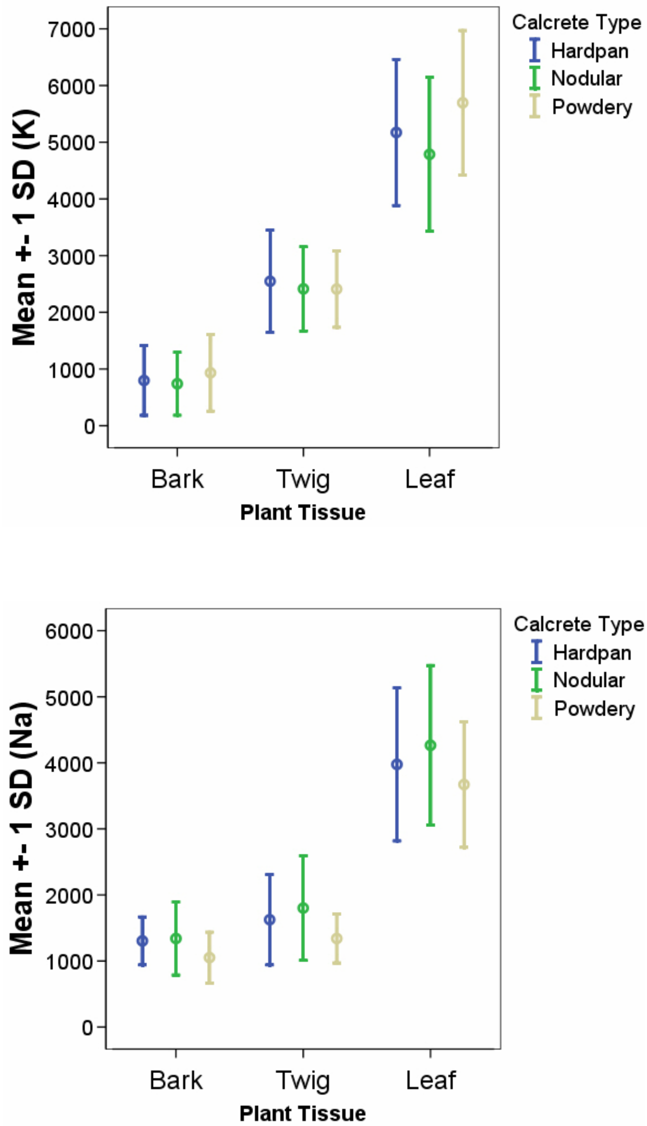


Figure 4.7 Variation of K and Na (ppm) in plant organs based on the regolith carbonate type in the substrate. The bar shows one standard deviation on each side of mean.

Table 4.7 Summary statistics of elemental concentrations (ppm) in each calcrete category for plant tissues

Tissue	Calcrete*		Ca	Fe	K	Mn	Na	Ni	Sr	Zn
Bark	Hardpan	N	31	31	31	31	31	31	31	31
		Mean	9397	53.2	797.6	8	1304	0.29	76.3	2.6
		SD	8083	30.2	614.7	10.6	362.6	0.3	64.1	2.5
	Nodular	N	31	31	31	31	31	31	31	31
		Mean	9082	55.2	740.6	7.9	1340	0.28	76.6	2.4
		SD	6286	37.2	555.7	9.5	553.6	0.24	60.8	2.3
	Powdery	N	19	19	19	19	19	19	19	19
		Mean	6348	61.9	933.3	8.9	1051	0.33	62.9	4.3
		SD	3205	49.5	676.4	7.7	385.2	0.24	45.2	3.8
Twig	Hardpan	N	31	31	31	31	31	31	31	31
		Mean	11297	36.1	2548	25.1	1625	0.72	119.8	8.2
		SD	4080	15.6	901.8	26.6	683.6	0.72	86.4	7.5
	Nodular	N	31	31	31	31	31	31	31	31
		Mean	12253	40.4	2414	31.4	1801	0.69	129	7.6
		SD	4903	13.5	743.1	31.9	791.2	0.39	54.1	4.4
	Powdery	N	19	19	19	19	19	19	19	19
		Mean	9975	40.3	2410	46.8	1341	1.15	106.1	10.5
		SD	2912	19.3	674.2	40.7	371.5	1.51	39.6	5.2
Leaf	Hardpan	N	31	31	31	31	31	31	31	31
		Mean	6226	77.2	5172	25.7	3976	1.02	62.5	9.4
		SD	2329	34.4	1288	15.9	1158	1.03	87.5	3.8
	Nodular	N	31	31	31	31	31	31	31	31
		Mean	6656	79	4787	33.4	4265	1.09	54.2	8.2
		SD	3070	36.6	1357	23.3	1207	0.88	36.6	2.6
	Powdery	N	19	19	19	19	19	19	19	19
		Mean	6157	87.8	5695	40	3671	1.37	44.2	11.5
		SD	1864	38	1273	23.7	950.2	1.07	33.7	4.3

*Values below detection were set to half the detection limit.

Trace element concentration responses in each plant tissue due to plant species and lithology variations

In assessing trace element behaviour of different mallee species, the results of ANOVA (Table 4.3, section 4.3.2) indicated that leaves and to a lesser degree bark samples have least variation among the mallee species, whereas in twigs, 8 of 20 elements studied show significant differences between species. It can be concluded that the leaves and bark of mallee eucalypts may be a better medium for reconnaissance biogeochemical exploration programs in the study areas. This result is in accord with

the earlier results (previous section) and the data of Arne et al. (1999), Cohen et al. (1998) and Hulme and Hill (2003), demonstrating that the leaves of species of non-malleeform eucalypts showed elevated amounts of trace elements over mineralized bedrock areas.

To investigate to what extent variation of multi-element concentrations in mallee plants reflect those in the underlying lithologies, the average abundance of some minor and trace elements in different rocks were considered (Tables 4.8 and 4.9).

The highest concentration of Co, Cr, Mn and Ni in biological material found over basic and ultrabasic substrates and the high values of Ba and Th in bark and leaf samples over the granite rocks are an indication that element accumulation in plant organs is affected by the underlying lithology (Figure 4.8). These results show that despite variations in the intensity of calcrete development, mallee eucalypts penetrate soil, calcrete and other regolith units and reflect the geochemical composition of the underlying bedrock.

Table 4.8 Average abundance (ppm) of some selected elements in the Earth's crust and several relevant rock types

	Earth's Crust [1]	Limestone [2]	Sandstone [2]	Granite [2]	Basalt [2]	Ultrabasic [2]
Ba	425	90	300	600	330	5
Co	25	0.1	0.3	4	45	110
Cr	102	5	35	10	250	2300
Hf	3	0.4	6	5	3	0.5
Mn	950	700	100	400	1500	1200
Ni	84	5	2	5	130	2000
Th	9.6	2	5	15	2.2	0.05
Zn	70	40	20	50	100	60

1.Wedepohl, Lide, Taylor and McLennan as cited in Reimann and de Caritat (1998)
2. Koljonen as cited in Reimann and de Caritat (1998)

Table 4.9 Summary statistics of elemental concentrations (ppm) for selected trace elements among mallee organs overlying different lithologies

Tissue	Bedrock*		Ba	Co	Cr	Hf	Mn	Ni	Th	Zn
Bark	Cz	N	10	10	10	10	10	10	10	10
		Mean	4.32	0.05	0.18	0.008	4.3	0.23	0.023	5.01
		SD	2.54	0.02	0.15	0.007	2.6	0.13	0.015	4.28
	LS	N	15	15	15	15	15	15	15	15
		Mean	2.95	0.05	0.13	0.009	8.0	0.23	0.012	2.44
		SD	1.19	0	0.08	0.007	9.3	0.20	0.013	2.03
	S	N	32	32	32	32	32	32	32	32
		Mean	4.46	0.05	0.11	0.008	5.6	0.23	0.019	2.51
		SD	2.7	0	0.05	0.005	3.6	0.12	0.011	2.92
	G	N	15	15	15	15	15	15	15	15
		Mean	4.88	0.06	0.22	0.017	10.0	0.27	0.04	2.92
		SD	3.97	0.02	0.2	0.022	13.2	0.27	0.052	1.94
	UB	N	13	13	13	13	13	13	13	13
		Mean	3.39	0.11	0.47	0.006	14.3	0.59	0.016	2.64
		SD	2.28	0.1	0.5	0.004	13.5	0.40	0.008	2.26
Twig	Cz	N	10	10	10	10	10	10	10	10
		Mean	2.5	0.05	0.21	0.005	14.7	0.60	0.011	7.61
		SD	0	0	0.24	0	15.6	0.60	0.007	3.32
	LS	N	15	15	15	15	15	15	15	15
		Mean	3.53	0.05	0.46	0.005	27.1	0.59	0.01	6.29
		SD	1.8	0	1.31	0.002	29.8	0.32	0.006	3.3
	S	N	32	32	32	32	32	32	32	32
		Mean	4.25	0.05	0.11	0.006	29.8	0.63	0.01	7.91
		SD	2.82	0	0.07	0.003	27.8	0.29	0.005	4.42
	G	N	15	15	15	15	15	15	15	15
		Mean	4.22	0.05	0.27	0.006	33.3	0.65	0.018	7.29
		SD	3.32	0	0.35	0.004	42.1	0.43	0.008	5.01
	UB	N	13	13	13	13	13	13	13	13
		Mean	5.24	0.06	0.36	0.006	52.0	1.76	0.015	13.82
		SD	3.85	0.04	0.21	0.003	37.5	1.83	0.009	10.12
Leaf	Cz	N	10	10	10	10	10	10	10	10
		Mean	2.85	0.06	0.1	0.008	18.4	0.79	0.019	9.72
		SD	1.11	0.04	0	0.005	15.4	0.76	0.011	3.23
	LS	N	15	15	15	15	15	15	15	15
		Mean	2.8	0.09	0.11	0.008	21.7	0.76	0.015	8.42
		SD	1.18	0.09	0.04	0.005	15.1	0.62	0.01	3.18
	S	N	32	32	32	32	32	32	32	32
		Mean	4.4	0.1	0.14	0.009	35.7	1.20	0.025	10.11
		SD	2.97	0.07	0.08	0.006	20.9	0.66	0.011	4.06
	G	N	15	15	15	15	15	15	15	15
		Mean	5.18	0.05	0.11	0.009	30.0	0.86	0.023	7.95
		SD	2.8	0.01	0.04	0.005	18.7	0.98	0.022	2.7
	UB	N	13	13	13	13	13	13	13	13
		Mean	4.36	0.14	0.4	0.006	44.5	1.78	0.014	10.15
		SD	3.06	0.14	0.33	0.002	25.1	1.62	0.008	3.8

*Cz: Unconsolidated Neogene sediments, LS: limestone, S: Sandstone, G: Granite, UB: Basic and ultrabasic rocks. Values below detection were set to half the detection limit.

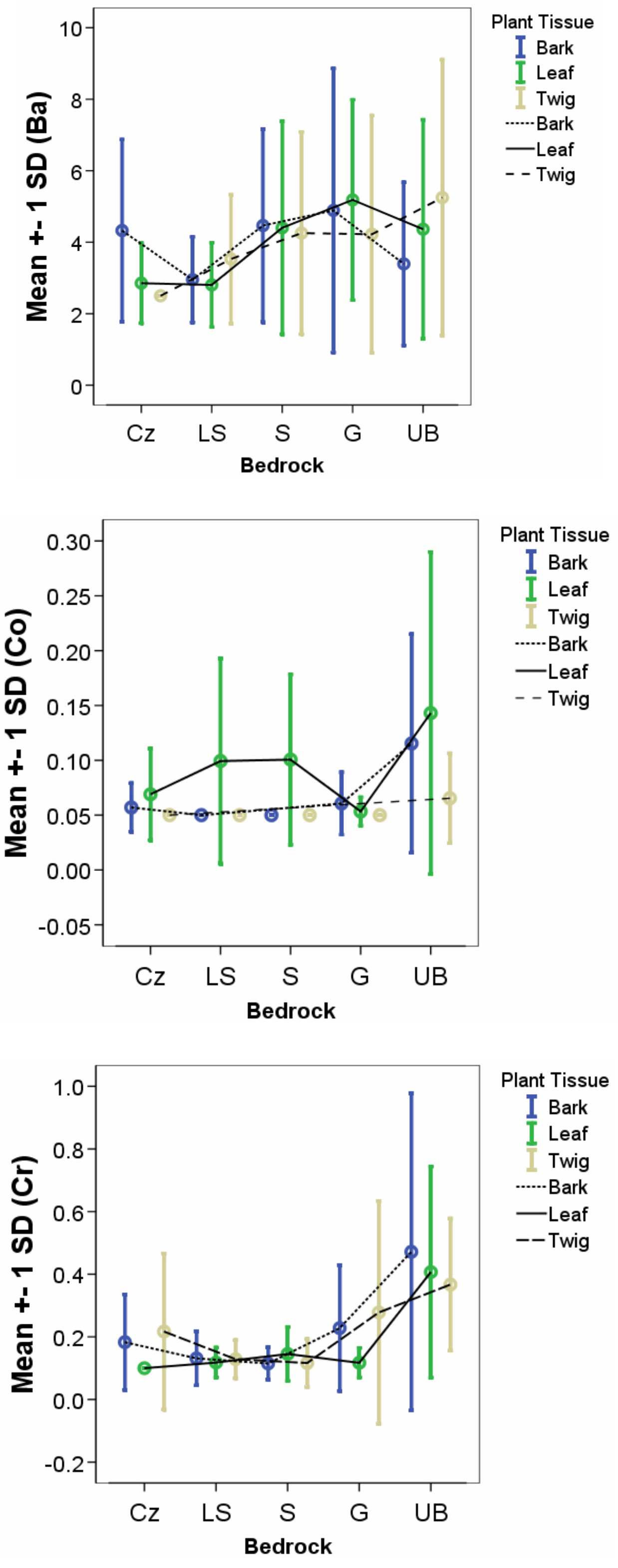


Figure 4.8 Comparison of elemental concentrations (ppm) of plant tissues among different lithologies. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, G: Granite, UB: Basic and ultrabasic rocks. The bar shows one standard deviation on each side of mean.

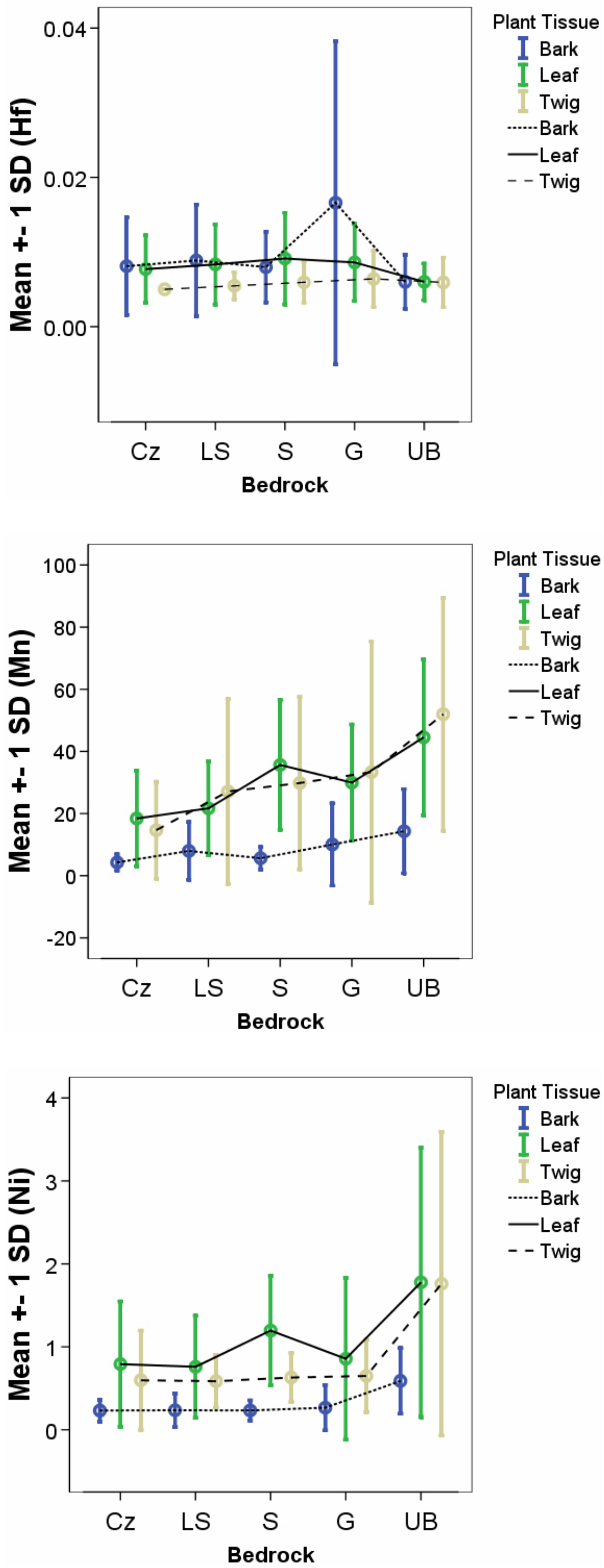


Figure 4.8 Comparison of elemental concentrations (ppm) of plant tissues among different lithologies. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, G: Granite, UB: Basic and ultrabasic rocks. The bar shows one standard deviation on each side of mean.

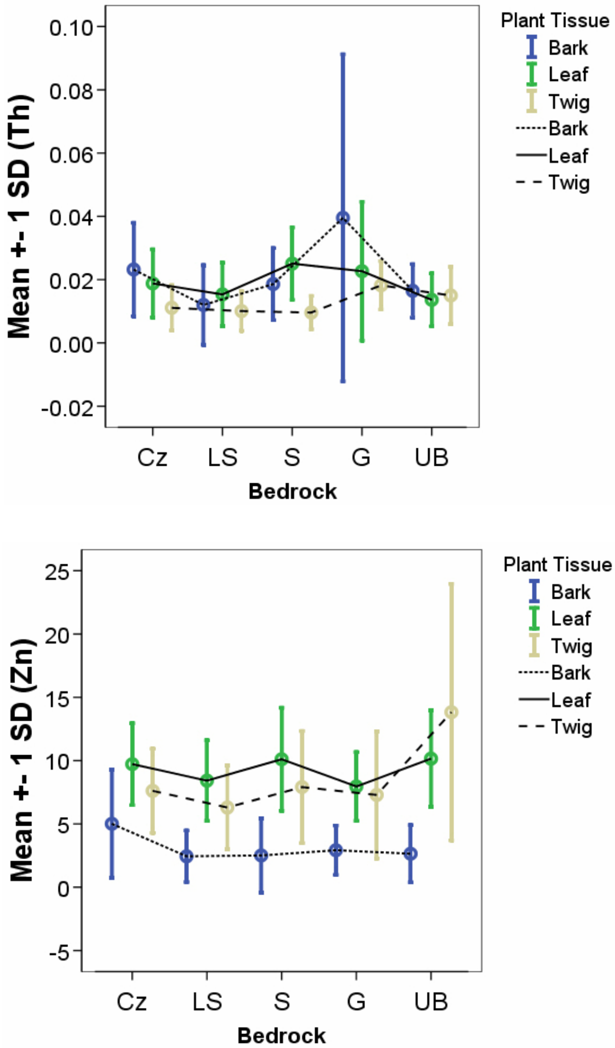


Figure 4.8 Comparison of elemental concentrations (ppm) of plant tissues among different lithologies. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, G: Granite, UB: Basic and ultrabasic rocks. The bar shows one standard deviation on each side of mean.

The REE concentrations in the plants over these lithologies are shown in Figure 4.9. Logarithms of the chondrite-normalized abundance of individual rare earths in plants are plotted against the individual rare earths in the order of their atomic number. Chondritic normalization has two important functions. Firstly, it eliminates the abundance variations between odd and even atomic number elements, and secondly, it allows any fractionation of the rare-earth group relative to chondritic meteorites to be identified (Oliveira et al., 2003). These meteorites are considered to represent the

naturally occurring lanthanide abundance, undisturbed by geological and biological partitioning (Henderson, 1984; Wyttenbach et al., 1998). Logarithms of the chondrite-normalised abundance of individual rare earths in biological sample types are expressed as logREEp/logREEc, where REEp is the concentration of individual rare earths in the plants and REEc is the concentration of individual rare earths in the chondrite. Concentrations of individual rare earths in the chondrite are cited from Henderson (1984). These results confirm the idea of a different uptake of REE by the plant as the substrate changes, once the concentration of REE in the plant of acid rocks actually higher than basic substrates.

The occurrence of REEs in the overlying vegetation may correlate with mineralisation, as the REE are not widely fractionated during weathering (Middelburg et al., 1988). The strong biogeochemical response to lithologically derived variations in the REE may suggest that the plants are active destructive agents of minerals such as monazite which are the major hosts for the REE.

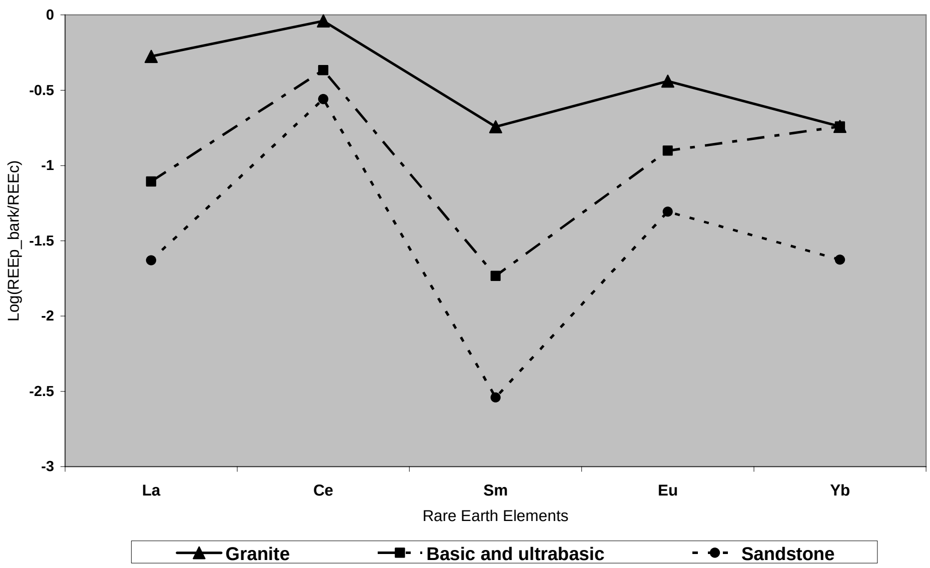


Figure 4.9 Chondrite-normalised REE patterns of biosamples (bark) in different lithotypes.

4.10 Summary

A number of distribution patterns emerge from the regional biogeochemical maps (Appendix D) and results from mallee in southern Australia. The spatial variation of As, Au, Co and Cr contents show generally the highest results from plants located in the central and western parts of the area. Specifically, most of the highest elemental concentrations occur in the Yilgarn Craton for all biological sample types (As, Au, Co, Cr, Fe, Ni and Zn) over basic and ultrabasic substrates, bark and twigs (As, Au) and all media (Ba and Fe) in granitic areas of Eyre and Yorke Peninsulas, twigs and leaves (Au), bark and twig (Cr and Zn) and in east of Adelaide and over granitic lithology in twig and bark (Au and Te).

In general, lower contents for many elements in mallee vegetation correspond to the eastern and central part of the field region in two areas (Murray Basin) where there are aeolian sandsheets (e.g. Cr, Co in all media) and limestone (e.g. Cr, Zn and Fe). Also, the lowest Ba and Rb values are mainly found in those parts of the Yilgarn Craton underlain by metabasic volcanic rocks where Cr, Fe and Ni show a distinctive anomaly in vegetation compared to other substrates.

The spatial distribution of Ca concentrations in plant tissues in the area varies depending on the physiology of the organs. The highest Ca contents of mallee twigs derive from the middle part of the study area where the abundance of regolith carbonates is areally more than 90% (Chen et al., 2002). High Ca contents in mallee bark occur overlying sandstone and siltstone bedrock, as well as on the northern Yorke Peninsula. The variation in the distribution pattern for each of the biological sample types suggests that the plant Ca contents may be dependent on intrinsic plant factors rather than expression of substrate influences.

Chapter 5 : REGIONAL RECONNAISSANCE SOIL GEOCHEMISTRY OF THE STUDY AREA

5.1 Introduction

Soil is a very specific component of the biosphere because it is not only a geochemical sink for trace elements, but also acts as a natural buffer controlling the transport of chemical elements and substances to the atmosphere, hydrosphere, and vegetation. Several methods have been developed to calculate the background contents of trace elements in soils. There is great demand for such data as reference values against which future changes can be quantified.

Baseline geochemical surveys provide invaluable information about the natural concentrations of chemical elements in the substrate which is the original resource for the agricultural and mineral industries.

The objectives of this chapter as a part of this research were to perform the first published reconnaissance pedogeochemical survey in southern Australia and to establish secondary dispersion of chemical elements in the soils of the study areas. In this chapter, we also investigate the relationship of soil chemistry to underlying lithologies. Background values of elements in soils were determined over different lithological units to indicate areas or regions within which more detailed study of soil could then be concentrated.

A further aim is to determine the relationship between trace-element uptake by plants and the concentration of the same elements in the substrate.

5.2 Numerical analysis of the soil geochemical data

Statistical analysis enables an objective examination of how lithological variations affect the elemental concentrations in soils. This relationship was examined by analysis of variance (ANOVA). Of 44 elements analysed by INAA and ICP-MS, 32 elements were treated by ANOVA and exploratory data analysis (EDA) was applied for the rest of the elements except Ag, Ir, Mo, Se and Te whose concentrations were below the detection limit of the analytical method used.

Table 5.1 Multi-element concentrations for 81 soils across the study areas used in the analysis of variance

Element	Method	ADL*	BDL*	Min.	Max.	Mean	Median	SD
As	INAA	79	2	<0.5	59.4	4.71	2.35	8.76
Ba	INAA	77	4	<50	529	188.1	169	91.2
Be	ICP-MS	81	0	0.08	0.48	0.251	0.25	0.103
Br	INAA	81	0	0.71	64.8	15.4	12.7	13.73
Ca	INAA	78	3	<0.1	19.1	3.72	2.035	4.23
Cd	ICP-MS	81	0	0.01	0.33	0.073	0.06	0.063
Ce	INAA	81	0	5.42	78.4	25.9	21.9	13.96
Co	INAA	81	0	0.74	38.5	7.39	4.65	8.01
Cr	INAA	81	0	7.6	1790	121.1	26.7	283.2
Cs	INAA	76	5	<0.5	3.5	1.53	1.39	0.68
Cu	ICP-MS	81	0	0.4	39.3	6.94	4.7	6.89
Eu	INAA	73	8	<0.2	1.41	0.54	0.52	0.22
Fe	INAA	81	0	0.28	7.72	1.88	1.43	1.67
Ga	ICP-MS	81	0	1.2	8.3	4.2	4.1	1.6
Hf	INAA	81	0	1.76	11	4.97	4.6	2.01
K	INAA	81	0	0.12	2.06	0.72	0.68	0.36
La	INAA	81	0	2.55	41.7	12.94	11	7.23
Li	ICP-MS	81	0	2	15.6	5.64	5.1	2.48
Lu	INAA	71	10	<0.1	0.44	0.18	0.17	0.07
Mn	ICP-MS	81	0	8.1	332.3	111.1	90.1	72.4
Na	INAA	81	0	0.022	1.53	0.22	0.151	0.25
Ni	ICP-MS	81	0	1.4	151.2	14.85	5.6	28.37
Pb	ICP-MS	81	0	1.1	40.4	8.04	6.6	6.01
Rb	INAA	79	2	<5	104	36.3	33.6	19.07
Sb	INAA	72	9	<0.1	3.9	0.4	0.28	0.57
Sc	INAA	81	0	1.02	33.1	6.77	5.09	6.01
Sm	INAA	81	0	0.5	5.6	2.4	2.0	1.1
Sr	ICP-MS	81	0	4.4	432.8	82.3	48	92.7
Th	INAA	81	0	1.32	17.5	5.89	5.57	3.16
Tl	ICP-MS	81	0	0.02	0.4	0.11	0.1	0.06
V	ICP-MS	81	0	3.4	63.6	17.8	13.7	14.7
Yb	INAA	81	0	0.35	3.14	1.21	1.13	0.55

ADL: number of samples above the detection limit.
BDL: number of samples below the detection limit.
Minimum (Min), maximum (Max), mean, median, standard deviation (SD).

A one-way ANOVA was performed to examine the effect of different lithologies on elemental concentrations. The geology factor has 5 levels; unconsolidated Neogene sediments (Cz), limestone (LS), sandstone and siltstone (S), granitic rocks (G), basic and ultrabasic rocks (UB).

Table 5.2 shows the one-way layout and results of the ANOVA. Sixteen of the 32 elements had significant differences among rock types at the confidence level of 0.01 (Table 5.2). Then, the directed pair-wise comparisons of individual groups were conducted using the Tamhane's T2 test at a 95% confidence interval (Appendix H).

Mafic and ultramafic rocks dominated the Yilgarn Craton sampling region and have significant differences from the areas dominated by the other 4 rock types. The soils derived from mafic rocks are rich in As, Cr, Co, Cu, Fe, Mn, Ni, Sb and V and poor in Br, K and Rb. There are few differences between soils over sandstone and unconsolidated Neogene sediments, although the respective rock types have characteristic geochemical features compared with granitic and basic and ultrabasic rocks. Granite-derived soils are relatively enriched in Ba, Be, K, Li, Hf, Pb, Rb, REE except Eu and Yb, Th and U compared to those collected over sedimentary, mafic and ultramafic rocks. Soils over limestone and unconsolidated Neogene sediments are enriched in Br, Ca and Sr compared with those from sedimentary, felsic and mafic rocks. The correspondence of elemental abundance in soil to surface lithology (Table 5.3) is clearly revealed by ANOVA (Appendix H).

As a result of the analysis of variance, the following elements were considered for standardization: As, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Sb, Sr and V and the rest of the chemical elements were log-transformed in the processing stage prior to geochemical mapping.

Table 5.2 Summary of ANOVA of the pedogeochemical survey

Element	between bedrocks
As	*
Ba	-
Be	-
Br	*
Ca	-
Cd	*
Ce	-
Co	*
Cr	*
Cs	-
Cu	*
Eu	*
Fe	*
Ga	-
Hf	-
K	-
La	-
Li	-
Lu	-
Mn	*
Na	*
Ni	*
Pb	-
Rb	-
Sb	*
Sc	*
Sm	-
Sr	*
Th	*
Tl	-
V	*
Yb	-

* Significant difference

Table 5.3 Average abundance (ppm) of some selected elements in the Earth's crust and several relevant rock types

Element	Earth's crust [1]	Limestone [2]	Sandstone [2]	Granite [2]	Basalt [2]	Ultrabasic [2]
As	1.8	1.5	0.5	3	0.7	0.7
Au(ppb)	4	0.1	0.5	2	1.5	0.5
B	10	20	35	15	8	3
Ba	425	90	300	600	330	5
Br	2.4	6	0.3	2	1	1
Ca	41500	380000	13000	9000	74000	25000
Cd	0.15	0.1	<0.04	0.1	0.2	0.05
Ce	66.5	12	30	90	16	3
Co	25	0.1	0.3	4	45	110
Cr	102	5	35	10	250	2300
Cs	3	0.5	1	4	0.8	0.05
Cu	60	6	2	12	90	40
Eu	2	.	.	.	.	.
Fe	56300	5000	10000	20000	86000	94000
Ga	19	1	8	18	17	0.5
Hf	3	0.4	6	5	3	0.5
K	20900	3000	11000	33000	8000	5000
La	39	6	20	50	6	1
Lu	0.8	0.1	0.3	0.7	0.5	0.04
Mn	950	700	100	400	1500	1200
Na	23600	6000	17000	25000	20000	6000
Ni	84	5	2	5	130	2000
Pb	14	5	10	20	4	0.05
Rb	90	4	40	120	30	2
Sb	0.2	0.15	0.05	0.3	0.2	0.1
Sc	22	1	3	5	35	10
Sr	370	500	100	220	400	10
Sm	7	2	3.2	8	3.5	0.6
Ta	2	0.01	1.5	2	1	0.07
Te(ppb)	1	2	2	5	6	1
Th	9.6	2	5	15	2.2	0.05
Tl	0.85	0.05	0.4	1.1	0.18	0.05
U	2.7	1	1.3	4	0.5	0.02
V	120	15	20	70	260	80
W	1.25	0.5	1	1.5	0.6	0.3
Yb	3.2	0.5	1.3	4.8	3.2	0.3
Zn	70	40	20	50	100	60
Zr	165	20	250	200	120	30

1.Wedepohl, Lide, Taylor and McLennan as cited in Reimann and de Caritat (1998)
2. Koljonen as cited in Reimann and de Caritat (1998)

5.3 Biological absorption coefficient

The biological absorption coefficient (BAC) is used to characterize the intensity of absorption of chemical elements by plants from their substrate. Kovalevsky (1995) has defined the biological absorption coefficient as follows:

$BAC = C_P / C_S$

where C_P is the concentration of an element in plant and C_S is the concentration of the same element in the soil. The range of BAC values varies widely from 0.0001 to 10 (Brooks et al., 1995). If BAC values are expressed on a dry-weight basis, the levels for most elements are below unity (Tables 5.4 and 5.5). Table 5.4 lists the BAC values obtained for each element studied at the different mallee plant organs. They were obtained as the mean value of the concentration of each element in soil and plant samples, in the study areas.

Table 5.4 Mean biological absorption coefficients (BAC) for soil-mallee plant-organs.

Element	Bark	Twig	Leaf
As	0.01	0.04	0.06
Au	0.07	0.07	0.06
B	2.9	3.5	18.2
Ba	0.05	0.04	0.05
Br	1.19	1.32	7.14
Ca	0.96	1.37	0.82
Cd	0.25	0.59	0.33
Co	0.01	0	0.05
Cr	0.011	0.017	0.007
Cs	0.03	0.02	0.02
Cu	0.32	0.87	0.94
Fe	0.005	0.004	0.007
Hf	0.004	0.003	0.003
K	0.24	0.48	1.01
Li	0.024	0.037	0.163
Mn	0.11	0.46	0.49
Na	1.1	1.41	3.42
Ni	0.05	0.11	0.17
Pb	0.018	0.02	0.017
Rb	0.03	0.03	0.04
REE	0.022	0.032	0.015
Sc	0.005	0.003	0.006
Sr	2.2	3.6	1.6
Th	0.006	0.004	0.006
V	0.009	0.008	0.009
Zn	0.11	0.27	0.28

Table 5.5 Biological absorption coefficients for some elements (after Brooks, 1983; and Kovalevsky, 1987)

Element	BAC
As	0.04
Au	0.01
B	1.7
Ba	0.03
Ca	0.14
Cd	0.55
Cr	0.003
Cu	0.13
Fe	0.004
K	0.12
Li	0.001
Mn	0.4
Na	0.01
Ni	0.03
Pb	0.02
REE	0.003
Sr	0.13
Th	0.005
V	0.0006
Zn	0.62

A comparison of BACs calculated in this study with other results mentioned in the literature (Table 5.5) indicates that elements Au, B, Br, Ca, Cr, Cu, K, Li, Na, REE, Sr and V have shown higher values in this study, whereas comparable values have been obtained for other elements (As, Ba, Fe, Mn, Pb and Th).

The mean BAC value for Zn which is a trace nutrient, but also quite toxic at higher concentrations, is lower than the value mentioned in the literature. Although we did not have any available information about this parameter elsewhere in Australia, it seems that this low BAC value may be related to partial exclusion mechanism by the plant and an overall low concentration of Zn in the substrate, although there is a BAC value of 0.82 for twig over basic and ultrabasic substrates.

The biggest differences of BAC values belong to Ca and Sr (a minimum of 6 times for Ca in leaf and a maximum 27 times for Sr in twig versus those previously reported

in the literature) which is related to the presence of regolith carbonate (calcrete) in the study areas. Iron, Hf, Sc and Th are characterised by very comparable ratios for all plant parts. This may be a suggestion that their uptake is strongly regulated to achieve an optimal level by plant internal processes. Another explanation could be that the concentration range for these trace elements is narrow relative to the effect of other environmental sources of variability.

In the study area, the transfer factors (BACs) obtained for REE changed from 0.015 to 0.032 being about ten times greater than the values reported in the literature (Table 5.5; and Maria et al., 2000), although the soil of the area presents a comparable REE concentration usually found in soils (Compton et al., 2003; Ohta et al., 2005). This may suggest that mallee eucalypts are capable of accumulating rare earths in their tissues and this is in agreement with other studies such as Cohen et al. (1999) who found elevated REE in non-malleeform eucalypts from northeastern New South Wales.

It is difficult to make comparisons with previous investigations, due to a difference in sample media and the scales of each survey, some only reporting results from vegetation (Arne et al., 1999) and in some cases their adjacent soil (Lintern et al., 1997a) in a small area (mostly a mineral deposit) and a paucity of data in this broad area of southern Australia.

5.4. Reconnaissance pedogeochemical patterns of trace elements

This section describes the geochemical maps of the assay results of soil samples across the study area. The complete soil chemistry data set and general affinities for each elemental component in the soil can be found in Appendices H and I, respectively.

Geochemical maps (Appendix L) of the assay results from the soil layer within the study area for selected chemical compositions illustrate that the soil material has a distinct chemistry. Variations in soil chemistry are described below in relation to underlying lithology within the study area, and, then, geochemical dispersions of some trace elements are discussed and compared to their patterns in vegetation.

5.4.1. Basic and ultrabasic bedrock

The chemical composition of soil associated with the areas of mafic bedrock (UB) is markedly different from the chemical composition of the other geological formations. Compared to the soil material in the other areas, the soils of this unit are relatively high in most trace elements. Specifically, median As values of 7.43 ppm, Co (21.9 ppm), Cr (561 ppm), Cu (18.8 ppm), Fe (5.05 %) and Ni (37.6 ppm) values are significantly higher than all median values of the soil material over other lithologies. The enrichment of these elements in the basic bedrock is reflected in the good correlation between them. In contrast, the soil material over this lithology is relatively low in Br (median value of 5.9 ppm), Ca (median of 1.47 %), K (0.61 %) and Sr (18.4 ppm).

The heavy rare earth elements (HREE) are also enriched in soils over basic bedrocks, including Eu (median value of 0.63 ppm), Lu (median of 0.21 ppm) and Yb (median of 1.39 ppm).

5.4.2. Granitic bedrock

This felsic lithology is found in the study area in two main regions, including parts of the Yilgarn Craton in Western Australia and part of the Gawler Craton in South

Australia, although some occurrences of granitic substrate are found in the western edge of the Murray Basin.

Granitic lithology influences the distribution of Cs, Hf, K, Rb, Th and U in the overlying soils. Compared to the other lithologies, the soil material in these areas is higher in Cs (median value of 1.78 ppm), Hf (median of 5.18 ppm), K (0.84 %), Rb (median of 54.9 ppm), Th (median of 8 ppm) and U (median of 1.33 ppm). Also, the higher concentrations of the light REE (LREE) including Ce (median value of 26.8 ppm), La (13.8 ppm) and Sm (2.49 ppm) are recorded in the soils over the more acid lithology.

5.4.3 Other lithologies

The chemical composition of soil is broadly similar over the other lithologies (including unconsolidated Neogene sediments, limestone and sandstone bedrocks) throughout the area, but there is a relative enrichment of Ca in the soils over limestone substrate (median of 5.22 %) and this is a reflection of the high contents of Ca in the central part of the study area (Nullarbor Plain).

5.4.4 Pedogeochemical dispersion of arsenic and gold

The spatial distribution of arsenic in the soils and vegetation exhibit a degree of similarity between the two sampling media (Figure 5.1). Both media display a strong response to known Au mineral occurrences, including near the goldfields of Kalgoorlie which is consistent with high positive correlation coefficient obtained between As in soil and plants (Table 5.6).

Although there are few sites where both media (soil and plants) simultaneously show Au concentration, they record a close correlation (Figure 5.2 and Table 5.7).

Table 5.6 Correlation coefficients for the number of samples relationship between As in soil and plants

		correlation coefficient (r)
As in bark and As in soil	(n=5)	0.79
As in twig and As in soil	(n=9)	0.9
As in leaf and As in soil	(n=12)	0.95

Table 5.7 Correlation coefficients for the number of samples relationship between Au in soil and vegetation

		correlation coefficient (r)
Au in bark and Au in soil	(n=4)	0.67
Au in leaf and Au in soil	(n=4)	0.93
Au in twig and Au in soil	(n=5)	0.97

Also, in several sites, biosamples recorded detectable Au and/or its pathfinder where there is no detectable Au in their adjacent soils. However, the results of this research may be compared with data from a previous study that used calcrete geochemistry profiles down to bedrock (Grevenitz, 2006) on exactly the same sites as the soil/biosamples localities. For these, the presence of Au at depth in ten sites was confirmed, so that for example, in one site Au has been recorded in weathered granitic bedrock at 5 m depth and in another site at about 2 m depth (Table 5. 8).

Also, there were recorded sites in which only vegetation have been able to show detectable values of Au or its pathfinders. This indicates that vegetation may be responding to the dispersion patterns existing in overburden at depth which are not affected by soil and regolith carbonates.

Table 5.8 The occurrence of gold and its pathfinders in vegetation, where no gold was detected in the topsoil

No	Province	bark	twig	leaf	topsoil	Au (ppb) in depth
98	Gawler Craton	Au, Te	–	As	–	calcrete at 1.05m depth (2.5)
104	Gawler Craton	Au	–	Au	–	–
113	Gawler Craton	–	As	Sb	–	calcrete at 0.9 m depth (2.6)
92	Gawler Craton	–	–	Se,Te	–	calcrete sample
100	Gawler Craton	–	Te	–	–	0.3 m depth (3.6)
114	Gawler Craton	–	–	Sb	–	calcrete at 0.8 m depth (3.1)
162	Gawler Craton	Te	–	Te	–	–
168	Gawler Craton	–	Te	–	–	–
173	Gawler Craton	–	Te	Te	–	–
203	Gawler Craton	–		Au	–	calcrete sample
217	Gawler Craton	Au	Te	–	–	calcrete sample
52	Murray Basin	–	Te	–	–	claystone at 1.9m depth (2.6)
53	Murray Basin	Te	Au	–	–	granite at 5m depth (2.4)
116	Yilgarn Craton	–	As	As	–	greenstone at 0.6 m depth (7.8)
134	Yilgarn Craton	Te	–	–	–	calcrete at 0.45 m (5.5)
167	Yilgarn Craton	–	As	As,Se,W	–	calcrete at 0.3 m depth (2.8)
216	Yilgarn Craton	Te	Au	W	–	calcrete at 0.5 m depth (11.9)

In many mineral exploration studies using regolith carbonate, it has been shown that in a calcrete profile there is a correlation between Ca and Au in deep weathering profiles (Lintern, 2002). The analysis of correlation between calcrete and vegetation in the study area demonstrates that there is a positive correlation between Ca in vegetation and Au in calcrete and soil (Table 5.9).

Table 5.9 Correlation coefficients for the number of samples relationship between Au in soil and Ca in leaves

		Correlation Coefficient (r)
Ca in leaves and Au in soil	n=9	0.80
Ca in leaves and Au in calcrete	n=27	0.43

It is postulated that both elements are taken up via roots, enter the plant tissue and ultimately, calcium consumed in plants through physiological processes and Au to be returned to the soil surface as litter and released by decay (Lintern et al., 1997a; Lintern et al., 2006). This finding may support using mallee leaves for gold exploration.

Concerning environmental aspects, the national guidelines for contaminated sites recommend that total arsenic concentrations in soil exceeding 20 mg/kg require environmental investigation (Australia and New Zealand Environment Council, 1992; National Environment Protection Council, 1999), and this level is exceeded in 3 of the 81 sites investigated. However, plants contributed very little to the arsenic diffusion, cycling and transfer from soil and atmosphere to biosphere in the study areas, since comparison of four times ultrasonic washing and unwashed plant parts in several sites throughout the area displays no significant differences in the assay values for washed samples (Table 5.10) and subtle differences between these two series of samples could be within the range of the natural variation. A low arsenic concentration in the above-ground plant biomass may be reflected in decreasing the risk of food chain contamination through grazing. Various studies have indicated the potential for vegetation to exert barriers against trace element uptake, especially elements that are toxic to plants (Kovalevsky, 1987). The presence of barriers could explain the low concentration of As in vegetation responses, but this may also be a function of analytical detection limits.

Table 5.10 Comparison of As contents among randomly-selected sites in which 5 of 8 sites were recorded in values below detection limit in both washed and unwashed leaf samples

unwashed	washed
0.18	0.18
0.17	0.21
0.46	0.46

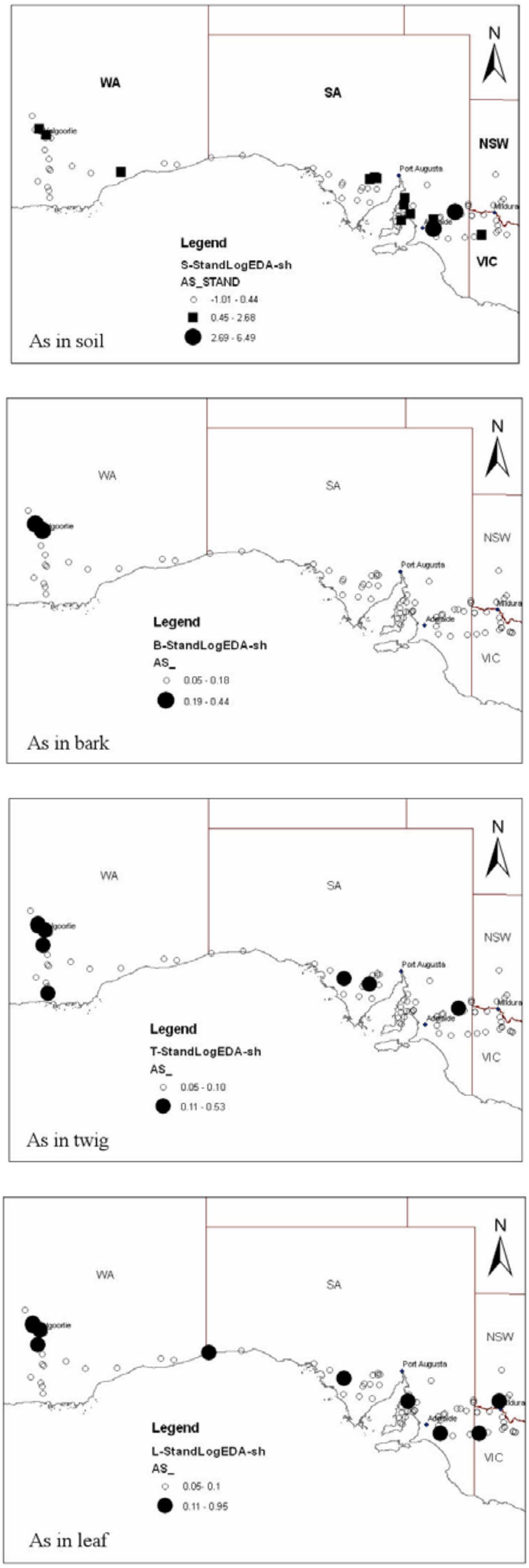


Figure 5.1 Spatial distribution of soil and biogeochemical data for As (ppm) in the study areas (WA: Western Australia, SA: South Australia, NSW: New South Wales, VIC: Victoria)

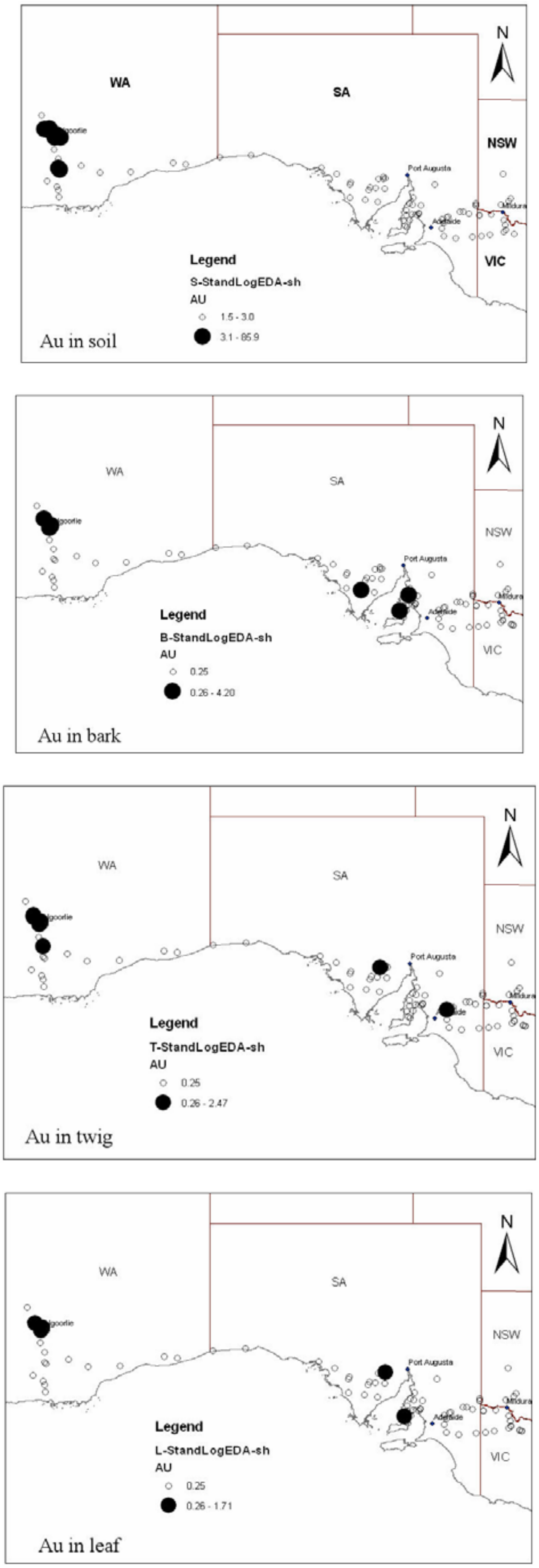


Figure 5.2 Spatial distribution of soil and biogeochemical data for Au (ppb) in the study areas

5.4.5 Pedogeochemical dispersion of chromium, cobalt and nickel

Figures 5.3, 5.4 and 5.5 show the regional soil and biogeochemical maps for Cr, Co and Ni. The Cr and Ni spatial distribution in soil are closely associated with the basic and ultrabasic rocks in the Yilgarn Craton, where the highest concentrations of the elements are found in soil and vegetation (especially for leaves). However, there are some elevated Cr and Ni contents for biosamples in Eyre and Yorke Peninsulas and south of Mildura. There is a positive correlation for Cr and Co in soils with Cr in bark and leaves, and Ni in soils with Ni in all biosamples, although the correlation between two media for Co was insignificant (Appendix K).

The behaviour of some trace elements like Co is complex, because they can occur in several oxidation states. At any oxidation state, trace elements in soils may occur in different forms including soluble, exchangeable, precipitated and coprecipitated with carbonate (Brooks et al., 1998b) and this may explain the low abundance of Co anomalies in the biosamples of the study areas.

Regarding the potential environmental impact of Co, Cr and Ni, a comparison was made with the established guidelines for the protection of natural systems (National Environment Protection Council, 1999; Department of Environmental Protection, 2003). Although low concentrations of some metals such as Cr and Co are required in animal diets and for plant growth, there can be adverse effects when in excess. The largest anthropogenic source of Cr emissions in the study area is the mining industry, although in urban and agricultural areas, Cr can be released from phosphates and potassium fertilisers. Chromium is of low mobility in most pH-Eh conditions, although at low pH the presence of Mn oxides can promote Cr oxidation to more mobile phases. Once mobilised from rocks or through human activities, Cr can replace Fe and Al in

oxyhydroxide structures and/or be adsorbed by clay minerals (Alloway, 1995). In surface soil horizons, Ni appears to occur mainly in organically bound forms, a part of which may be readily soluble chelates. However, the fraction of soil-Ni carried in the oxides of Fe and Mn seems also to be the form most available for plants (Kabata-Pendias, 2001).

In the soils analysed in this study, Co, Cr and Ni correlate strongly with As, Fe, Mn, Sb, Sc and with each other, reflecting their geochemical affinities. Their highest concentrations were found in mineral occurrences in the Eastern goldfields of the Yilgarn Craton. Lower Cr values have been mostly recorded for sediments from the Murray Basin area.

Generally, the Cr concentrations found in the study area do not exceed the recommended level for soils related to ecosystems (210 ppm), except 11 of the 81 sites investigated, which are located in the Yilgarn Craton and most likely relate to mining activity and/or mineralisation.. The concentration of Co and Ni in the soil samples of this research do not exceed the recommended guidelines (40 ppm and 600 ppm, respectively).

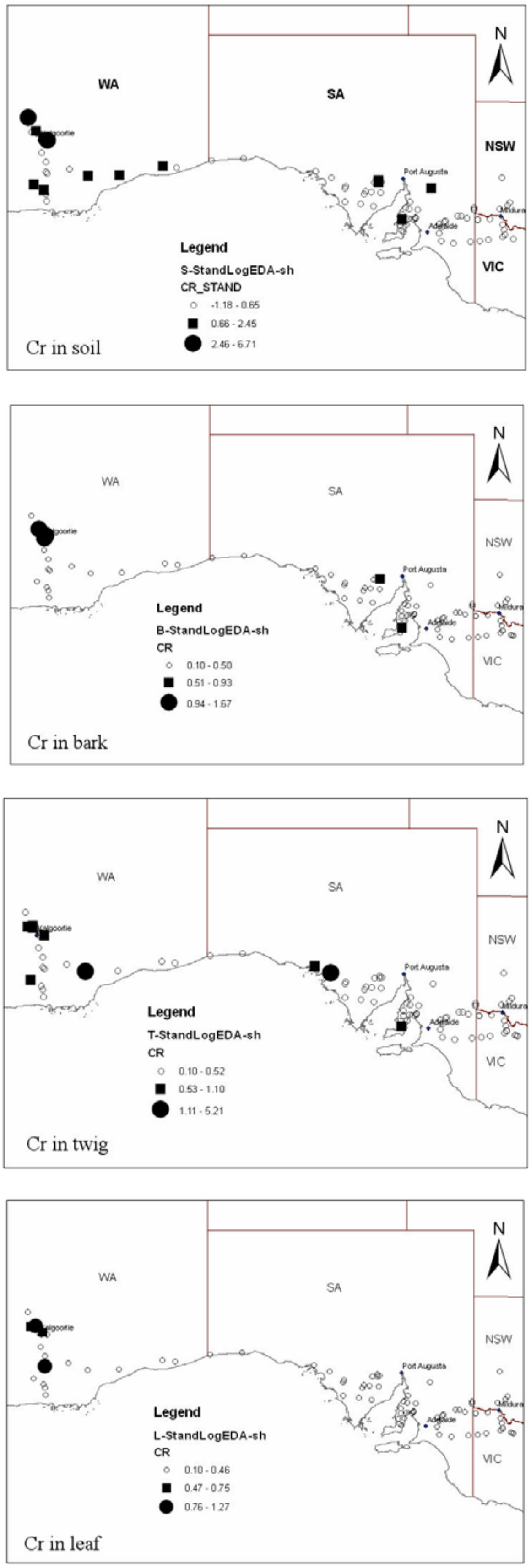


Figure 5.3 Spatial distribution of soil and biogeochemical anomalies for Cr (ppm) in the study areas

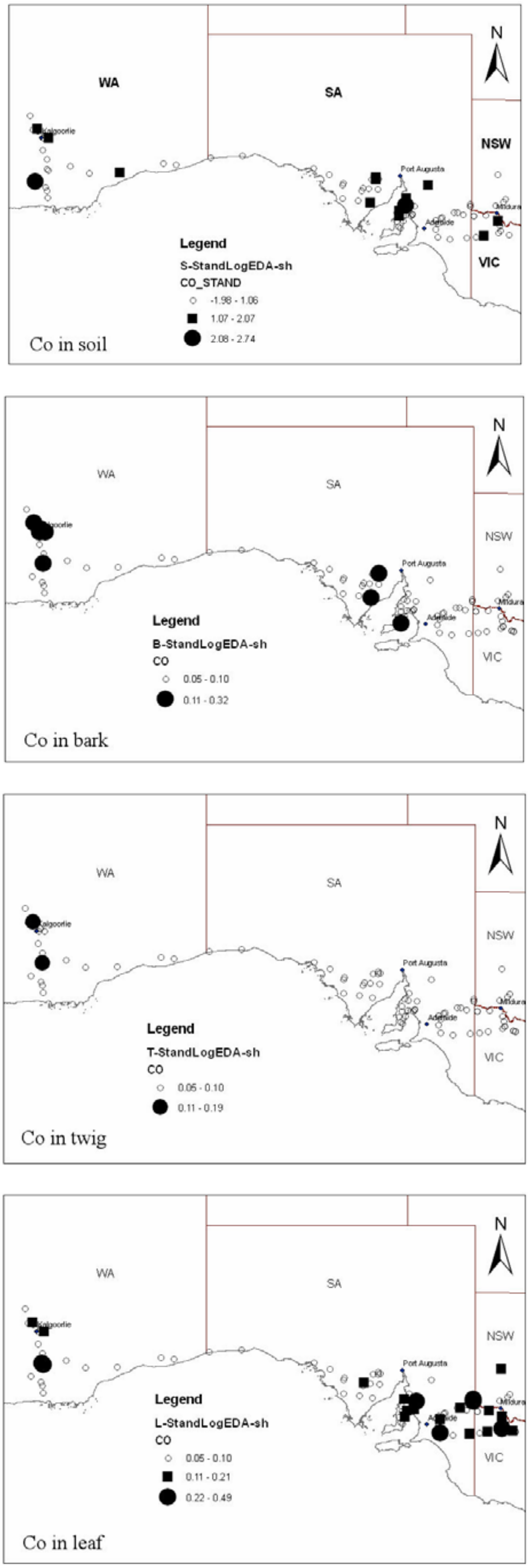


Figure 5.4 Spatial distribution of soil and biogeochemical anomalies for Co (ppm) in the study areas

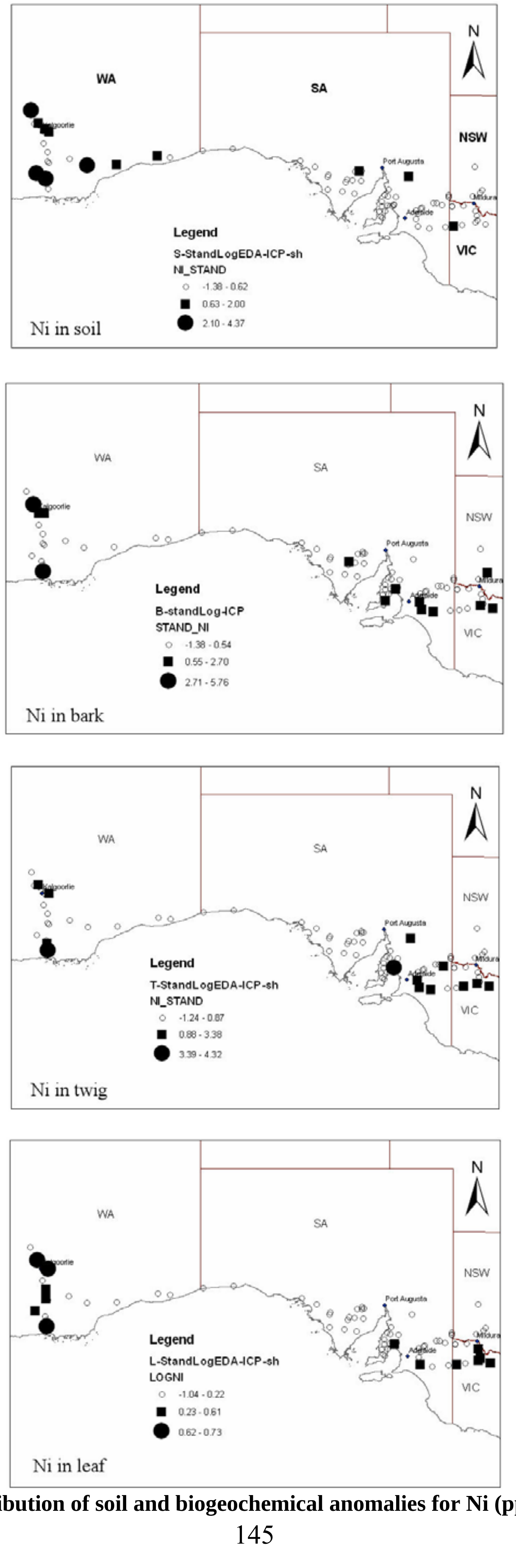


Figure 5.5 Spatial distribution of soil and biogeochemical anomalies for Ni (ppm) in the study areas

5.4.6 Pedogeochemical dispersion of lead

The terrestrial abundance of Pb indicates a tendency for Pb to concentrate in acid rocks and argillaceous sediments in which the common Pb concentrations range from 10 to 40 ppm. The geochemical characteristics of Pb^{2+} somewhat resemble the divalent alkaline-earth group of metals; thus, Pb has the ability to replace elements such as Ba and K in minerals, which reflects the close correlation of Pb abundances with Ba, Ce, Cs, K and Rb contents in the soils of the survey area.

The median value for Pb in world soils is reported to be 17 ppm, whereas soils of the study area have lower contents (median of 6.6 ppm). Also, the minimum and maximum Pb concentrations have been recorded over siltstone and sandstone lithologies (1.1 ppm and 40.4 ppm, respectively), which is below the recommended level (300 ppm) for assessment of contaminated sites in Australia (Department of Environmental Protection, 2003).

The spatial regional distribution of soil Pb contents in the area is generally within background values, except some sites in Eyre and Yorke Peninsulas which are possibly a reflection of proximity to the world's largest Pb smelter at Port Pirie. Also, vegetation (especially bark and leaves) show similar patterns in the study area (Figure 5.6 and Table 5.11).

Table 5.11 Correlation coefficient (r) between Pb in soil and vegetation

	bark	twig	leaf
Soil	71* (0.54)	81 (0.35)	73 (0.53)

* Number of samples in each plant organs.

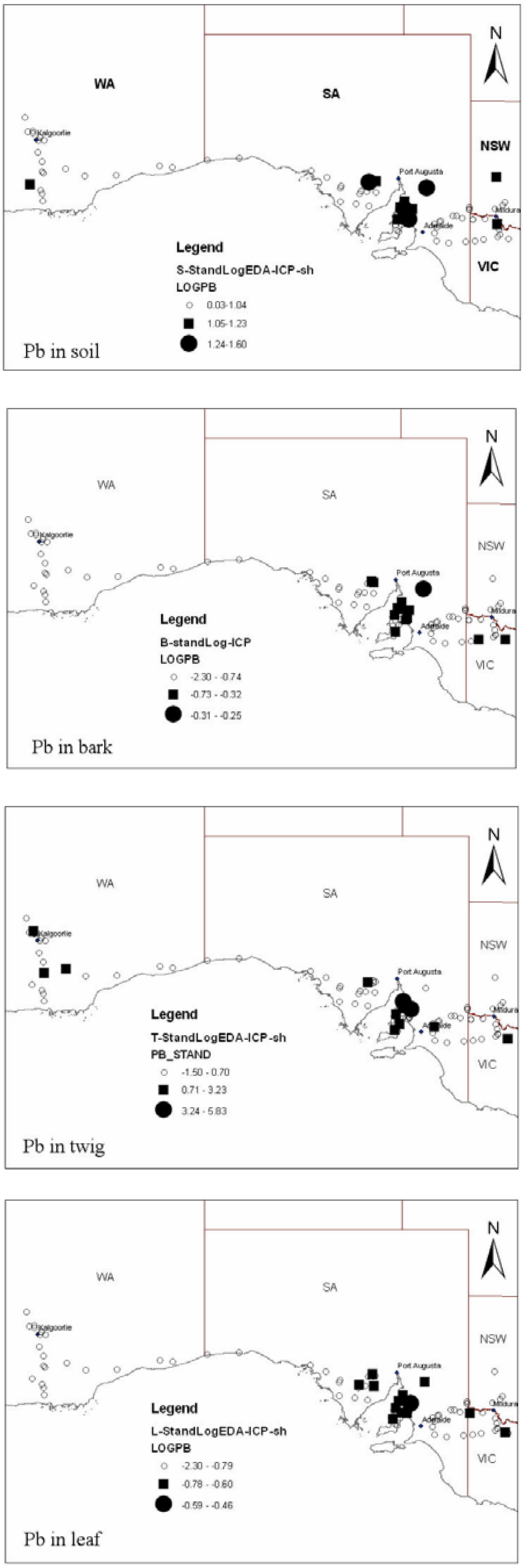


Figure 5.6 Spatial distribution of soil and biogeochemical anomalies for Pb (ppm) in the study areas

5.4.7 Rare earth elements

The patterns shown by individual REE are similar, although not identical. Around the granites at Eyre and Yorke Peninsulas, there are highly elevated REE concentrations in the soils. The REE contents in soils from different lithologies suggest that soils over granite bedrock are significantly richer in REE (and especially LREE) than those occurring over other geological units.

A plot of the REE concentrations in the soils of the study area divided by the REE contents in chondrites over different lithologies (Figure 5.7) shows higher REE values in granitic substrate than other lithologies. The common pattern of REE abundances in the soils of each lithotype is of decreasing chondrite-normalised contents from La to Lu, as found for other studies elsewhere (Maria et al., 2000; Lee et al., 2004).

The spatial correlation between REE contents in soils and vegetation varied, depending on the plant organs (Appendix K), which is more pronounced for bark and leaves (for La and Sm).

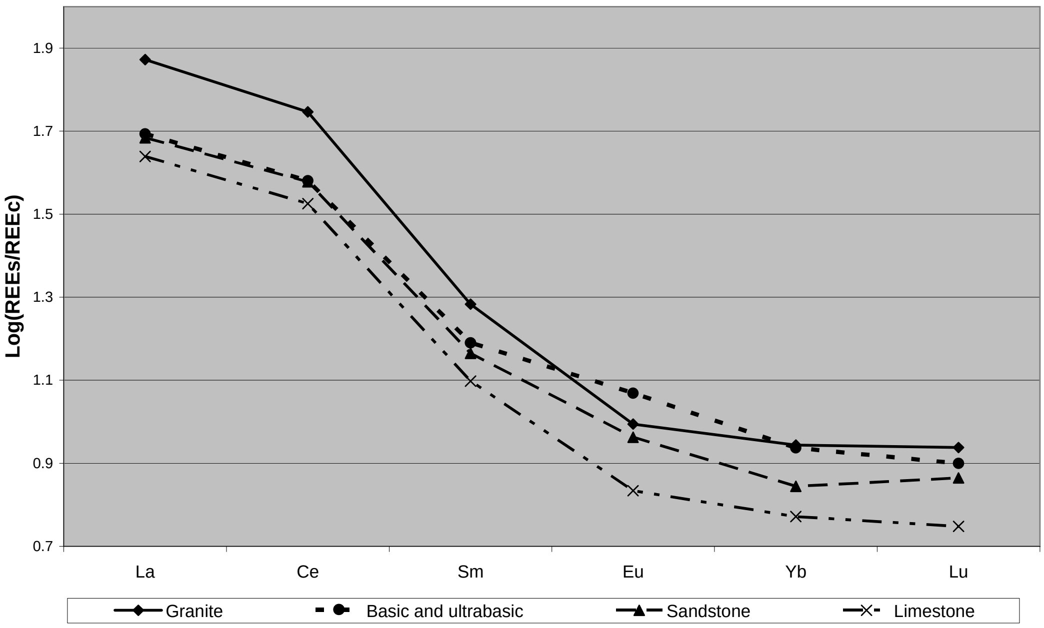


Figure 5.7 Chondrite-normalized REE patterns of soils in different lithotypes.

5.4.8 Other elements

The regional pattern of Ba in soils (Appendix L) generally restricts higher values to areas containing alluvium, sedimentary and acidic igneous rocks, including in the vicinity of the granites of the central section of the study area and the granites NE of Adelaide.

The regional arrays for geochemically less mobile elements, such as Ta and W are broadly similar. At 26 and 8 sites respectively, the highest concentrations of Ta and W are mainly found over metamorphosed basic and ultrabasic volcanic and intrusive rocks near the mineral occurrences of the Kalgoorlie area in the western part of the study area, whereas the regional distribution of Ta in the soil also indicates some elevated contents over parts of the Gawler Craton at Eyre Peninsula.

The main Zr-bearing mineral in soils is zircon ($ZrSiO_4$). Zircon is an accessory mineral in many rocktypes. ANOVA for Zr in soils was not performed due to the high proportion of samples (over 40%) recording values below detection limit. However, the median content of Zr in soils over sandstone and siltstone units is higher than for other lithologies which correspond to its higher average abundance than for other rock types (Table 5.3).

Reimann and de Caritat (1998) report the median value for Zr in world soils to be 230 mg/kg, whereas in the soils of the study area the median value is 253.5 mg/kg. Since zircon is a very persistent mineral, it is concentrated in highly weathered soils as more soluble components are removed, and many Australian soils are the product of a long weathering history.

The regional distribution of high field strength elements (Zr and Hf) show close association in the eastern section of the study area within the Murray Basin over

siltstone and sandstone, which is reflected at highly significant correlation coefficient between these two elements. The regional Hf pattern shown by vegetation (especially bark and leaves) resembles that of the soil in this area (Appendix L)

The median Th assay in world soils is 9.4 mg/kg (Reimann and de Caritat, 1998). The soils of the study area have lower values averaging 5.9 ± 3.1 mg/kg. Thorium is present mainly in the minerals thorite ($ThSiO_4$), monazite [$(Ce,La,Nd,Th)PO_4$ and thorianite (ThO_2). Monazite is probably the most abundant. The vegetation (bark and leaves) and soil Th concentrations displayed significant correlation in the study area and both media show highest contents over Gawler Range Volcanics in Eyre Peninsula.

The regional distribution of other radioactive elements, K, Rb and U in the soils of the study area are generally similar to Th. Parts of the Murray Basin in South Australia and the Eyre and Yorke Peninsulas are the common areas for elevated values of these elements in the soils studied. For these elements, except U due to lack of data above the detection limit for plants, the correlation coefficients between the two media were statistically insignificant.

Chapter 6 : MULTIVARIATE ANALYSIS OF BIOGEOCHEMICAL DATA

6.1 Introduction

In previous chapters, we have considered the analysis of data consisting of a single element on each plant sample. We will now examine techniques for the analysis of multivariate data, in which each sample is characterized by several elements. Multivariate models allow us to consider changes in several properties simultaneously.

Cluster analysis

Cluster analysis refers to a set of techniques designed to classify observations so that members of the resulting groups are similar to each other and distinct from the other group. The classification procedures can be grouped into four types (Davis, 2002):

1) Partitioning methods which operate on the multivariate observations themselves, or on projections of these observations onto planes of lower dimensions.

2) Arbitrary origin methods operate on the similarity between the observations and a set of arbitrary points.

3) Mutual similarity procedures group together observations that have a common similarity to other observations.

4) Hierarchical clustering joins the most similar observations, and then successively connects the next most similar observations to these. First an $m \times n$ matrix of similarities between all pairs of observations is calculated. Those pairs having the highest similarities are then merged, and the matrix is recomputed. This is done by

averaging the similarities that the combined observations have other observations. The process iterates until the similarity matrix is reduced to 2 × 2. The progression of levels of similarity at which observations merge is displayed as a dendrogram.

Clustering is an efficient way of displaying relationships among objects. The great benefits of cluster analysis are that it provides a relatively direct way to classify objects, and it presents results in a manner that is both familiar and easy to understand. While other multivariate techniques, such as factor analysis, provide more insight into the underlying structure of the data set, the use of these techniques requires further analyses to identify distinct groups.

Factor analysis

The purpose of factor analysis methodology is to share the common objective of attempting to reveal underlying structures that are presumed to exist within a set of multivariate observations. Factor methods all operate by extracting the eigenvalues and eigenvectors from a square matrix produced by multiplying a data matrix by its transpose.

Factor models can be divided into two broad classes, R-mode and Q-mode techniques. The first is concerned with interrelations between variables, and operates by extracting eigenvalues and eigenvectors from a covariance or correlation matrix. The second is concerned with the relationships between objects, commonly as an attempt to discern patterns of groupings within their arrangement in multivariate space.

The first step in R-mode factor analysis is to convert the data matrix into a square, symmetric matrix (R) that expresses either the degree of interrelationships between the variables:

$$R = X^{'}X$$

where X and $X^{'}$ are matrices of raw data (consisting of n rows of observations and m columns of variables) and its transpose. The elements of the m variables:

$$r_{jk} = \sum_{i=1}^{n} x_{ij} x_{jk}$$

where j and k are two columns of the data matrix.

In factor analysis terminology, the vector formed by multiplying an eigenvector by its corresponding singular value (eigenvalue) is referred to as a factor. The individual elements of a factor are called loadings which relate the factor to the original variables. In matrix notation, the R-mode factors are:

$$A^{R} = U\,D$$

where U is an m × r matrix whose columns are the eigenvectors of R, and D is an r × r square matrix containing r nonzero eigenvalues along the diagonal; all off-diagonal elements of D are zero.

The loadings represent the proportion or weighting that must be assigned to each variable in order to project onto the factors as scores.

The first step was to standardize the raw data. Let x_i, …, x_p denote P variables, each with *N* observations. The *j*th observation of the *i*th variable is $X_{i,j}$, where *i* = 1, …, P and j = 1, …, N. If x_m and S_i denote the mean and standard deviation, respectively, computed from the *N* observations of the *i*th variable, then the *j*th observation of the *i*th variable is expressed in standardized units as,

$$Z_{ij} = \frac{X_{i,j} - x_m}{S_i}$$

where Z_{ij} is the jth value of the standardized variable, Z_i. The mean and variance of Z_i are zero and one, respectively, for all values of *i*. Standardization tends to increase the influence of variables whose variance is small, and reduce the influence of variables whose variance is large. Furthermore, the standardization procedure eliminates the influence of different units of measurement, and makes the data dimensionless.

R-mode scores are found by multiplying the data set matrix by the loading:

$$S^R = X A^R$$

which project the n individual objects onto the factors. For a specific observation, *i*, :

$$S_{ik} = \sum_{j=1}^{m} a_{jk} x_{ji}$$

where S_{ik} is the score of the *i*th observation on the *k*th factor, x_{ji} is the value of variable *j* measured on object *i*, and a_{jk} is the loading of variable *j* on factor *k*. In turn, a_{jk} is the product of element j of the *k*th eigenvector, times the square root of the *k*th eigenvalue.

Factor rotation

In some cases, positions of the p orthogonal factor axes in m space may be constrained by m-p unnecessary axes, which also must be placed orthogonally through the sample space. However, we need only p factor axes to explain our data. If we cut off the irrelevant orthogonal axes, it seems possible to further rotate the factors and perhaps find a better position for them. We can do this by a variety of rotational procedures. The particular technique we will employ is called Kaiser’s Varimax scheme, which has as its objective the moving of each factor axis to positions such that projections from each variable onto the factor axes are either near the extremities or near the origin. The method operates by adjusting the factor loadings so they are either

near ±1 or near zero. For each factor, there may be a few significantly high loadings and many insignificant loadings. Interpretation, in terms of original variables, is thus made easier.

The Varimax criterion involves maximization of the variance of the loadings on the factors. We define the variance, s_k^2, of the loadings on the Kth factor as

$$s_k^2 = \frac{p\sum_{j=1}^{m}(a_{jp}^2 / h_j^2)^2 - (\sum_{j=1}^{m} a_{jp}^2 / h_j^2)^2}{p^2}$$

where, p is the number of factors, m is the number of original variables, a_{jp} is the loading of variable j on factor p, and h_j^2 is the communality of the jth variable. The quantity we wish to maximize is

$$V = \sum_{k=1}^{p} s_k^2$$

The variance is calculated from the factor loadings, a_{jp}, which are corrected by dividing each by its communality, h_j^2. In other words, only the common part of the variance of each variable is considered, removing the constraint imposed by the m-p additional components necessary to account for all of the variance of each variable. Maximizing the variance implies maximizing the range of the loadings, which tends to produce either extreme (positive or negative) or near-zero loadings, satisfying the purpose of factor rotation.

6.2. Results

6.2.1. Vegetation

Hierarchical clustering of biogeochemical data

An R-mode cluster analysis was performed on the data set of each individual plant organ analysed by INAA and ICP-MS, using the average linkage method (between groups) based on correlation coefficients. This method is the most appropriate to reveal correlation between variables. The results are shown in the form of dendrograms which illustrate the grouping made at each successive stage of the clustering process (Figures 6.1-6.3). The distance axis represents the degree of association between groups of variables, i.e. the lower the value on the axis, the more significant the association.

In cluster analysis (CA) for vegetation, the following elements were considered due to available data:

B, Br, Ca, Cu, Fe, Ga, K, La, Li, Mn, Na, Ni, Pb, Sc, Sm, Sr, Th, Tl, V and Zn.

In bark, Fe and Sc are very well correlated with each other and form another cluster with Th. Association of La and Sm is joined to them at a quite high distance. Also, Ca and Sr form a cluster in the bark's dendrogram.

In twigs, Fe and Sc are again associated in a cluster where V joins a little further distant. Also, a second cluster is formed by Br and Na. Rare earth elements La and Sm are very well correlated with each other and Li is joined to the La-Sm cluster at some distance.

The result of CA of mallee leaf samples is somewhat similar to twigs, where Fe-

Sc cluster is connected closely to V and these are correlated to Th. La-Sm, Li-Pb and Br-Na form independent clusters with quite high values of distances, while K seems to be isolated.

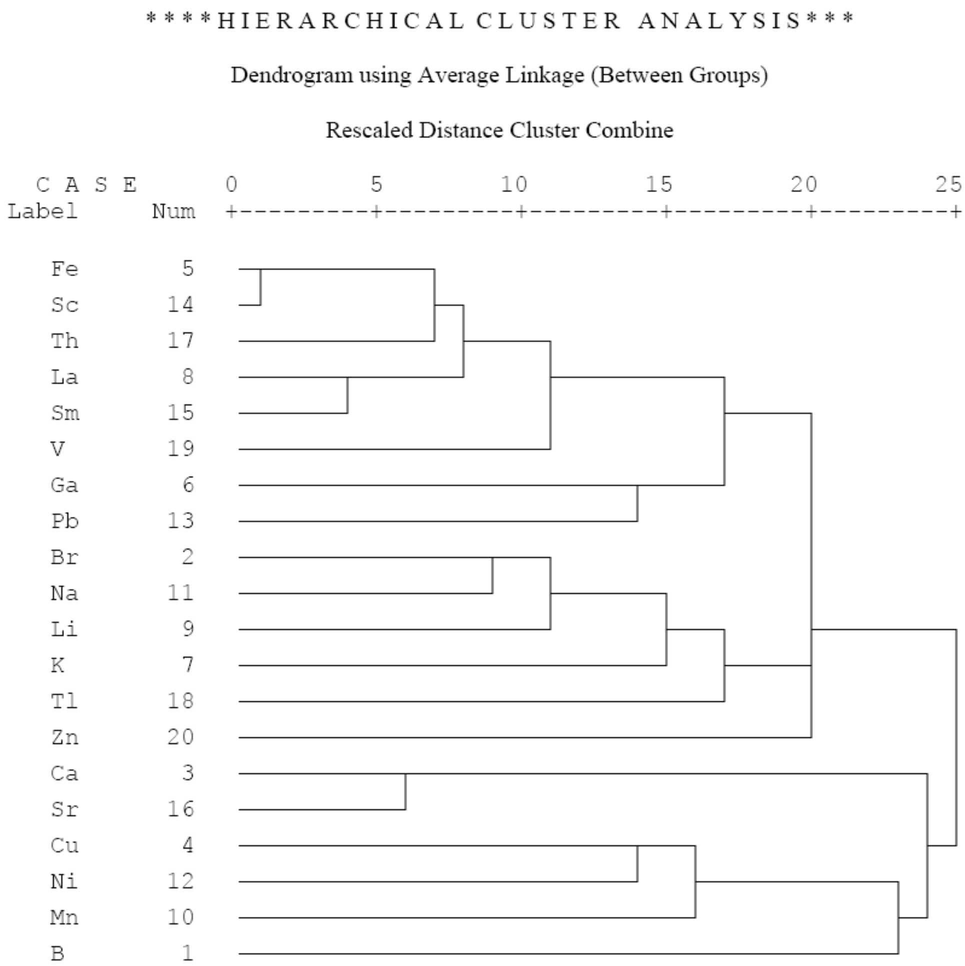


Figure 6.1 Cluster dendrogram for elemental abundances in mallee bark samples

* * * H I E R A R C H I C A L   C L U S T E R   A N A L Y S I S * * *

Dendrogram using Average Linkage (Between Groups)

Rescaled Distance Cluster Combine

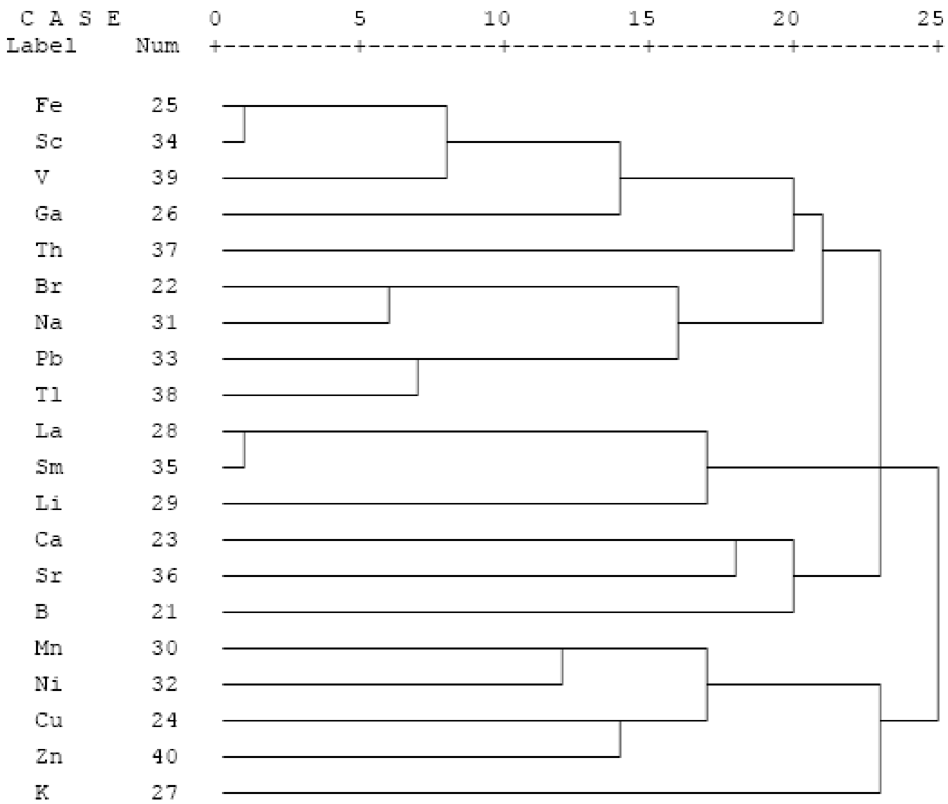


Figure 6.2 Cluster dendrogram for elemental abundances in mallee twig samples

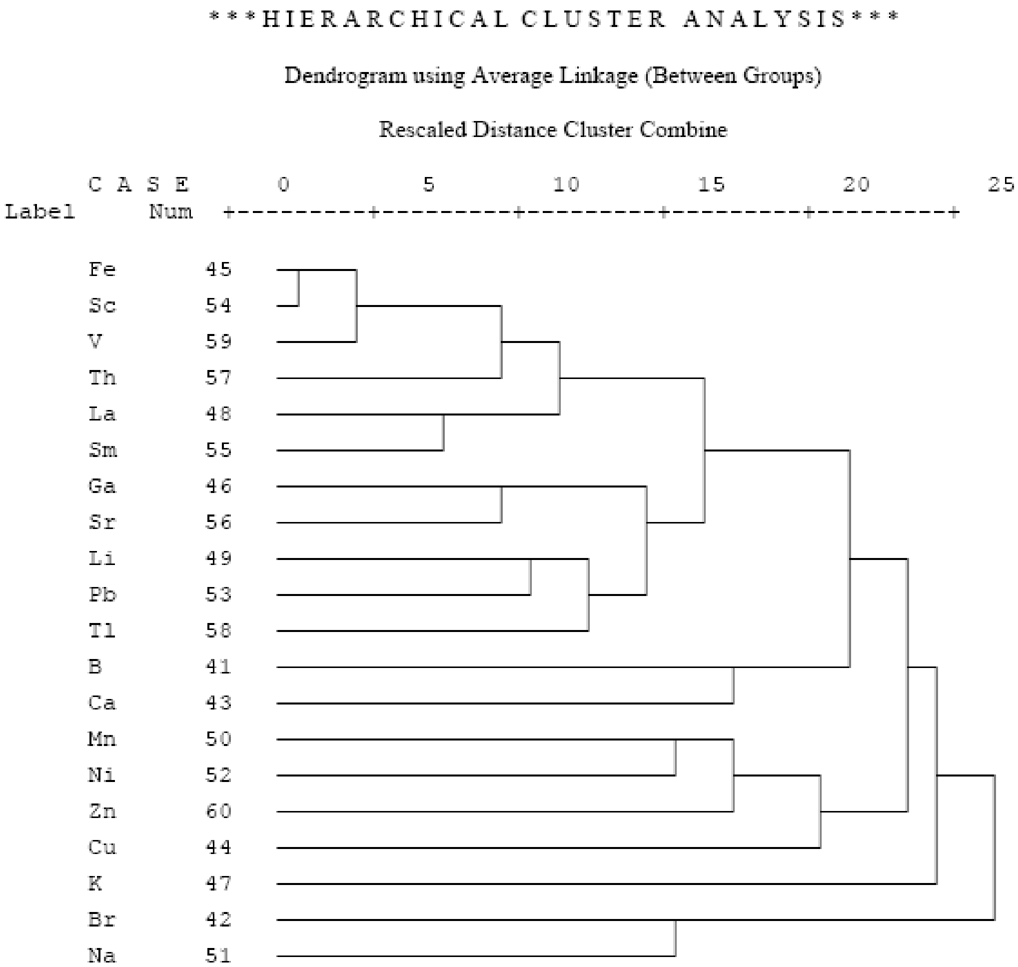


Figure 6.3 Cluster dendrogram for elemental abundances in mallee leaf samples

R-mode factor models of trace elements in plant organs

The results of the factor analysis are presented in Tables 6.1- 6.3. The same group of elements as applied in cluster analysis was used for this analysis.

Bark

According to the results of the initial eigenvalues, six factors are considered which account for 71.7% of the total variance. The eigenvalues of the first five extracted factors are greater than one, and the sixth becomes greater than one after the rotation. The communalities shown by the variables, considering six factors, vary from 54% for Zn to 88 % for Sc. All the elements are consequently well represented by this six-factor model. The initial factor matrix for bark indicates that Fe, La, Sc and Sm are associated, displaying high loadings in the first factor (F1), while Th, Mn and Ni are distributed in the first three factors.

The rotation of the matrix contributes to clarify these factors; F3 includes Ca and Sr, and Th is well attributed to F1. Manganese and Ni show high negative loadings in F4.

Twig

The factor analysis of twig samples is displayed in Table 6.2. Here six factors are retained, accounting for more than 66% of the total variance. The communalities shown by the variables all display high values, except Cu, Mn and Th.

The rotated factor matrix determines five associations: F1 includes Fe, Sc and V. F2 corresponds to the second factor for bark, including Br and Na. Two rare earth elements, La and Sm, are assigned to the third factor, while F4 is attributed to Ni and Zn. The association of Ca-Sr in F6 is similar to F3 in bark.

Table 6.1 Total variance explained and rotated factor loadings matrix (six factors selected) for bark

Total Variance Explained				Extraction Sums of Squared Loadings					
Factor	Initial Eigenvalues			Before rotation			After rotation		
	(I)	(II)	(III)	(I)	(II)	(III)	(I)	(II)	(III)
1	5.37	26.83	26.8	5.37	26.83	26.8	4.39	21.93	21.9
2	3.40	17.00	43.8	3.40	17.00	43.8	2.85	14.25	36.2
3	1.98	9.88	53.7	1.98	9.88	53.7	2.26	11.29	47.5
4	1.33	6.67	60.4	1.33	6.67	60.4	1.82	9.11	56.6
5	1.25	6.26	66.6	1.25	6.26	66.6	1.74	8.68	65.3
6	1.02	5.09	71.7	0.96	5.09	71.7	1.30	6.48	71.7
7	0.88	4.41	76.1						
8	0.71	3.57	79.7						
9	0.63	3.14	82.9						
10	0.61	3.06	85.9						
11	0.52	2.60	88.5						
12	0.47	2.35	90.9						
13	0.40	1.98	92.9						
14	0.35	1.75	94.6						
15	0.28	1.39	96.0						
16	0.27	1.34	97.3						
17	0.19	0.95	98.3						
18	0.18	0.91	99.2						
19	0.13	0.65	99.8						
20	0.03	0.16	100						

(I) Total, (II) % of Variance, (III) Cumulative %

Rotated factor loadings matrix*

	F1	F2	F3	F4	F5	F6
B	-0.03	0.01	-0.04	0.00	-0.12	**0.91**
Br	0.24	0.67	-0.11	-0.34	0.17	-0.03
Ca	0.14	-0.15	**0.86**	0.07	-0.23	0.01
Cu	0.13	-0.25	0.07	0.60	0.08	0.39
Fe	**0.91**	0.03	0.10	0.07	0.09	0.04
Ga	0.28	-0.03	0.08	0.00	0.75	-0.05
K	-0.11	0.68	-0.34	-0.07	-0.10	0.10
La	**0.79**	0.25	0.09	-0.09	0.22	-0.17
Li	0.32	0.68	-0.21	-0.11	0.08	-0.18
Mn	-0.02	-0.01	-0.18	**0.80**	-0.04	-0.16
Na	0.04	**0.78**	-0.09	-0.14	0.05	-0.04
Ni	0.19	-0.20	0.12	**0.72**	0.06	0.01
Pb	0.16	0.22	-0.19	0.03	**0.79**	-0.07
Sc	**0.92**	-0.01	0.06	0.14	0.07	-0.03
Sm	**0.74**	0.35	0.05	-0.11	0.34	-0.12
Sr	0.11	-0.13	**0.88**	-0.02	0.08	-0.12
Th	**0.84**	-0.11	0.03	0.12	-0.01	-0.02
Tl	0.05	0.62	0.37	0.20	0.39	0.03
V	0.64	0.25	-0.19	0.17	0.27	0.17
Zn	0.24	0.19	-0.53	0.15	-0.04	-0.38

* Rotation method: Varimax with Kaiser normalization. Rotation converged in 5 iterations.

Table 6.2 Total variance explained and rotated factor loadings matrix (six factors selected) for twig

Total Variance Explained				Extraction Sums of Squared Loadings					
Factor	Initial Eigenvalues			Before rotation			After rotation		
	(I)	(II)	(III)	(I)	(II)	(III)	(I)	(II)	(III)
1	3.70	18.52	18.5	3.70	18.52	18.5	2.96	14.82	14.8
2	2.58	12.88	31.4	2.58	12.88	31.4	2.38	11.91	26.7
3	2.36	11.80	43.2	2.36	11.80	43.2	2.26	11.28	38.0
4	1.92	9.62	52.8	1.92	9.62	52.8	2.16	10.82	48.8
5	1.49	7.44	60.3	1.49	7.44	60.3	2.02	10.08	58.9
6	1.30	6.49	66.7	1.30	6.49	66.7	1.57	7.83	66.7
7	0.96	4.79	71.5						
8	0.94	4.70	76.2						
9	0.82	4.10	80.3						
10	0.69	3.47	83.8						
11	0.66	3.29	87.1						
12	0.61	3.03	90.1						
13	0.40	2.01	92.1						
14	0.38	1.91	94.0						
15	0.32	1.59	95.6						
16	0.30	1.48	97.1						
17	0.25	1.23	98.3						
18	0.16	0.80	99.1						
19	0.10	0.49	99.6						
20	0.07	0.37	100						

(I) Total, (II) % of Variance, (III) Cumulative %

Rotated factor loadings matrix*

	F1	F2	F3	F4	F5	F6
B	0.20	0.21	-0.27	0.46	0.17	0.48
Br	0.03	**0.81**	0.02	-0.04	0.27	0.12
Ca	0.04	0.17	-0.07	-0.15	-0.09	**0.77**
Cu	-0.30	0.08	0.20	**0.59**	-0.08	0.06
Fe	**0.81**	0.28	-0.10	0.06	-0.08	0.13
Ga	0.58	-0.41	0.13	0.23	0.28	-0.06
K	-0.40	0.01	0.01	0.33	-0.02	0.07
La	0.26	0.05	**0.80**	0.13	0.30	-0.04
Li	-0.15	-0.02	0.67	-0.10	-0.37	0.18
Mn	0.18	0.00	0.20	**0.49**	-0.44	-0.04
Na	0.07	**0.81**	-0.10	0.16	0.22	-0.05
Ni	0.13	0.05	-0.09	**0.71**	-0.23	0.01
Pb	0.18	0.07	0.17	-0.16	**0.80**	0.03
Sc	**0.83**	0.32	0.07	0.09	-0.06	0.09
Sm	0.07	0.02	**0.88**	0.12	0.20	-0.08
Sr	0.05	-0.34	0.26	0.03	0.23	**0.70**
Th	0.27	0.56	0.16	0.05	-0.24	-0.02
Tl	0.04	0.43	0.16	-0.17	0.66	0.10
V	**0.84**	-0.06	0.18	0.03	0.24	0.04
Zn	0.14	-0.08	0.08	**0.73**	0.04	-0.38

* Rotation method: Varimax with Kaiser normalization. Rotation converged in 6 iterations.

Table 6.3 Total variance explained and rotated factor loadings matrix (six factors selected) for leaf

Total Variance Explained				Extraction Sums of Squared Loadings					
Factor	Initial Eigenvalues			Before rotation			After rotation		
	(I)	(II)	(III)	(I)	(II)	(III)	(I)	(II)	(III)
1	6.40	31.99	32.0	6.40	31.99	32.0	4.97	24.84	24.8
2	2.19	10.94	42.9	2.19	10.94	42.9	2.63	13.14	38.0
3	1.96	9.80	52.7	1.96	9.80	52.7	1.96	9.79	47.8
4	1.81	9.04	61.8	1.81	9.04	61.8	1.90	9.50	57.3
5	1.21	6.04	67.8	1.21	6.04	67.8	1.70	8.51	65.8
6	1.01	5.04	72.9	1.01	5.04	72.9	1.41	7.07	72.9
7	0.93	4.63	77.5						
8	0.75	3.77	81.3						
9	0.69	3.43	84.7						
10	0.60	2.99	87.7						
11	0.50	2.51	90.2						
12	0.49	2.44	92.6						
13	0.33	1.65	94.3						
14	0.29	1.44	95.7						
15	0.22	1.10	96.8						
16	0.20	0.99	97.8						
17	0.19	0.94	98.7						
18	0.12	0.58	99.3						
19	0.10	0.51	99.8						
20	0.03	0.16	100						

(I) Total, (II) % of Variance, (III) Cumulative %

Rotated factor loadings matrix*

	F1	F2	F3	F4	F5	F6
B	0.24	0.34	0.36	-0.12	-0.02	-0.62
Br	0.06	0.15	-0.03	-0.02	**0.76**	-0.11
Ca	-0.01	0.00	**0.82**	0.12	-0.22	-0.24
Cu	-0.12	**0.76**	0.04	0.39	-0.10	0.04
Fe	**0.93**	0.04	0.08	0.10	0.15	-0.03
Ga	0.49	0.30	0.62	0.04	0.06	0.28
K	0.01	0.10	0.03	0.11	-0.12	**0.78**
La	**0.70**	0.20	0.15	0.13	-0.24	-0.07
Li	0.40	**0.71**	0.12	-0.15	0.04	-0.10
Mn	0.04	-0.18	0.39	**0.76**	0.03	-0.08
Na	-0.10	-0.08	-0.18	-0.08	**0.79**	0.01
Ni	0.14	0.09	-0.18	**0.78**	0.00	0.09
Pb	0.27	**0.81**	0.12	0.01	0.15	0.01
Sc	**0.93**	0.06	0.04	0.09	0.17	0.03
Sm	**0.76**	0.11	0.12	0.15	-0.21	0.01
Sr	0.32	0.44	**0.65**	-0.10	-0.10	0.11
Th	**0.77**	0.10	0.00	0.04	-0.08	-0.02
Tl	0.33	0.52	0.20	-0.05	0.44	0.44
V	**0.86**	0.25	0.14	0.04	0.15	-0.01
Zn	0.21	0.13	0.02	0.65	-0.16	0.17

* Rotation method: Varimax with Kaiser normalization. Rotation converged in 6 iterations.

Leaf

The concentrations of 20 elements in leaf tissue were treated the same way, the results being displayed in Table 6.3. On the basis of results of the initial eigenvalues, extracted factors account for about 73% of the total variance. The communalities indicated by the elements, for six factors, fluctuate from maximum 91% for Sc to minimum 54% for Zn. Most of the elements are therefore suitably related by this factor model. Factors 1, 3 and 4 are consistent with the first, third and fourth factors for bark, respectively. Bromine and Na are associated, exhibiting great loadings in the F5.

6.2.2. Soil

Hierarchical Cluster analysis (HCA)

The cluster analysis of pedogeochemical data was performed using the same method as applied for the vegetation. The dendrogram for the elements is shown in Figure 6.4. The 32 elements can be classified into three major groups: from Ce to Li, from As to V and Br-Ca-Sr cluster.

Based on HCA, the rare earth elements Ce, La, Lu, Sm and Yb are well correlated and K-Th cluster is connected to them at rather low distance. The lower part of the dendrogram illustrates the close association Fe, Co, Cr, Ni and Sc in which, V joins them at further distance. The Br, Ca and Sr cluster seems to be independent of other clusters. Hafnium is independent of other elements, while As-Sb and Cu-Mn make clusters at a quite low level of rescaled distance in dendrogram.

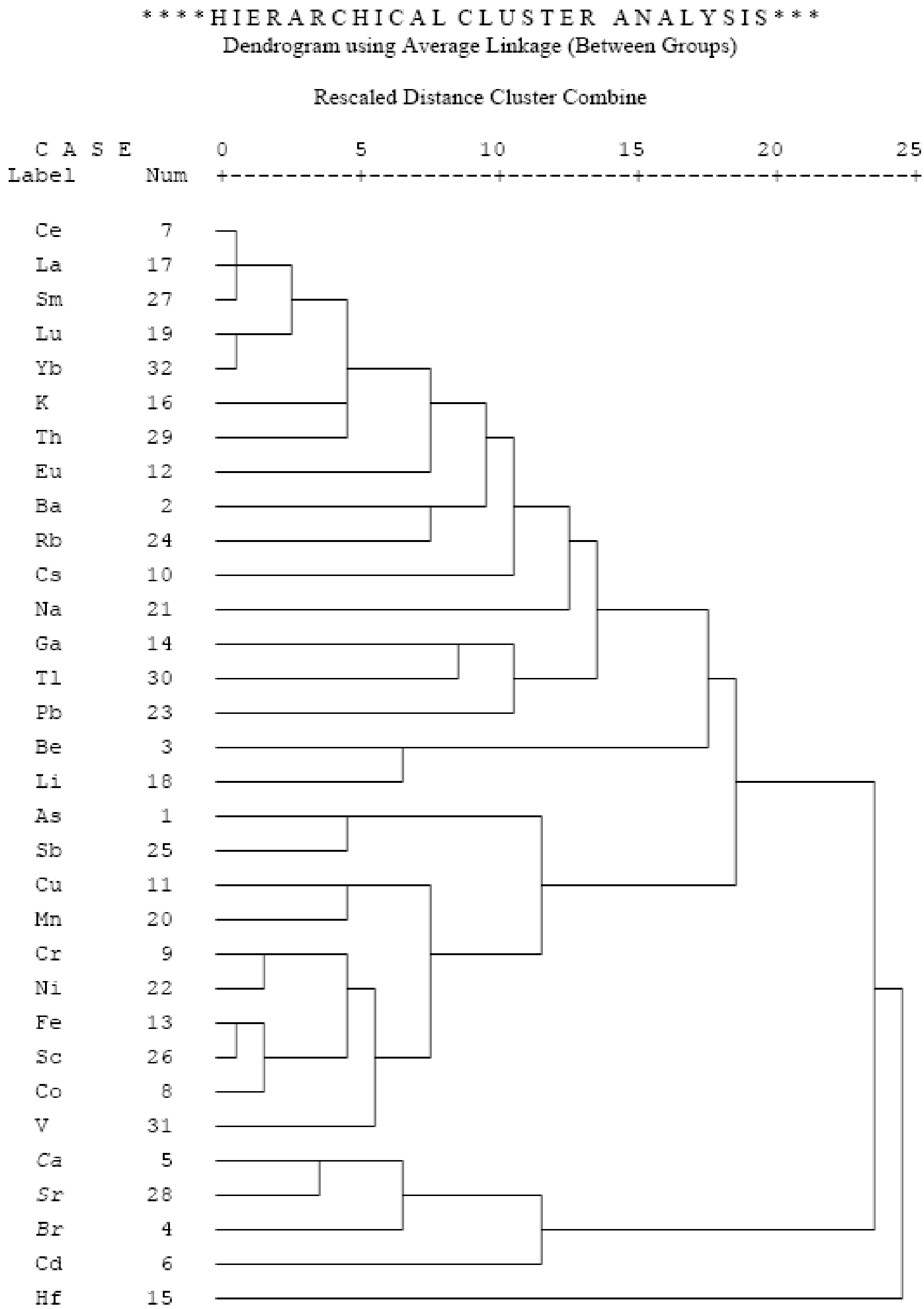


Figure 6.4 Cluster tree of elements using cluster analysis of soil data based on Pearson's correlation coefficients.

R-mode factor analysis of soil data

The results of the factor analysis are presented in Table 6.4. The same group of elements as applied in cluster analysis was used for this approach.

According to the results of the initial eigenvalues, five factors are considered which account for 85.1 % of the total variance. The eigenvalues of the first four extracted factors are greater than one, and the fourth becomes greater than one after the rotation. The communalities shown by the variables, considering five factors, vary from 62.8 % for Hf to 97 % for Fe. All the elements are therefore well represented by this five-factor model.

The rotated factor matrix determines five associations: F1 includes Ba, Hf, K, Na, Rb, Th and REE. The second factor encompasses nine elements, As, Co, Cr, Cu, Fe, Mn, Ni, Sc and V. F3 corresponds to the fourth cluster of CA (Br-Ca-Sr) and factor four includes a Be-Li association. Two metalloids, As (which also is present in F1) and Sb, are assigned to F5.

6.3. Discussion and summary

Vegetation

Multivariate statistical treatment of elemental concentrations in mallee plant organs indicates their association or grouping into factors.

The results of cluster analysis and factor analysis provide insight into the compositional variation in the plant chemistry of the study area. The similarity used in cluster analysis is a type of proportional similarity which is not sensitive to the order of magnitude of the data. Therefore, the degree of efficiency obtained in the analysis may be attributed to the variability of different types of sample media and geochemical characters of elements.

Table 6.4 Total variance explained and rotated factor loadings matrix (four factors selected) of soil data

Total Variance Explained				Extraction Sums of Squared Loadings					
Factor	Initial Eigenvalues			Before rotation			After rotation		
	(I)	(II)	(III)	(I)	(II)	(III)	(I)	(II)	(III)
1	15.57	48.67	48.7	15.57	48.67	48.67	9.38	29.30	29.30
2	5.13	16.03	64.7	5.13	16.03	64.70	8.51	26.60	55.89
3	3.33	10.40	75.1	3.33	10.40	75.10	4.10	12.82	68.71
4	2.13	6.66	81.8	2.13	6.66	81.76	3.80	11.88	80.59
5	1.08	3.39	85.1	0.95	3.39	85.14	1.46	4.56	85.14
6	0.841	2.629	87.8						
7	0.625	1.953	89.7						
8	0.396	1.237	91.0						
9	0.356	1.113	92.1						
10	0.352	1.100	93.2						
11	0.321	1.004	94.2						
12	0.266	0.831	95.0						
13	0.228	0.712	95.7						
14	0.196	0.611	96.3						
15	0.183	0.573	96.9						
16	0.177	0.553	97.5						
17	0.139	0.434	97.9						
18	0.121	0.378	98.3						
19	0.103	0.320	98.6						
20	0.083	0.259	98.9						
21	0.072	0.224	99.1						
22	0.067	0.209	99.3						
23	0.053	0.167	99.5						
24	0.048	0.149	99.6						
25	0.042	0.131	99.7						
26	0.029	0.091	99.8						
27	0.020	0.061	99.9						
28	0.014	0.045	99.9						
29	0.011	0.033	100						
30	0.006	0.018	100						
31	0.004	0.011	100						
32	0.002	0.008	100						

(I) Total, (II) % of Variance, (III) Cumulative %

Rotated factor loadings matrix*

	F1	F2	F3	F4	F5
As	0.156	**0.703**	0.073	0.031	**0.602**
Ba	**0.748**	0.078	0.049	0.182	0.365
Be	0.357	0.002	-0.027	**0.849**	0.105
Br	0.255	0.009	**0.864**	0.075	-0.078
Ca	0.127	0.066	**0.936**	-0.130	-0.012
Cd	0.312	0.381	**0.721**	0.112	0.146
Ce	**0.902**	0.182	0.182	0.276	0.025
Co	0.261	**0.923**	0.128	0.078	0.024
Cr	0.096	**0.960**	-0.115	-0.007	0.041
Cs	0.545	0.201	0.058	0.493	0.387
Cu	0.090	**0.851**	0.325	0.144	0.032
Eu	**0.646**	0.418	0.244	0.205	-0.135
Fe	0.400	**0.884**	-0.011	0.163	0.048
Ga	0.299	0.501	0.306	0.627	0.072
Hf	**0.735**	-0.245	-0.131	-0.037	-0.094
K	**0.825**	0.107	0.296	0.268	0.145
La	**0.897**	0.178	0.183	0.290	0.042
Li	0.170	0.136	-0.179	**0.878**	-0.044
Lu	**0.878**	0.345	0.100	0.106	0.023
Mn	0.268	**0.740**	0.363	0.082	0.209
Na	**0.711**	0.384	0.217	-0.341	0.185
Ni	-0.078	**0.938**	-0.035	0.083	0.099
Pb	0.410	0.218	0.259	0.579	0.184
Rb	**0.741**	0.036	0.047	0.403	0.118
Sb	0.103	0.570	-0.028	0.142	**0.686**
Sc	0.394	**0.873**	0.037	0.180	-0.083
Sm	**0.880**	0.246	0.226	0.255	0.007
Sr	-0.053	-0.158	**0.921**	0.014	0.048
Th	**0.744**	0.343	0.073	0.413	-0.029
Tl	0.427	0.309	0.514	0.544	-0.103
V	0.132	**0.845**	-0.131	0.180	0.290
Yb	**0.894**	0.339	0.094	0.130	0.023

* Rotation method: Varimax with Kaiser normalization. Rotation converged in 6 iterations.

So, grouping of elements in plant tissues has similarities and differences, depending on the organ's physiology. The results of factor analysis confirm the outcomes of cluster analysis in defining elemental associations, and in addition, it provided more detailed information than the cluster analysis in the sense that it enables us to predict the importance of each association and their contributions in revealing underlying structures that are presumed to exist within our multivariate observations.

Also, the factor scores represent estimates of the contribution of various factors to each site.

The distribution of the elemental associations in form of factor loading score maps resulting from R-mode factor analysis, are shown for each of plant organs in Appendix M.

The results show the influence of environmental controls on plant chemistry which is reflected in the different patterns of factor scores for plant organs. Nevertheless, some factors may respond to the lithological variations in the substrate. e.g. the highest scores of factor four in plant organs correspond to basic and ultrabasic rocks which suggest a lithogenic control over this factor. The factors three (in bark and leaves) and six in twigs may represent a macronutrient factor which accounts for about 86%, 82% and 77% of the total variance of Ca in bark, leaves and twigs, respectively.

Soil

In the soils of the study area, hierarchical cluster analysis (HCA) assisted in identifying relatively homogenous groups of variables and classifying elements of different sources on the basis of the similarities of their chemical properties.

The elements in the first major group (Ba, Be, Ce, Cs, Eu, Fe, Ga, Hf, K, La, Lu, Na, Pb, Rb, Sm, Tl and Yb) have relatively high concentrations in granite and their association in the soils of the study area reflecting their common sources. This group includes a quite distinct subcluster (Ce, La, Sm, Lu, and Yb) to which K and Th join.

The carrier of Th is mainly monazite, ($CePO_4$) where Th may substitute for the REE (Kabata-Pendias, 2001), which may explain its connection to the REE in this subcluster. The highly significant correlation of K with REE and Th (Appendix J) is

reflected in its inclusion at this cluster which arises from their common geochemical behaviour.

The association of Fe-Co-Cr-Ni-Sc can be reasonably designated as the signature of the underlying mafic rocks in the soils of the study area.

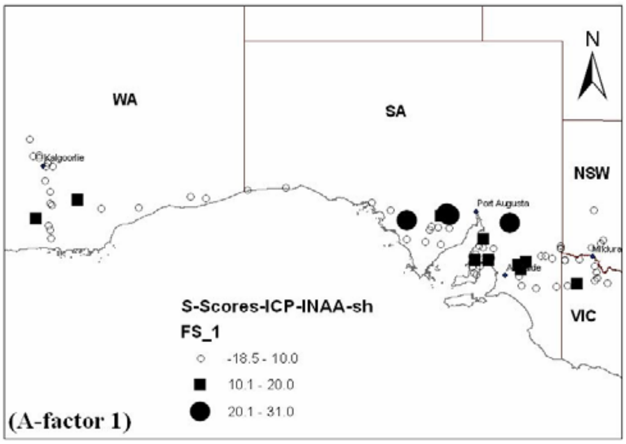
Arsenic and Sb are connected together which is explained by the geochemical characteristics of Sb which are closely related to those of As, and antimony may substitute for arsenic in several minerals.

The last major group is Br-Ca-Sr. Bromine and Sr are the only elements that have significant positive correlation with Ca in our soils (Appendix J). Br is a very volatile element and its salts are readily soluble. Therefore, its geochemistry is closely related to water chemistry and to evaporite deposits (Kabata-Pendias, 2001). So its correlation with Ca may be related to evaporation associated with pedogenic carbonate in southern Australia, where the same correlation between Br and Ca in calcrete is reported (Grevenitz, 2006).

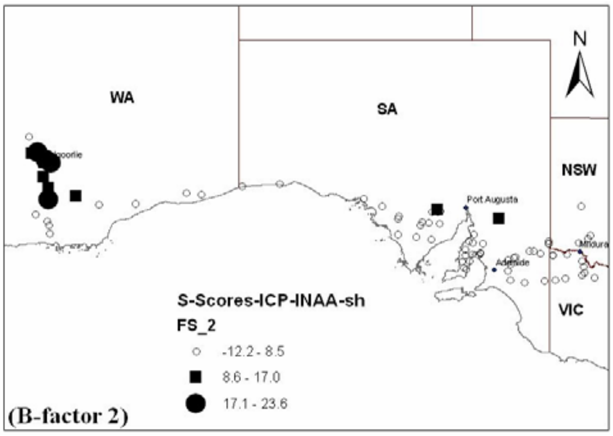
The element classification from R-mode factor analysis (RFA) of soil data is consistent with the results from HCA: F1 from RFA and first group from HCA, F2 and F5 from RFA with second group of HCA and F3 with the third group in HCA.

Based on RFA, 29.3% of the total variance emerges from factor one identified as a reflection of felsic rock source. The second factor contributes 26.6% of the total variance, and is soil-derived from basic and ultrabasic sources. The third factor shows the contribution of coprecipitation of Br, Ca and Sr during pedogenesis, with a variance of 12.8%. The factor four account for 11.8% of the variability which belongs to the high factor loading of Be and Li. This association in the soils of the study area can be attributed to their relationship in igneous rocks (e.g. pegmatite and granites). The factor

5 at 4.5% total variance is included high loadings of As and Sb (0.6 and 0.69, respectively) in the soils of the area. Since both elements belong to the shallowest zone of hydrothermal aureoles (Rose et al., 1979) and both are related to lateral and axial zoning in different types of deposits (e.g. gold-quartz deposits and copper-gold deposits), this factor may be considered as a mineralisation factor. In arid and semi-arid areas of low water table where the formation of near-surface hydromorphic dispersion pattern is inhibited, the major surface indication of buried ore may be biogenic anomalies resulting from the uptake of metal by deep-rooted plants and this may be reflected in their adjacent soils in the study area.



(A-factor 1)



(B-factor 2)

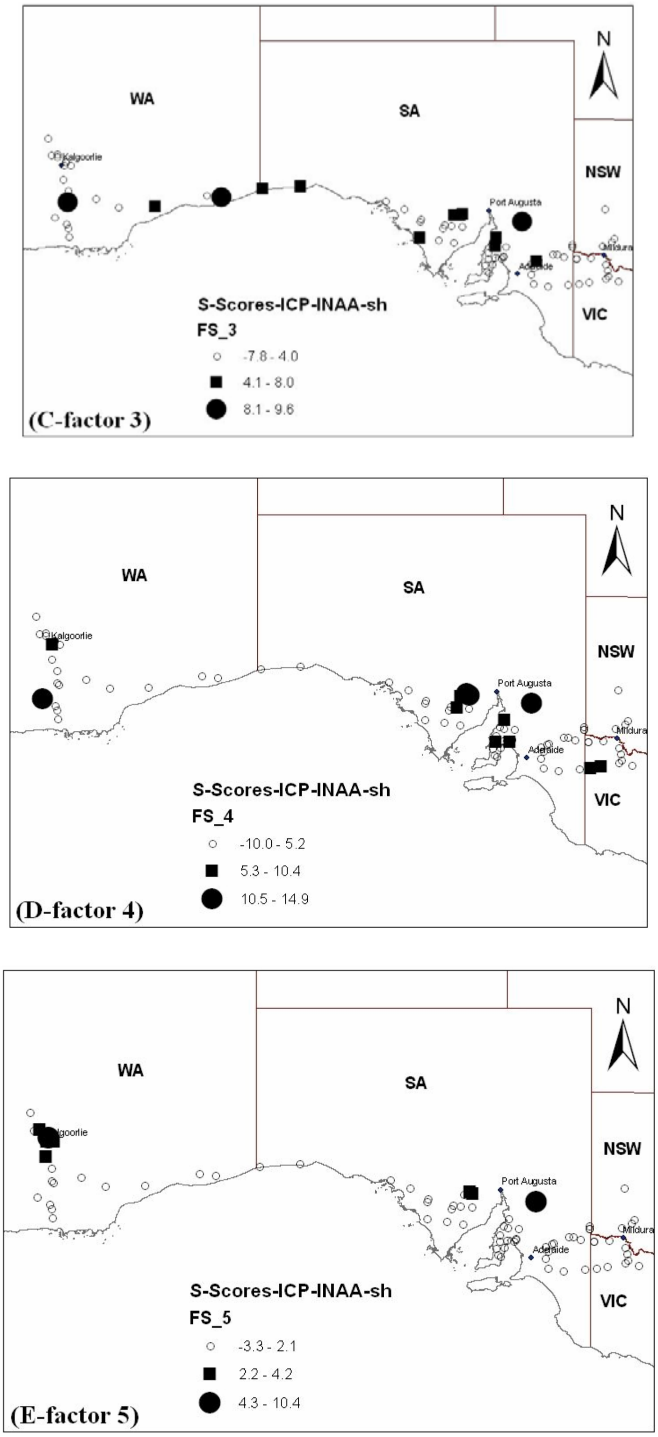


Figure 6.5 Spatial distribution of factor scores for soils in the study area

To examine the contribution of each factor at every site, we computed factor scores. Each original data point gains factor scores, representing the affiliation of the samples to the newly defined factors. The mapping of factor scores produces a set of

new maps. Comparative study of these maps with a geological map serves as a powerful tool in reinterpreting the data to provide direct differentiation of all rocks units on a factor score map.

The investigation of the standard factor score map of F1 (Figure 6.5, A), indicates clearly the outlining of the following areas:

1) Granites of Eyre and Yorke Peninsulas

2) Acid intrusive rocks at the eastern margin of the Adelaide Fold Belt

3) Granite and gneiss of the Yilgarn Craton

Also, some high values of factor scores of F1 indicate some areas with sandstone and siltstone lithology inside the Adelaide Fold Belt. Since this factor includes high loadings of rare earth and radioactive elements (e.g. Cs, K, Rb and Th) it may delineate the high radioactivity of this unit. This idea may be confirmed by comparison of factor score map of F1 with spatial distribution of uranium in the soils of the study area whose high concentration correspond to high scores of F1 (Appendix L).

The standard score map of F2 (Figure 6.5, B) distinguishes the basic and ultrabasic rocks of the Yilgarn Craton. Also, we have some high score of this factor for the soils over granitic lithology which may be attributed to a contribution of some REE in this factor (e.g. Eu, Lu, Sm and Yb with factor loadings 0.42, 0.34, 0.24 and 0.34 respectively).

Since most of the study area is covered by pedogenic carbonates, the factor scores of factor 3 (Br-Ca-Sr association) have been affected equally throughout the area, and so its higher scores may reflect the influence of the factor loadings of other elements on this factor (e.g. Cd and Tl).

The map of scores of factor five (Figure 5, E) may distinguish three mineralised regions:

- the eastern goldfields of the Yilgarn Craton (in the vicinity of Kalgoorlie)
- the granitic rocks of the Gawler Craton (west of Port Augusta)
- the eastern margin of the Adelaide Fold Belt (NE of Adelaide).

It can be concluded that factor analysis is an effective means of manipulating, interpreting, and representing data concerning soil geochemistry. The model described the main regional multielement pedogeochemical patterns in the study area and geographical distribution of the factor scores delineated boundaries which define how surficial material is affected by underlying lithology.

Chapter 7 : BIOGEOCHEMICAL INVESTIGATION OF THE MENNINNIE DAM PROSPECT

7.1 Introduction

This chapter describes the bio- and pedogeochemical patterns at the Menninnie Dam Zn-Pb prospect, which is located in the Gawler Craton, South Australia. The biogeochemical research conducted at the site was encouraged by Terramin Australia Ltd. which holds the tenement. Recently (in 2005) Zinifex Australia committed to invest up to $8 million on the Menninnie Dam prospect under a new joint venture.

This chapter begins with a description of the study site, geological setting, and then discusses elemental distribution for sampling media and these form the basis for the first biogeochemical survey conducted at this mineral prospect.

7.2 Study site setting

The Menninnie Dam prospect is located 130 km WSW of Port Augusta, on the Yardea (SI 53-4) 1:250 000 map sheet (Figure 7.1). The area is relatively flat at an elevation of approximately 220 m, immediately south of the Gawler Ranges and is used for sheep grazing. There has been no prior mining on the property. The most significant nearby historic base metal workings were at the small Miltalie Mine near Cowell, 100 km to the SE.

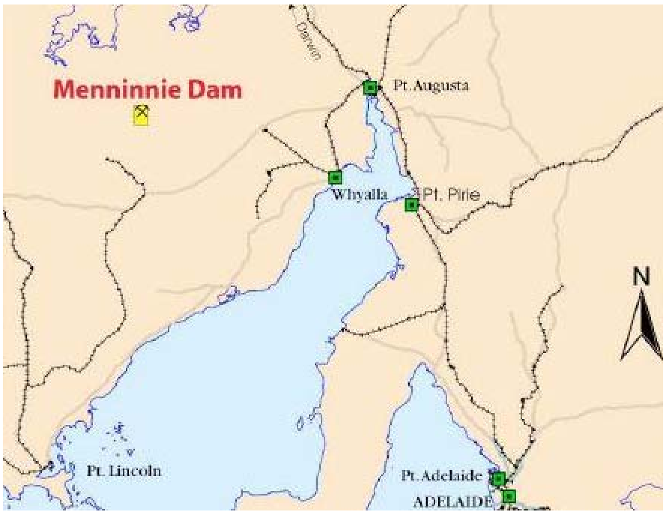


Figure 7.1 Location of Menninnie Dam prospect in South Australia

Regional Geology

Menninnie Dam lies within the Cleve sub-domain of the Archaean to Mesoproterozoic Gawler Craton. The Cleve Sub-domain constitutes most of the eastern half of the Eyre Peninsula and is bounded by the Coulta and Moonta Subdomains on the west and east respectively. To the north, it is concealed beneath Mesoproterozoic Gawler Range Volcanics (GRV) and pre-Adelaidean continental sediments of the Carriewerloo Basin. Within the Cleve Sub-domain, mixed chemical/clastic metasediments and minor volcanics of the Palaeoproterozoic Hutchison Group unconformably overlie Archaean to earliest Proterozoic garnetiferous, gneissic basement of the Sleaford Complex and Miltalie Gneiss (Higgins et al., 1990).

The Hutchison Group was intruded by pre- to syntectonic granitoids of the Lincoln Complex and was multiply deformed and metamorphosed to upper amphibolite facies grade, during the Kimban Orogeny at the close of the Palaeoproterozoic. It was subsequently intruded by feeder dykes to the unconformably overlying GRV and by comagmatic Hiltaba Suite granitoids. The Hutchison Group is divided into the basal Warrow Quartzite, central Middleback Subgroup and an upper unit of Yadnarie

Schist/Bosanquet Formation. The Middleback Subgroup is further divided into Katunga Dolomite, Lower Middleback Jaspilite, Cook Gap Schist and Upper Middleback Jaspilite. Regional facies variation is evident in the subgroup BIFs, from carbonate dominant in the west to iron oxide dominant in the east (Higgins et al., 1990).

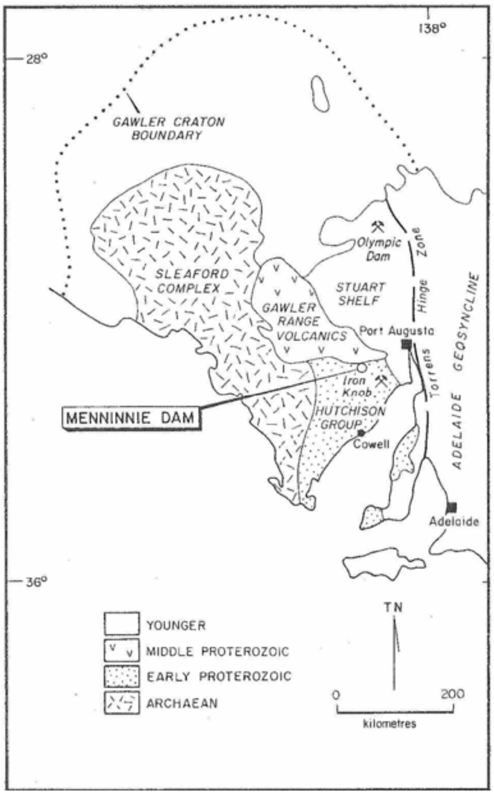


Figure 7.2 Regional geological setting of Menninnie Dam (after Higgins et al., 1990)

Local Geology

The original discovery at the northern end of the prospect is located in a Hutchison Group inlier. It is within but near the southern limit of GRV outcrop. To the south, relatively flat-lying subcropping GRV overlie Hutchison Group to a steadily increasing depth of about 350 m. They include lavas, intrusive rocks, ignimbrites and breccias that commonly contain a high Hutchison Group component (Terramin Australia Ltd., 2003). These areas are characterized by moderate to dense mallee/myall scrub.

The mineralisation has no surface expression, being covered by up to 60 m of kaolinitic overburden with silcrete and calcrete to 10 m from surface, or volcanic rocks. The base of weathering is typically at about 100 m but varies between extremes of 8 m and 310 m due to a deep weathering trough over the carbonate units.

Within the prospect area, the near vertical but overall west dipping Hutchison Group sequence has been divided into five suites above the Warrow Quartzite on the east (Figure 7.3). These may correlate with the formal stratigraphic units as shown in Table 7.1.

Table 7.1 Correlation of lithologies with mapped stratigraphic units

suite 5	quartzo-feldspathic gneiss and schist	>150m	Yadnarie Schist
suite 4	calcsilicate with amphibolitic BIF	>500m	Upper Middleback Jaspilite
suite 3	calcitic marble	0-120m	Upper Middleback Jaspilite
suite 2	biotite-sillimanite-garnet schist, amphibolite	0-140m	Cook Gap Schist
suite 1	graphitic schist/gneiss, ankeritic dolomite	>100m	Lower Middleback Jaspilite & Katunga Dolomite

The contact between suites 4 and 5 is a major N-S fault, which dips steeply to the east. A ‘dirty chert unit’ (hydrothermally altered suite 5) is recognised locally in association with the fault and there appears to be a narrow but persistent zone of mineralisation parallelling this structure on the east side. The base of suite 4 is marked by a distinct magnetic BIF marker bed, which can be traced for more than 2 km. Wollastonite (calcium silicate) is present near the top of suite 3. At least one retrogressive metamorphic event is recognised by the presence of green biotite, green hornblende, serpentine and chlorite replacing earlier high-grade assemblages.

An array of NW faults with south-side up/dextral displacements of less than 100 m have been proposed and NE-oriented dislocations are also interpreted from ground magnetic data.

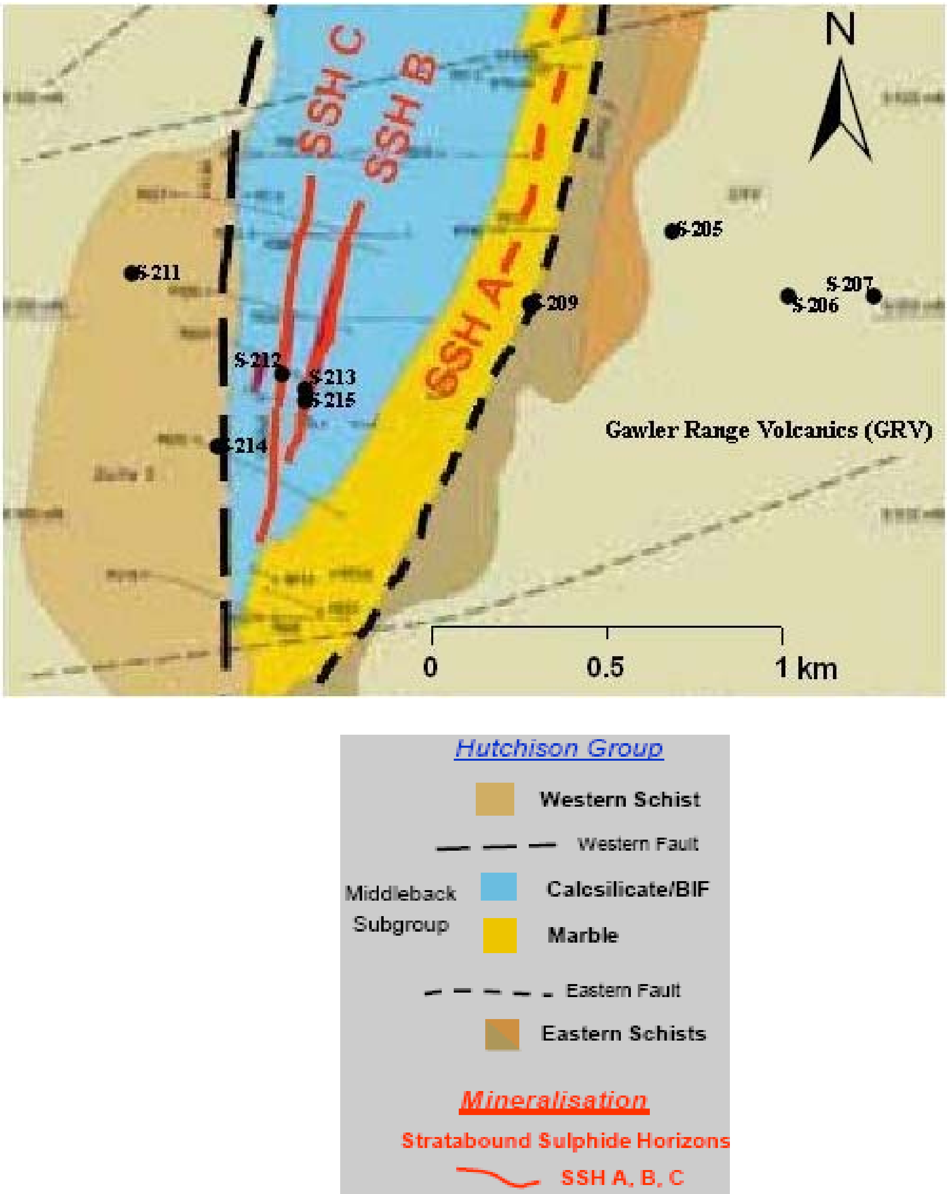


Figure 7.3 Spatial distribution of sampling sites at the Menninnie Zinc prospect showing projections of interpreted zinc ore shoots and geology (modified after Terramin Australia Ltd., 2003).

Mineralisation

Mineralisation of significant grade commonly occurs in clusters of 0.5 m wide bands, consisting of massive pyrite, sphalerite, galena and minor chalcopyrite. Starting 200 m above the stratigraphic base, suite 4 may host four such zones, in which the immediate host rocks to mineralisation are dolomites. There are also at least two

similarly mineralised zones in the upper half of suite 3. All clusters appear to be less than 20 m thick. There is a tendency for increasing grade up-dip, particularly for silver. This suggests potential for higher grade material in the sparsely tested 100 to 300 m depth interval. However, sulfides persist in weathered host rock and it is likely that such material is partially oxidised, with higher grades being due to secondary enrichment.

Low-grade veinlet and breccia mineralisation in suites 1 and 2, particularly near unit boundaries, has been ascribed to retrograde metamorphic events. Around 8000 N, a significant flat-lying zone of partially oxidised sulfidic clay and sulfide-clast breccia occurs at the base of the kaolin zone overlying suite 3 in particular. This has been proposed to be an eruptive GRV unit constituting evidence that mineralisation is Mesoproterozoic in age and thus of replacement origin in the Hutchison Group. However, other alternatives are equally possible on the available data, e.g. inclusions of mineralised Hutchison within GRV or a palaeo-regolith of mineralised Hutchison Group. Isotopic studies have been used to argue in favour of both syngentic and replacement origin. Thus, as for most sulfide deposits in deformed/metamorphic terrains, genesis is contentious (Roache et al., 2000) .

Exploration history

The minerals division of a major international oil company discovered blind zinc-lead mineralisation at Menninnie Dam in 1981 while seeking Broken Hill style sedimentary-exhalative deposits. The immediate area is one of almost no outcrop but lies north along strike from outcropping banded iron formation (BIF). Regional Rotary Air Blast (RAB) drilling of linear aeromagnetic anomalies paralleling stratigraphy was

followed up with ground magnetics, gravity and Sirotem surveys to define a 3km x 1km north trending anomalous zone. More recent exploration programs have been conducted by Terramin Australia Ltd. since 2003. Importantly, the biogeochemical surveys of this study were taken just prior to a major prospect drilling compaign by Teramin. Prior to this, the land surface (and vegetation) had been little disturbed by exploration.

7.3 Biogeochemical results

The following section features point-source biogeochemical maps of seven elements for mallee plants and soil samples taken at the Menninnie Dam prospect (Appendix O). Soil and plant chemistry data are included in Appendix N. Silver, Ir, Lu, Mo, Sb, Ta, U and Zr in all plants and Au, Ag, Ir, Mo and Te for soils were below detection limit for the methods used (INAA and ICP-MS). Arsenic, Au, Cd, Co, Cu, Pb and Zn were selected for further examination of biogeochemical patterns among which Cu, Pb and Zn are the most important elements associated with underlying mineralisation in the study area.

7.3.1 Arsenic (As)

Arsenic values are generally low for the soil in the study area. The highest As contents are recorded for the soil (median of 2.29 ppm), with the highest value (2.63 ppm) recorded for site 207 outside the projected mineralisation and over Gawler Range Volcanics.

All vegetation material returned values below the detection limit for the analytical method used (INAA), the exception being one leaf sample.

7.3.2 Gold (Au)

All soil and plant material (except in twig) recorded below the detection limit for the analytical method used (INAA), so no maps for soil and plant chemical compositions are presented in this research, except for twig. One twig sample (0.53ppb) had detectable Au. The Au value is recorded peripheral to known mineralisation and over a volcanic lithology.

7.3.3 Cadmium (Cd)

Cadmium is a pathfinder for many types of ore deposits. It is closely related to Zn and is commonly found in association with Zn, Pb-Zn and Pb-Cu-Zn ores (Rose et al., 1979).

All soil and most vegetation samples provided Cd assays above the detection limit for the method used (ICP-MS), however the twig results (median of 28.8 ppb) are significantly higher than those obtained for bark (median of 10.4 ppb) and leaves (median of 7.8 ppb). The highest Cd concentrations are recorded for the soil (median of 110 ppb), with the highest value (560 ppb) over an inferred fault around Stratabound Sulfide Horizon A (SSHA).

Cadmium shows a strong correlation with Zn and Pb in all plant tissues, whereas this is not the case for soils in the area (Appendix P).

7.3.4 Cobalt (Co)

The highest Co contents are recorded for the soil (median of 7.92 ppm), with the highest value (10.6 ppm) recorded over mineralization where the highest Co value for

leaves was also recorded (0.13 ppm). All bark and twig samples returned values below detection limit for the analytical method used (INAA).

7.3.5 Copper (Cu)

The Cu concentrations in mallee samples are lower in the bark (median of 1.06 ppm) compared to the twigs (1.66 ppm) and the leaves (2.22 ppm). The highest Cu assays from plant tissues are from the eastern section of the sampling area and over the Gawler Range Volcanics (GRV). The Cu response in leaf mallee shows an affinity to Zn, while no significant correlation is found in other plant organs or soil.

7.3.6 Lead (Pb)

In general, Pb values are relatively low for each sampling medium in the study area. Soil values (median of 16.8 ppm) are significantly higher than those recorded for plant material. Exploratory data analysis indicates that the two highest values recorded (79.1 ppm and 60.1 ppm) for the soil are outliers (Appendix Q).

All the vegetation samples have Pb contents above the detection limit for the method used (ICP-MS), with the highest Pb content found in twig tissue (0.7 ppm).

7.3.7 Zinc (Zn)

The highest Zn assays are recorded for the soil material (median of 58 ppm), which is considerably higher than for all of the biological material (median of 7.94 ppm, 17.5 ppm and 11.6 ppm for bark, twigs and leaves respectively). The highest Zn assays in the study area are 105 ppm, 96 ppm, and 87.1 ppm in the soil samples. All plant

samples have Zn contents above the detection limit. Bark recorded the highest Zn assay for the biosamples in the study area (50.5 ppm) which was significantly higher than for the other plant tissues.

7.4 Summary and discussion

Figure 7.4 illustrates the Zn content variations for vegetation and soil across the projected mineralisation (Figure 7.3). All plant material shows a maximum concentration in one site (site 209, here labelled A) whereas the easternmost site (site 207, here labelled B) in the traverse shows the highest Zn content in soil. The maximum concentration of Zn in vegetation at site 209 which is over an inferred fault zone (Figure 7.3) can be considered as a reflection of a leakage halo around the stratabound sulfide horizon A (SSHA).

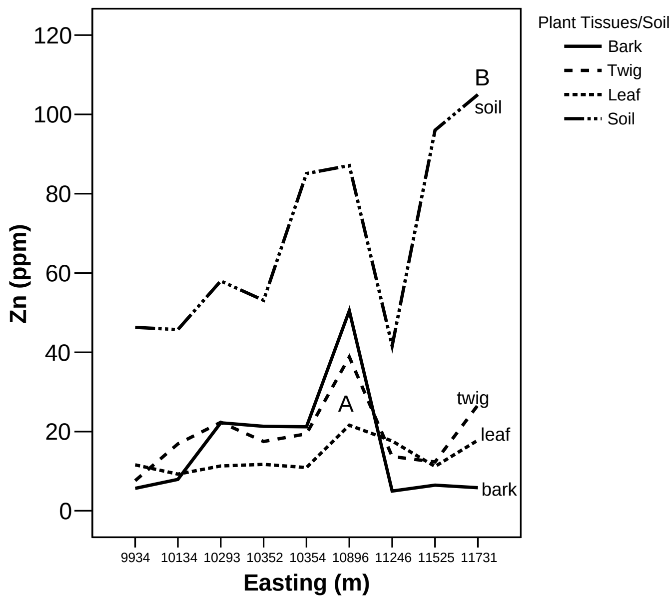


Figure 7.4 Distribution of Zn in soil and mallee tissues (projected as a W-E section) across the Menninnie Dam prospect

The geochemical maps for the study area show that the highest Pb assays for the soil are found outside the projected mineralisation area (site 205; B in Figure 7.5) and

over GRV, while the SSHA layer has been identified by the highest Pb concentrations in plant tissues (A in Figure 7.5). The variation of Cd concentrations, as a pathfinder for Pb-Zn deposits, across the traverse (Figure 7.6) indicates two zones, Zone A which is over SSHA and common for soil and plant organs, and zone B which is over stratabound horizons B and C (SSHB and SSHC) where only vegetation defines the tenor and location of the underlying mineralisation. It is worth mentioning that one bark sample has a tungsten concentration above detection limit, whereas there is no detectable W in soil at this site. These outcomes suggest that vegetation may better delineate sulfide horizons than soils, especially where anomalies for mobile elements (such as Zn) are distorted due to the depth of overburden.

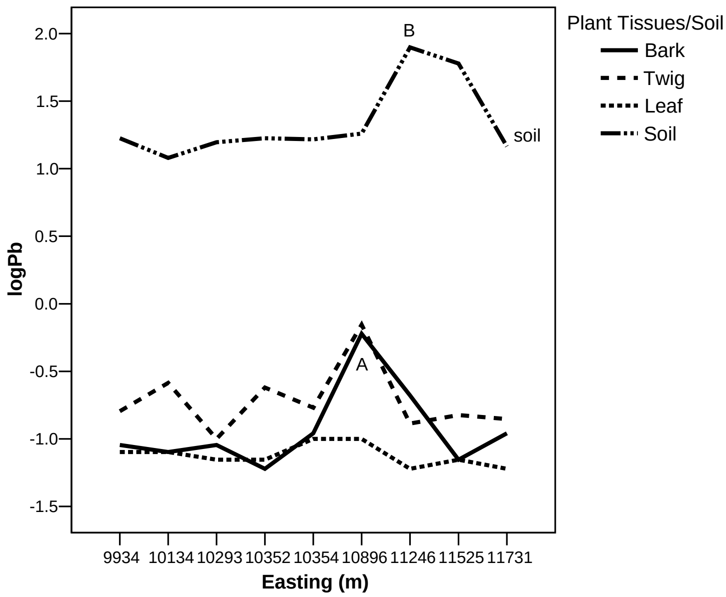


Figure 7.5 Distribution of Pb (log ppm) in soil and mallee tissues across the Menninnie Dam prospect

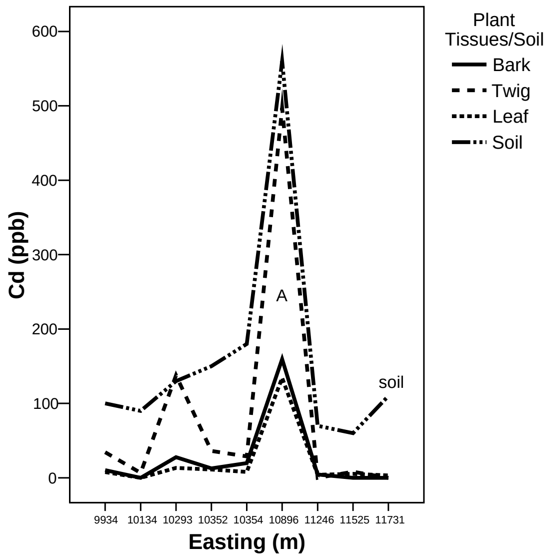


Figure 7.6 Distribution of Cd in soil and mallee tissues across the Menninnie Dam prospect

To investigate how vegetation identifies Zn mineralisation at the Menninnie Dam (MD) prospect, the mean values of these sites are compared with the mean values of the other five lithologies which were sampled across southern Australia (Figure 7.7). The average Zn concentration in vegetation in Menninnie Dam prospect is higher than its average concentrations throughout the other study areas, which is confirmed by the results of soil geochemistry.

The results of soil analysis at the Menninnie Dam show that the REE patterns are characterised by enrichment at the prospect compared to the means of southern Australian lithologies (Figure 7.8). A similar result is observed for radioactive elements where their mean concentrations in the prospect are significantly higher than other lithotypes (Figure 7.9). It is implied that the REE abundances in soils are definitive indicators of alteration and mineralisation at the prospect area.

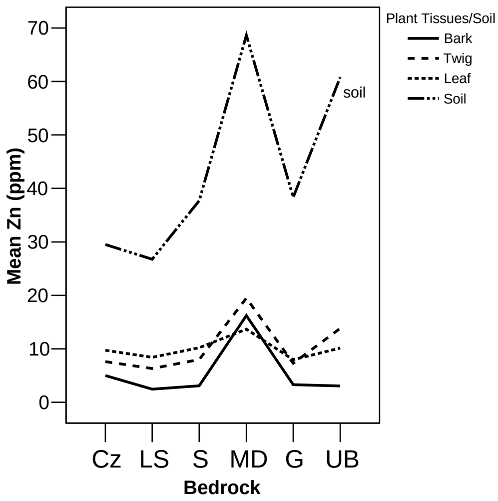


Figure 7.7 Comparison of mean Zn content in vegetation and soil at the Menninnie Dam prospect with the other lithologies studied across southern Australia. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, MD: Menninnie Dam prospect, G: Granite, UB: Basic and ultrabasic

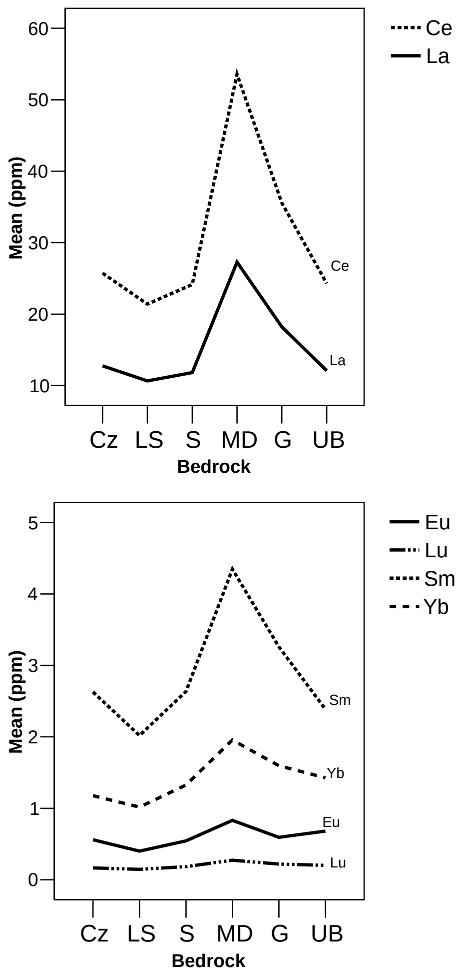
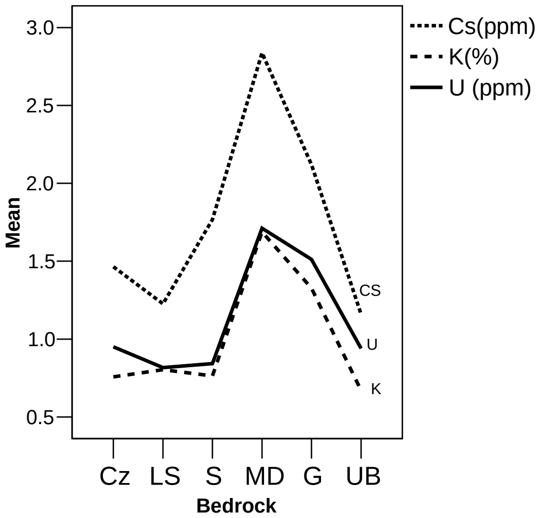


Figure 7.8 Comparison of pedogeochemical patterns of some REEs in Menninnie Dam with the other lithologies studied across southern Australia. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, MD: Menninnie Dam prospect, G: Granite, UB: Basic and ultrabasic



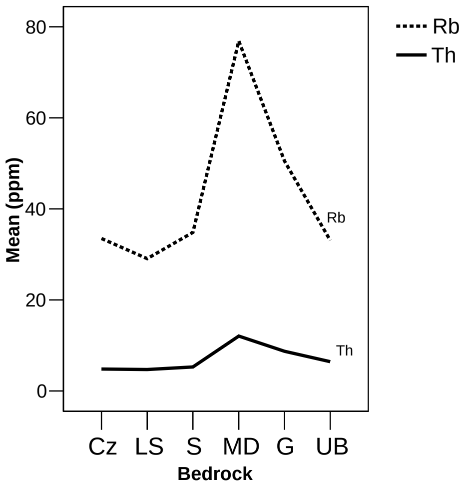


Figure 7.9 Comparison of pedogeochemical patterns of some radioactive elements in Menninnie Dam with other lithologies studied across southern Australia. Cz: unconsolidated Neogene sediments, LS: limestone, S: Sandstone, MD: Menninnie Dam prospect, G: Granite, UB: Basic and ultrabasic

In summary, the relative contents of the trace elements within mallee plant samples are decreased as: Zn > Cu > Co (only in leaf) > Pb > Cd with the concentrations of As and Au are below the detection limit in most mallee plant samples.

Zn contents in the tissues of mallee are higher at Menninnie Dam than the other lithologies studied across southern Australia. The concentration of Cd, Pb and Zn in mallee vegetation indicates projected sulfide horizons whereas the highest contents of Zn and Pb in soil are recorded outside the projected mineralisation.

Chapter 8 : CONCLUSIONS AND SUMMARY

Environmental characteristics affect the chemistry of plants and may be summarised as internal factors (e.g. plant uptake and translocation strategies) and external factors (e.g. underlying lithological variation). These provide an understanding of the elemental dispersion patterns in mallee vegetation and their applications for mineral prospecting programs.

As discussed earlier, most of plant tissues show a degree of correlation between plant tissues and substrate chemical characteristics, but in some elements and some tissues (e.g. twig) this correlation is not clear, suggesting that there are other factors that also influence major and trace element content in plants. Two such factors may be plant uptake strategy and elemental translocation through the plant tissues.

Plant uptake strategies

The chemical composition of the mallee vegetation in southern Australia varies between tissues, and one of the influences on plant chemical composition is therefore the variation in uptake strategy by plants for different plant organs. In general, the uptake of certain elements by plants varies depending on the nutrient requirements of the plant and on the varying degrees of resistance-accumulation within the plant to the uptake of the trace elements from the substrate (Baker, 1983). Nutrients are required in different amounts, which in part are reflected in relatively higher concentrations of certain elements such as K and Ca, whereas non-essential elements such as As, Au and Rb can be taken up only in very small amounts. This pattern is exhibited in all

biological sample types of southern Australia; however, there are some variations from this.

Although Na is not typically considered to be a major nutrient for plant growth, it is recorded in relatively high concentrations in the plants of the study area, particularly for the leaf tissues. It is proposed that Na is required by the plant for the operation of the C4 appendage in transporting CO_2 to the bundle sheath cells where it is reduced to carbohydrate. The active pumping of Na to the photosynthetic tissues of the leaves would in part explain the high Na concentrations recorded for the vegetation in this biogeochemical survey. In addition, salt is secreted at the leaf surface, as a means of regulating salt contents within the plant tissues, and as such this would elevate detectable levels of Na and K within the leaf samples of the survey.

Translocation of elements

Element uptake is not distributed uniformly throughout the plants, with most elements generally concentrated more so in the leaves and then bark and then the twigs, but this varies for some elements. A concentration of elements in the leaf tissue may in part be due to the greater rate of metabolic activity in the leaf tissue (Gobran et al., 2001; Kabata-Pendias, 2001), although this does not necessarily apply to every element. Selective uptake of ions is related to a capability of plants for active selective sorption and discrimination of available ions or compounds in the substrate. Also, among the plant organs leaves have been least affected by plant species variation, where this is most for twigs. Some macro nutrients, in particular Ca, are generally more enriched in the tissues of the twigs, while some other trace elements (e.g. Cs and Hf) are concentrated in the mallee bark.

Although leaf material generally contains higher elemental concentrations, there are no instances of hyperaccumulation. This is reflected in the strong correlation among the plant organs for most elements in the survey.

The proportion of each element in certain plant tissues greatly depends on the relative mobility in the phloem and its physiological function. Nutrient concentrations in the tissue, in particular the leaves, therefore can be highly variable. For example, the irregular distribution of Ca through the plant may in part be due to Ca being structurally bound to be retained in cell walls and, therefore, it is not mobile (Williams and Woinarski, 1997). This may explain the elevated levels of Ca in the twigs and bark of plants within southern Australia.

Calcium is one of the nutrients, the concentration of which in the plant tissues is affected not only by Ca levels in the root zone but also by the regulation of plant transpiration. Ca concentration in the solution may affect the rate of absorption of both anions and other cations (Adriano, 1992). Two effects are involved. Firstly, low concentrations of Ca in the solution are required to maintain the integrity of membranes and secondly, higher concentrations of Ca may depress cation absorption or enhance anion absorption. Ca is commonly associated with Sr in both media, namely soil and vegetation (Appendices G and J). The Ca to Sr ratio seems to be relatively stable in the biosphere and therefore is commonly used for the identification of enhanced concentrations of Sr in a particular environment. A Ca:Sr ratio less than 8 indicates a possible toxicity of Sr (Kabata-Pendias, 2001). This ratio varies between minima of 60, 31, 15 and 11 to maxima of 1480, 308, 340 and 492 in soil, bark, twig and leaf samples respectively. Calcium, on the other hand, has also been shown to inhibit the uptake of

Cd which is reflected in a negative correlation between the two elements in vegetation (Appendix G). Other nutrients such as K, Na and Fe are more easily transported through the plant tissues and are therefore not concentrated in the bark and twigs.

The elemental concentrations in the tissues of the mallee indicates that where calcrete is least intensely developed as powdery accumulations or grain coatings, the bedrock influence appears to be strongest and this is, in turn, reflected in higher responses in plant composition.

The distribution of minor elements in soils is also influenced by the biogeochemical cycle. Trace elements are solubilised at the root system of the plants and are transferred through the aerial parts, where they are finally deposited as metal complexes in leaves or twigs. At senescence, the leaves fall and decay. The more soluble components, such as carbonates of the alkali metals and alkaline earths, sulfates, phosphates, and humic complexes of Fe and Mn, are leached through the soil profile by rainwater. Sparingly soluble or insoluble compounds and compleaxes of other metals, such as hydroxides and protein or humic complexes, are retained in the humic horizon of the soil (Brooks, 1983). The cumulative effect of this process may produce an enrichment of certain elements in the topmost layer of the soil which have been contributed by the decay of vegetation.

External factors

Variations in bedrock underlying the study area influence the plant elemental distribution patterns, either directly or by its influence in the regolith. As they are

largely concealed by cover, it is unknown whether the underlying lithologies are entirely homogenous throughout the areas.

Specifically, relatively high Co and Cr contents (bark and leaf) and Mn and Ni (in all plant tissues) associated with basic and ultrabasic substrates and the high values of Ba, Th and REE in bark samples related to granite and granodiorite bedrock reflects the relatively high concentrations of those elements in the underlying lithologies.

Although the composition of plants growing in soils should reflect both hydromorphic and mechanical dispersion processes operating within an area, the lack of strong correlation between soils and adjacent vegetation chemistry for some elements may be related to a lack of chemical equilibrium between groundwater and soils. The rate of obtaining equilibrium is dependent on the mineralogical form of trace elements in the soils and the residence time for surface and groundwater in the area (Cohen et al., 1999).

In the semi-arid environment, such as that of southern Australia, root penetration may be to depths of tens of metres, permitting the extraction of metals from both underlying bedrock and soil. The net result is that a plant does not extract elements from just the surface soil, but from the entire soil profile, groundwater and in some cases bedrock; it selects the elements it needs for efficient metabolic function, excludes others, and stores yet others in cells (e.g. bark) where potentially toxic metals do not interfere with plant growth and health (Dunn et al., 1996). Nevertheless, the results showed that chemical signatures of soil and vegetation studied in this research are similar for some trace elements (e.g. As, Au, Ba, Mn, Ni and Th), but differ for others (e.g. Co, Rb and Zn).

In low-density, regional geochemical surveys, including reconnaissance exploration or environmental baseline surveys, there are inherent risks in attempting to characterise the geochemistry of sub-regions on the basis of a single sampling medium (Dunn et al., 1991). This is demonstrated by the differences in geochemical patterns observed in soils and vegetation in southern Australia. The results of this study suggest that a combination of vegetation and soil geochemistry may provide a more reliable indication of the presence of mineral potential or sub-region lithology than does soil geochemistry alone.

In semi-arid areas with deep water-tables where the formation of near-surface hydromorphic dispersion patterns is inhibited, the only surface indication of buried ore may be biogenic anomalies resulting from the uptake of metal by deep-rooted plants. That is why mallee vegetation in the Menninnie Dam prospect may be responding to the present or paleo-hydromorphic dispersion patterns that have been defined at depth by RAB sampling. The maximum concentration of zinc in vegetation at the site over an inferred fault zone can be considered as a reflection of a leakage halo around the stratabound sulfide horizon A. It is also reasonable to expect a substantial upward movement of groundwater to replenish the moisture lost by evaporation and transpiration from the fringe zone above the water table as well as lateral transport of dissolved metals in groundwater.

Also, the results illustrate how low-density multimedia sampling methodology cost-effectively yields information about regional patterns in soil and plant quality, mineral prospectivity and potential geohealth risk. This multi-elemental reconnaissance study has enabled us to get invaluable information about the natural concentrations of chemical elements in this substrate and to contribute to a baseline bio-soil geochemical

survey established, against which future changes can be quantified and to recognise new potential areas for mineral prospecting.

Further research

The current research was carried out over a very large area and, as such, is limited to some extent in detail for individual plant species. Important outcomes could be achieved using other individual species and systematic local-scale sampling programs.

Further research is needed on biogeochemical and microscopic analysis of mallee root system for a better understanding of the interaction of vegetation and substrate (soil and calcrete).

Also, microscopic investigation of plant organs is recommended in which some important trace elements (e.g. Au, Te, Sb and W) have been found, with the aim of understanding their specific location and form in plants.

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APPENDIX B: PRECISION CHARTS OF BIOLOGICAL MATERIALS AND SOILS ANALYSED BY INAA AND ICP-MS.

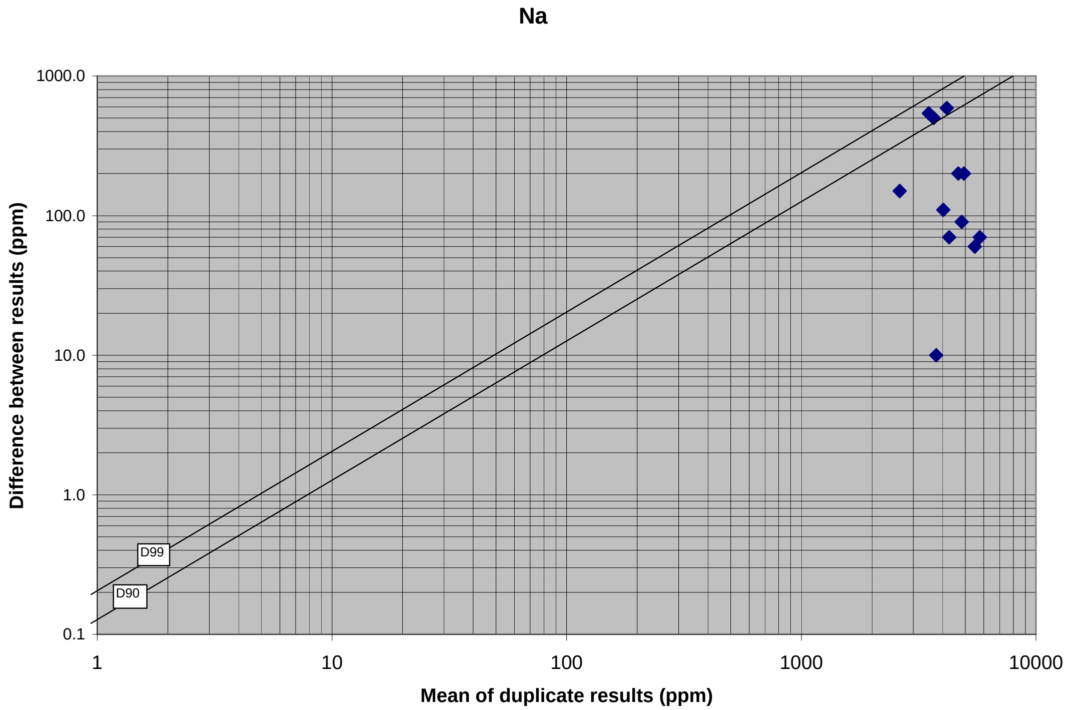


Figure B.1 Precision Control chart for the determination of Na in biosamples by INAA.

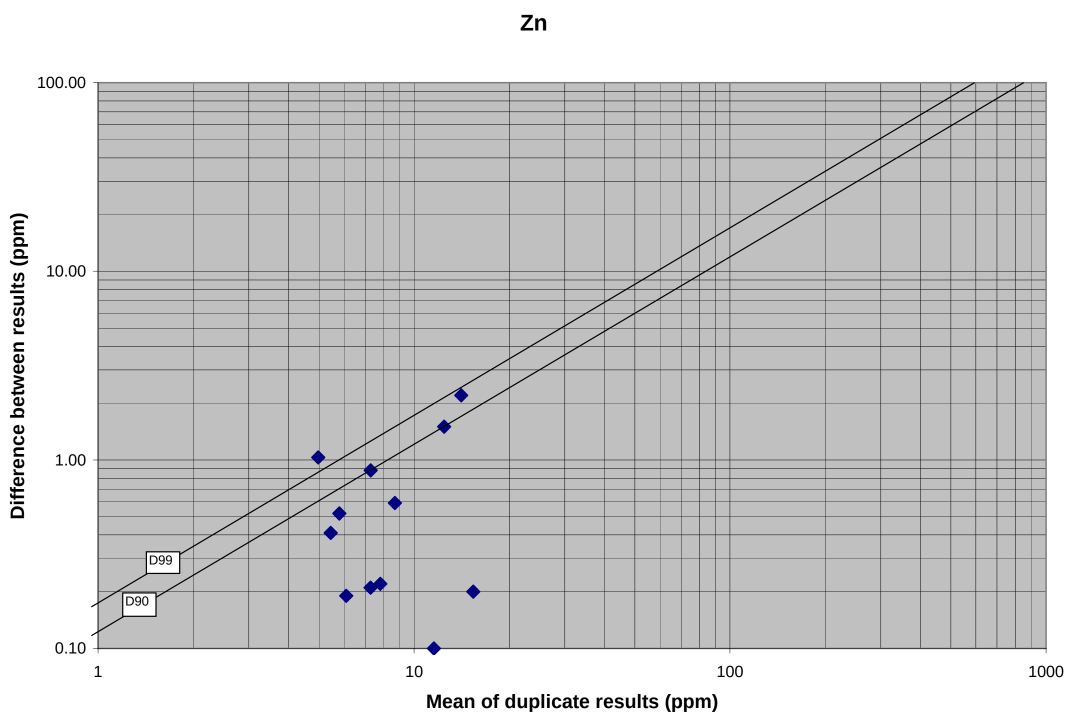


Figure B.2 Precision Control chart for the determination of Zn in biosamples by INAA.

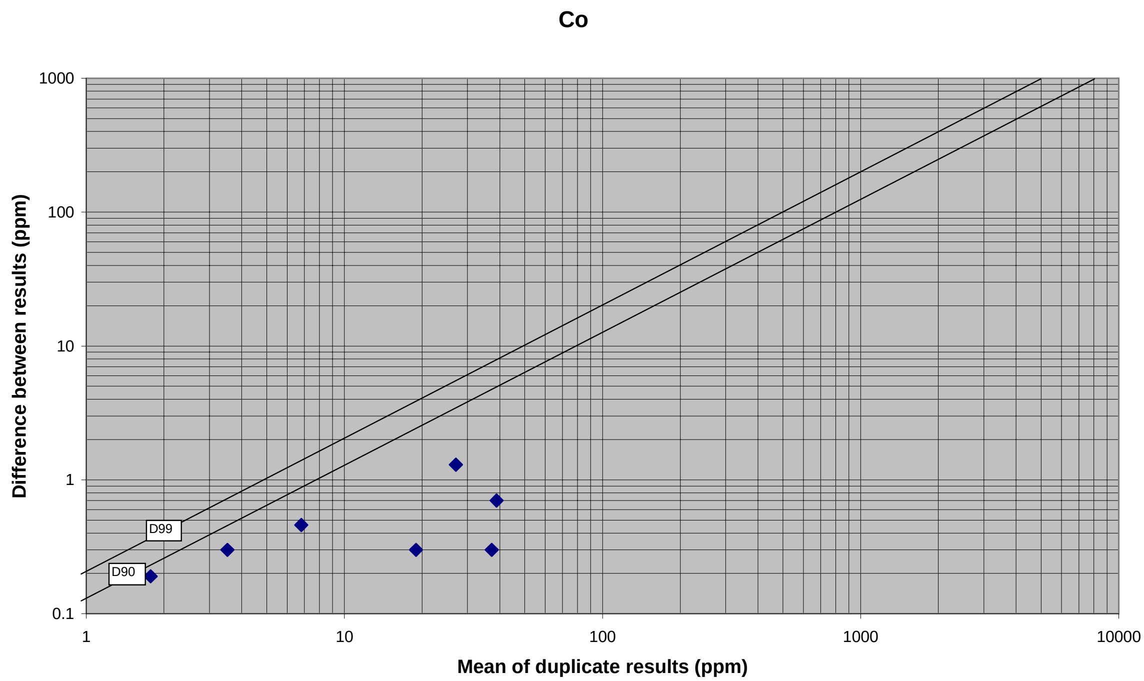


Figure B.3 Precision Control chart for the determination of Co in soil samples by INAA

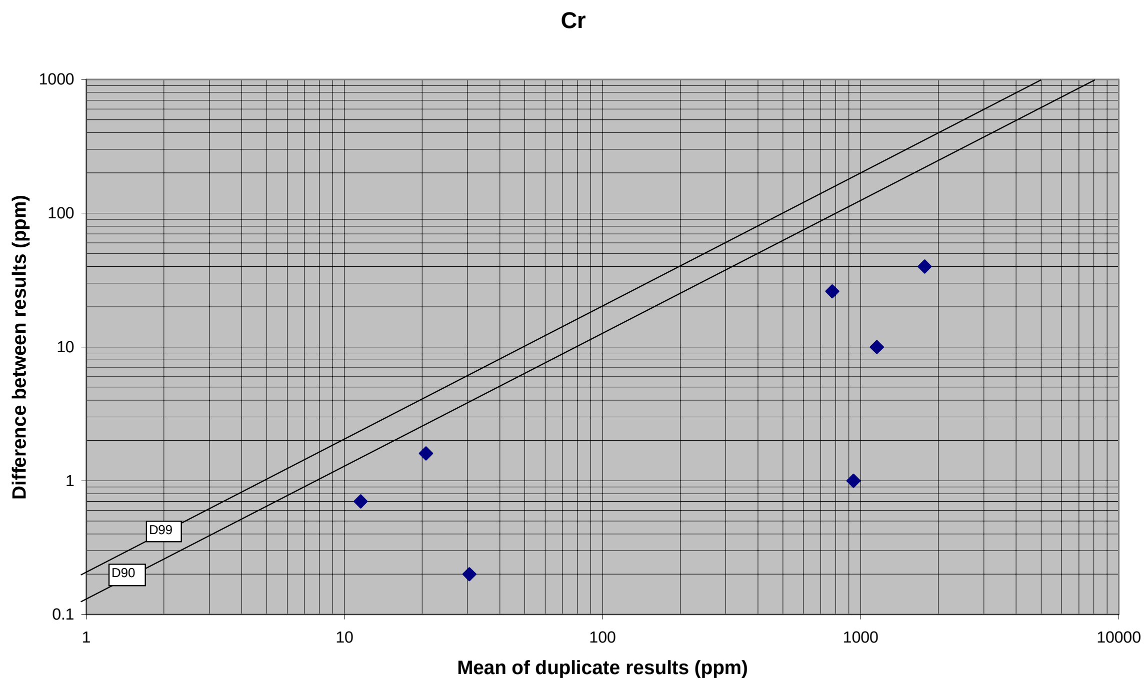


Figure B.4 Precision Control chart for the determination of Cr in soil samples by INAA

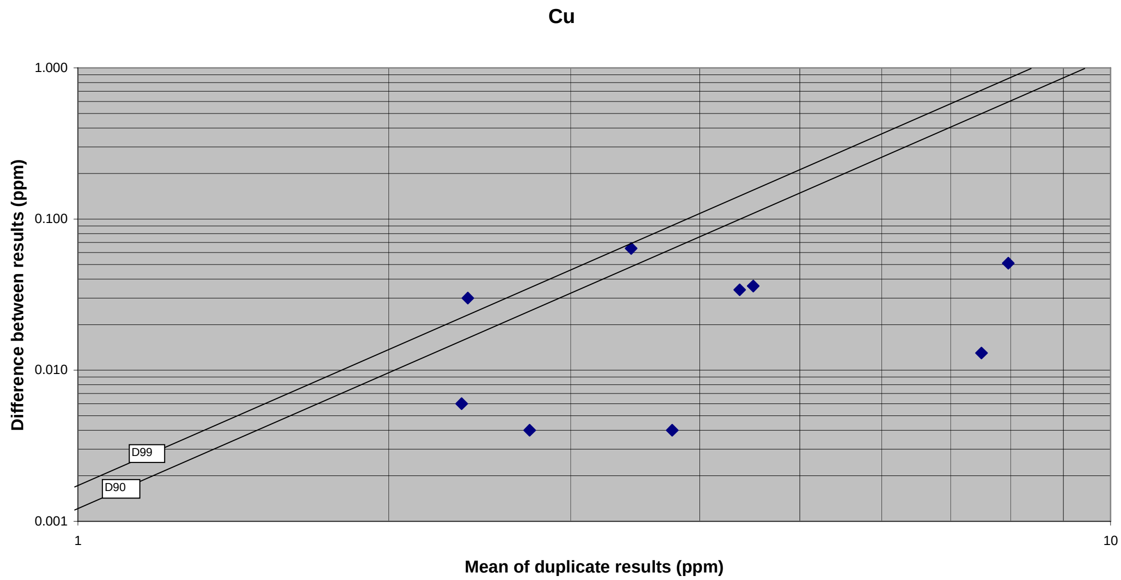


Figure B.5 Precision Control chart for the determination of Cu in biosamples by ICP-MS

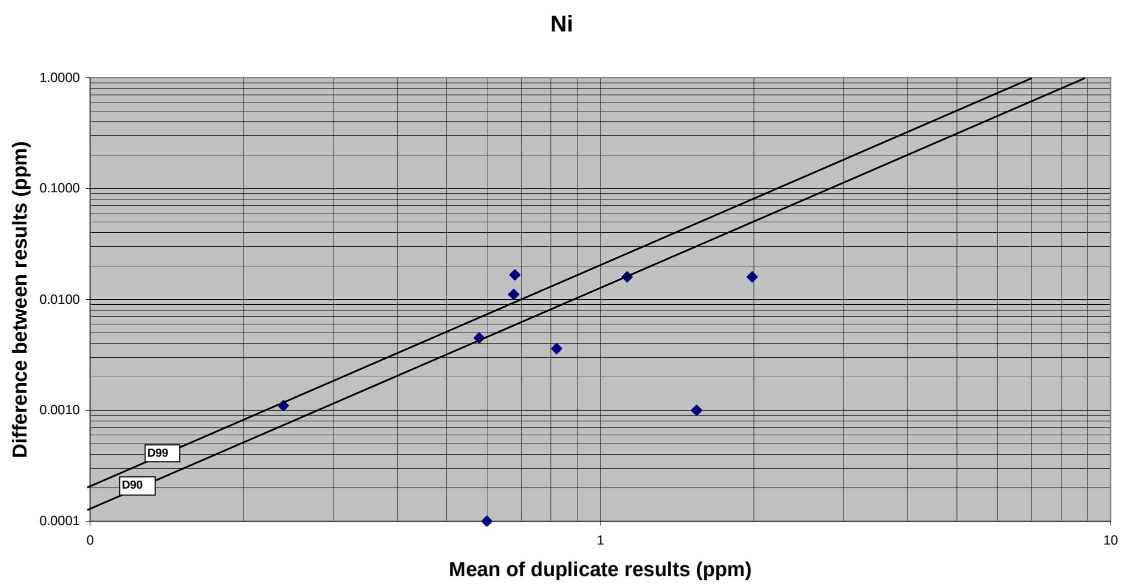


Figure B.6 Precision Control chart for the determination of Ni in biosamples by ICP-MS

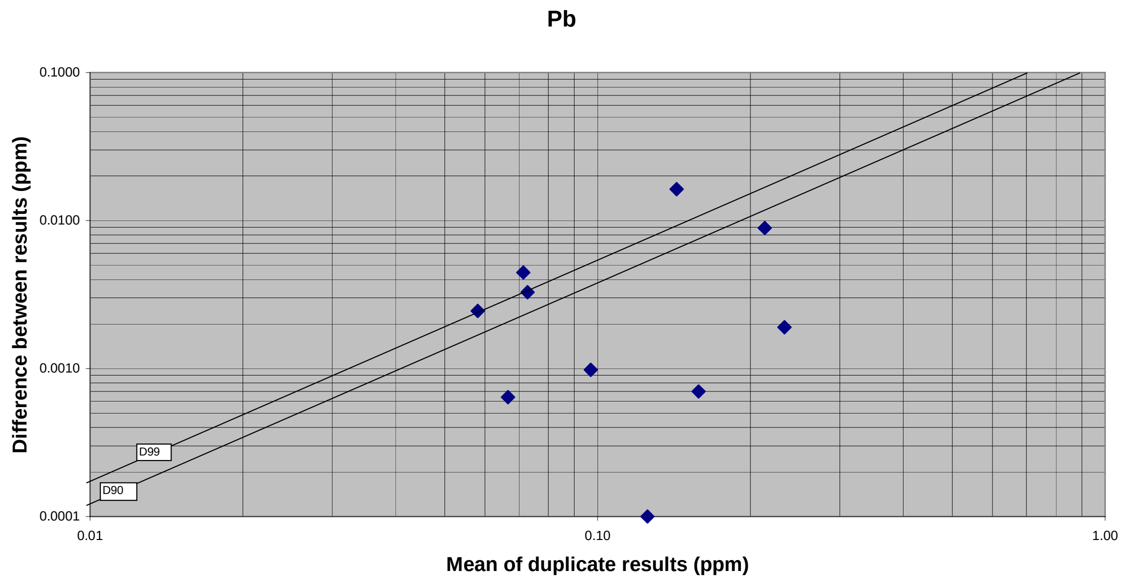


Figure B.7 Precision Control chart for the determination of Pb in biosamples by ICP-MS

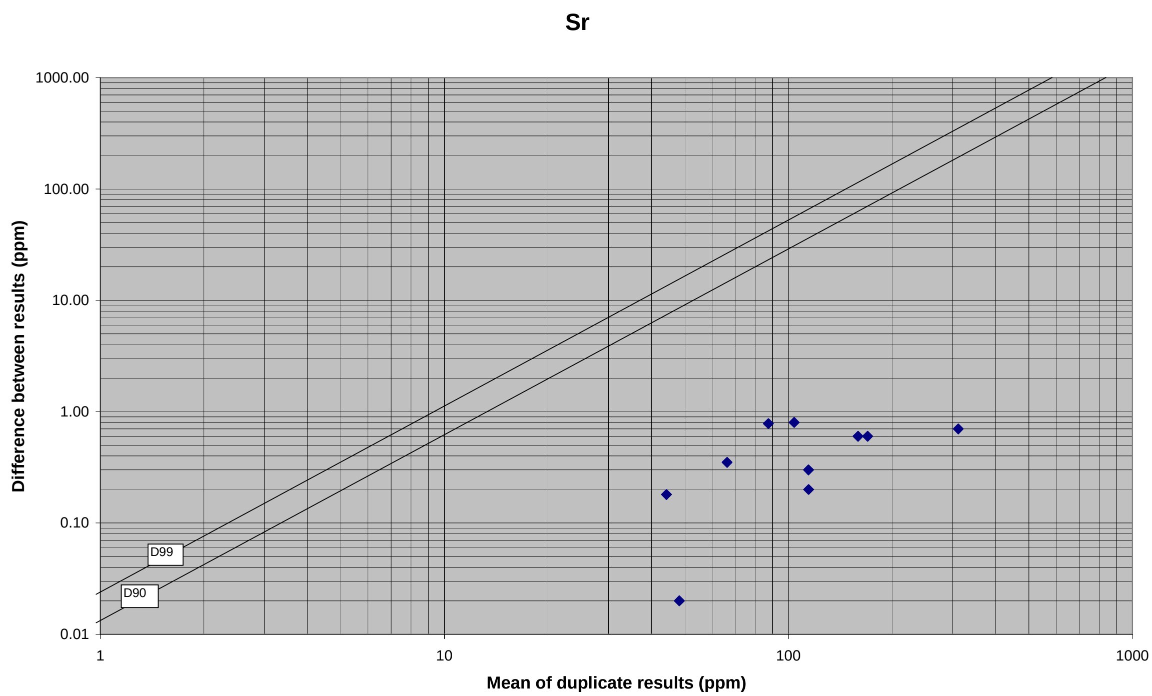


Figure B.8 Precision Control chart for the determination of Sr in biosamples by ICP-MS

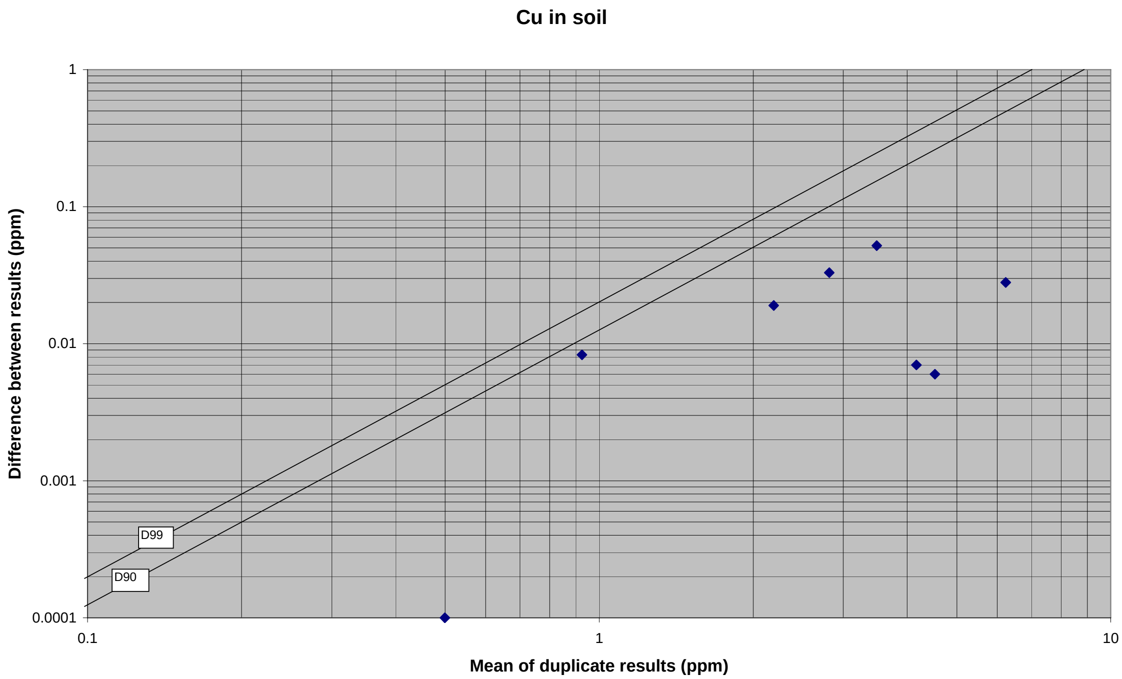


Figure B.9 Precision Control chart for the determination of Cu in soil samples by ICP-MS

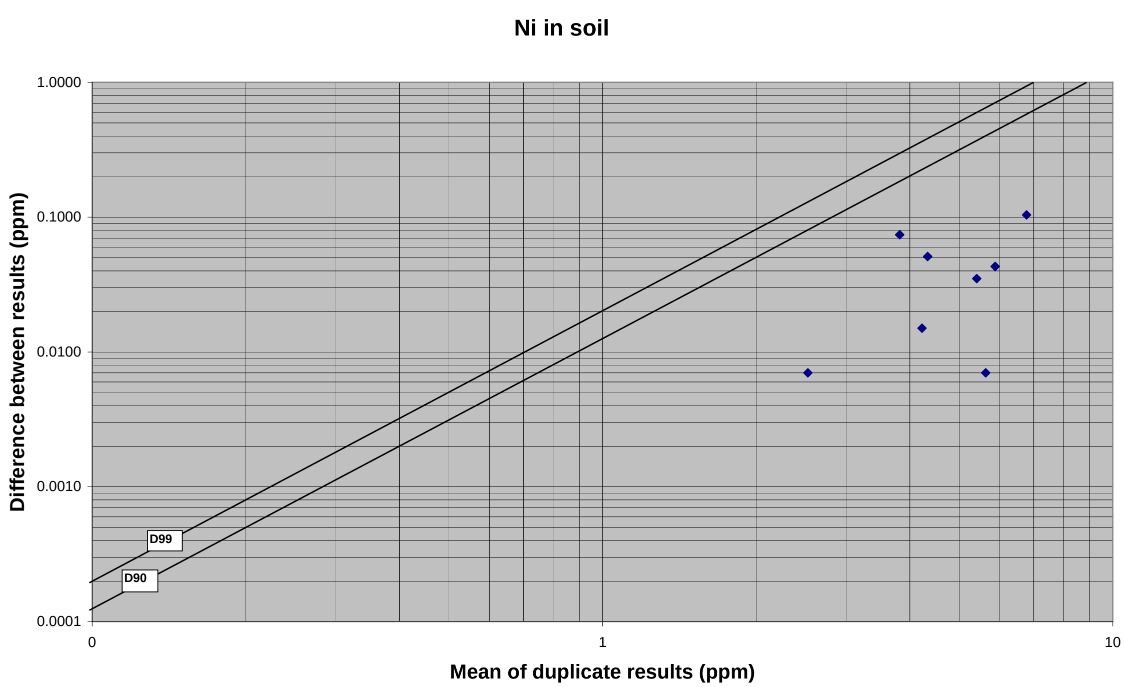


Figure B.10 Precision Control chart for the determination of Ni in soil samples by ICP-MS

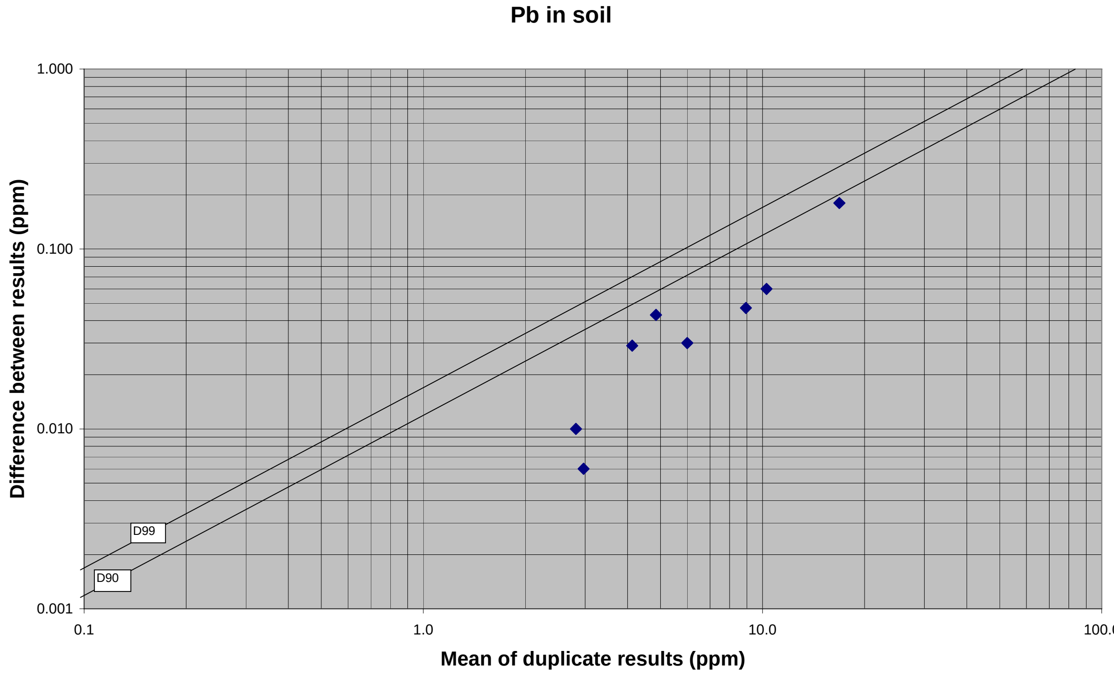


Figure B.11 Precision Control chart for the determination of Pb in soil samples by ICP-MS

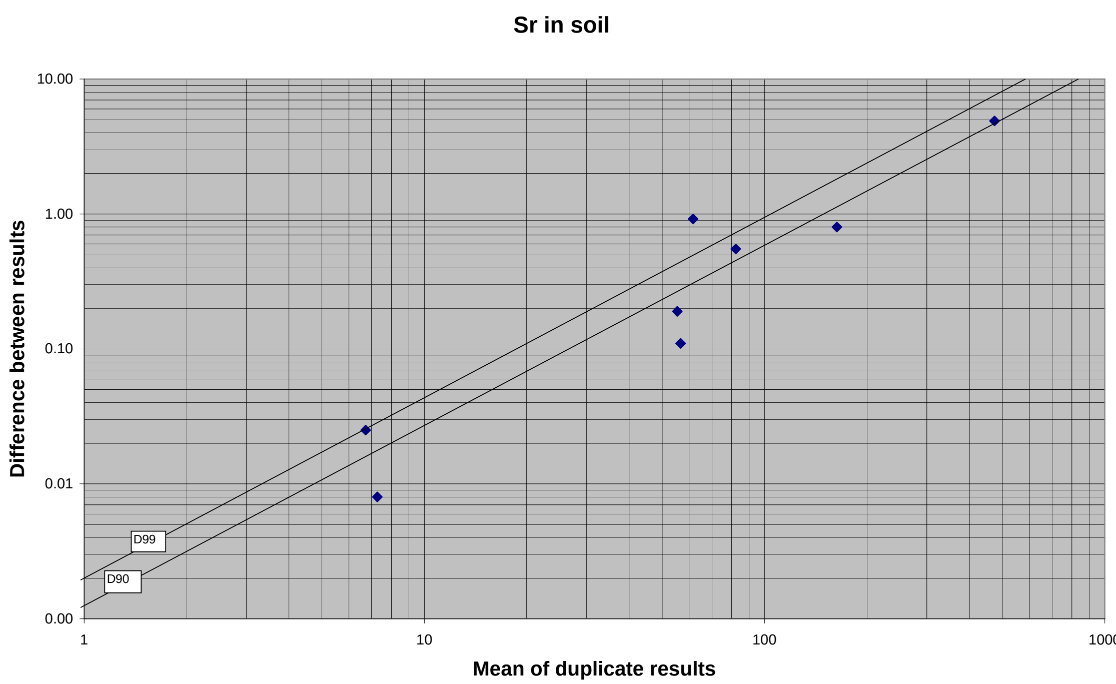


Figure B.12 Precision Control chart for the determination of Sr in soil samples by ICP-MS

APPENDIX C: RESULTS OF ANALYSIS OF VARIANCE

PART1. One-way ANOVA Tables

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logBr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	33.476(a)	2	16.738	596.064	.000
Intercept	351.492	1	351.492	12517.090	.000
tissue	33.476	2	16.738	596.064	.000
Error	7.835	279	.028		
Total	392.802	282			
Corrected Total	41.311	281			

a R Squared = .810 (Adjusted R Squared = .809)

Multiple Comparisons

Dependent Variable: logBr
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.06690(*)	.026674	.039	-.13117	-.00262
	Leaf	-.76203(*)	.022724	.000	-.81683	-.70724
Twig	Bark	.06690(*)	.026674	.039	.00262	.13117
	Leaf	-.69514(*)	.023759	.000	-.75245	-.63783
Leaf	Bark	.76203(*)	.022724	.000	.70724	.81683
	Twig	.69514(*)	.023759	.000	.63783	.75245

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logCa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.472(a)	2	1.736	38.598	.000
Intercept	4269.871	1	4269.871	94942.344	.000
tissue	3.472	2	1.736	38.598	.000
Error	12.548	279	.045		
Total	4285.890	282			
Corrected Total	16.019	281			

a R Squared = .217 (Adjusted R Squared = .211)

Multiple Comparisons

Dependent Variable: logCa
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.18634(*)	.034245	.000	-.26908	-.10360
	Leaf	.07817	.034241	.070	-.00456	.16090
Twig	Bark	.18634(*)	.034245	.000	.10360	.26908
	Leaf	.26451(*)	.022923	.000	.20928	.31974
Leaf	Bark	-.07817	.034241	.070	-.16090	.00456
	Twig	-.26451(*)	.022923	.000	-.31974	-.20928

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logFe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.366(a)	2	2.183	40.544	.000
Intercept	816.087	1	816.087	15156.573	.000
tissue	4.366	2	2.183	40.544	.000
Error	15.022	279	.054		
Total	835.476	282			
Corrected Total	19.388	281			

a R Squared = .225 (Adjusted R Squared = .220)

Multiple Comparisons

Dependent Variable: logFe
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	.10649(*)	.036074	.011	.01945	.19354
	Leaf	-.19407(*)	.036425	.000	-.28194	-.10620
Twig	Bark	-.10649(*)	.036074	.011	-.19354	-.01945
	Leaf	-.30056(*)	.028437	.000	-.36908	-.23204
Leaf	Bark	.19407(*)	.036425	.000	.10620	.28194
	Twig	.30056(*)	.028437	.000	.23204	.36908

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	39.241(a)	2	19.620	428.392	.000
Intercept	3025.428	1	3025.428	66057.042	.000
tissue	39.241	2	19.620	428.392	.000
Error	12.778	279	.046		
Total	3077.447	282			
Corrected Total	52.019	281			

a R Squared = .754 (Adjusted R Squared = .753)

Multiple Comparisons

Dependent Variable: logK
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.59065(*)	.036258	.000	-.67841	-.50290
	Leaf	-.89909(*)	.035596	.000	-.98532	-.81286
Twig	Bark	.59065(*)	.036258	.000	.50290	.67841
	Leaf	-.30844(*)	.018487	.000	-.35299	-.26389
Leaf	Bark	.89909(*)	.035596	.000	.81286	.98532
	Twig	.30844(*)	.018487	.000	.26389	.35299

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logLa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.744(a)	2	1.372	9.154	.000
Intercept	470.981	1	470.981	3142.058	.000
tissue	2.744	2	1.372	9.154	.000
Error	41.821	279	.150		
Total	515.547	282			
Corrected Total	44.565	281			

a R Squared = .062 (Adjusted R Squared = .055)

Multiple Comparisons

Dependent Variable: logLa

Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.07243	.052382	.425	-.19866	.05381
	Leaf	.16343(*)	.056712	.013	.02670	.30016
Twig	Bark	.07243	.052382	.425	-.05381	.19866
	Leaf	.23586(*)	.060065	.000	.09111	.38060
Leaf	Bark	-.16343(*)	.056712	.013	-.30016	-.02670
	Twig	-.23586(*)	.060065	.000	-.38060	-.09111

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logNa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.478(a)	2	6.739	262.138	.000
Intercept	3012.060	1	3012.060	117163.307	.000
tissue	13.478	2	6.739	262.138	.000
Error	7.173	279	.026		
Total	3032.711	282			
Corrected Total	20.651	281			

a R Squared = .653 (Adjusted R Squared = .650)

Multiple Comparisons

Dependent Variable: logNa
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.12109(*)	.025308	.000	-.18207	-.06012
	Leaf	-.51230(*)	.022206	.000	-.56584	-.45876
Twig	Bark	.12109(*)	.025308	.000	.06012	.18207
	Leaf	-.39121(*)	.022525	.000	-.44552	-.33689
Leaf	Bark	.51230(*)	.022206	.000	.45876	.56584
	Twig	.39121(*)	.022525	.000	.33689	.44552

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logSc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.801(a)	2	1.401	20.294	.000
Intercept	921.476	1	921.476	13350.498	.000
tissue	2.801	2	1.401	20.294	.000
Error	19.257	279	.069		
Total	943.534	282			
Corrected Total	22.059	281			

a R Squared = .127 (Adjusted R Squared = .121)

Multiple Comparisons

Dependent Variable: logSc
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	.13739(*)	.038434	.001	.04462	.23015
	Leaf	-.10609(*)	.042256	.038	-.20793	-.00424
Twig	Bark	-.13739(*)	.038434	.001	-.23015	-.04462
	Leaf	-.24347(*)	.033807	.000	-.32498	-.16196
Leaf	Bark	.10609(*)	.042256	.038	.00424	.20793
	Twig	.24347(*)	.033807	.000	.16196	.32498

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logSm

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.536(a)	2	.268	4.636	.010
Intercept	798.736	1	798.736	13805.865	.000
tissue	.536	2	.268	4.636	.010
Error	16.141	279	.058		
Total	815.414	282			
Corrected Total	16.678	281			

a R Squared = .032 (Adjusted R Squared = .025)

Multiple Comparisons

Dependent Variable: logSm
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.05533	.037160	.360	-.14486	.03421
	Leaf	-.10680(*)	.033449	.005	-.18742	-.02619
Twig	Bark	.05533	.037160	.360	-.03421	.14486
	Leaf	-.05148	.034542	.359	-.13474	.03178
Leaf	Bark	.10680(*)	.033449	.005	.02619	.18742
	Twig	.05148	.034542	.359	-.03178	.13474

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logZn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	18.831(a)	2	9.416	97.339	.000
Intercept	154.437	1	154.437	1596.585	.000
tissue	18.831	2	9.416	97.339	.000
Error	26.988	279	.097		
Total	200.256	282			
Corrected Total	45.819	281			

a R Squared = .411 (Adjusted R Squared = .407)

Multiple Comparisons

Dependent Variable: logZn
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.50211(*)	.053211	.000	-.63048	-.37373
	Leaf	-.58484(*)	.046953	.000	-.69858	-.47110
Twig	Bark	.50211(*)	.053211	.000	.37373	.63048
	Leaf	-.08273(*)	.033738	.046	-.16425	-.00122
Leaf	Bark	.58484(*)	.046953	.000	.47110	.69858
	Twig	.08273(*)	.033738	.046	.00122	.16425

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	34.106(a)	2	17.053	381.353	.000
Intercept	388.302	1	388.302	8683.628	.000
tissue	34.106	2	17.053	381.353	.000
Error	12.476	279	.045		
Total	434.883	282			
Corrected Total	46.582	281			

a R Squared = .732 (Adjusted R Squared = .730)

Post Hoc Tests

Plant Tissue

Multiple Comparisons

Dependent Variable: logB
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.0458	.02750	.265	-.1121	.0205
	Leaf	-.7596(*)	.03359	.000	-.8405	-.6786
Twig	Bark	.0458	.02750	.265	-.0205	.1121
	Leaf	-.7137(*)	.03114	.000	-.7889	-.6386
Leaf	Bark	.7596(*)	.03359	.000	.6786	.8405
	Twig	.7137(*)	.03114	.000	.6386	.7889

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logCu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	11.479(a)	2	5.740	141.482	.000
Intercept	23.789	1	23.789	586.406	.000
tissue	11.479	2	5.740	141.482	.000
Error	11.318	279	.041		
Total	46.586	282			
Corrected Total	22.797	281			

a R Squared = .504 (Adjusted R Squared = .500)

Post Hoc Tests

Multiple Comparisons

Dependent Variable: logCu

Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.4072(*)	.02986	.000	-.4792	-.3353
	Leaf	-.4461(*)	.02845	.000	-.5147	-.3776
Twig	Bark	.4072(*)	.02986	.000	.3353	.4792
	Leaf	-.0389	.02981	.476	-.1107	.0330
Leaf	Bark	.4461(*)	.02845	.000	.3776	.5147
	Twig	.0389	.02981	.476	-.0330	.1107

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logGa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.943(a)	2	1.472	12.437	.000
Intercept	206.306	1	206.306	1743.420	.000
tissue	2.943	2	1.472	12.437	.000
Error	30.885	261	.118		
Total	238.879	264			
Corrected Total	33.829	263			

a R Squared = .087 (Adjusted R Squared = .080)

Post Hoc Tests
Plant Tissue

Multiple Comparisons

Dependent Variable: logGa
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.2469(*)	.05489	.000	-.3792	-.1145
	Leaf	-.1991(*)	.05129	.000	-.3228	-.0753
Twig	Bark	.2469(*)	.05489	.000	.1145	.3792
	Leaf	.0478	.04993	.712	-.0726	.1682
Leaf	Bark	.1991(*)	.05129	.000	.0753	.3228
	Twig	-.0478	.04993	.712	-.1682	.0726

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logLi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31.360(a)	2	15.680	93.304	.000
Intercept	143.367	1	143.367	853.120	.000
tissue	31.360	2	15.680	93.304	.000
Error	44.701	266	.168		
Total	217.448	269			
Corrected Total	76.061	268			

a R Squared = .412 (Adjusted R Squared = .408)

Post Hoc Tests

Plant Tissue

Multiple Comparisons

Dependent Variable: logLi
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.1561(*)	.05795	.023	-.2958	-.0164
	Leaf	-.7840(*)	.06228	.000	-.9341	-.6339
Twig	Bark	.1561(*)	.05795	.023	.0164	.2958
	Leaf	-.6279(*)	.06284	.000	-.7794	-.4764
Leaf	Bark	.7840(*)	.06228	.000	.6339	.9341
	Twig	.6279(*)	.06284	.000	.4764	.7794

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logMn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23.254(a)	2	11.627	92.772	.000
Intercept	370.066	1	370.066	2952.756	.000
tissue	23.254	2	11.627	92.772	.000
Error	34.967	279	.125		
Total	428.287	282			
Corrected Total	58.221	281			

a R Squared = .399 (Adjusted R Squared = .395)

Multiple Comparisons

Dependent Variable: logMn
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.5638(*)	.05518	.000	-.6968	-.4308
	Leaf	-.6461(*)	.04587	.000	-.7567	-.5356
Twig	Bark	.5638(*)	.05518	.000	.4308	.6968
	Leaf	-.0823	.05339	.330	-.2111	.0465
Leaf	Bark	.6461(*)	.04587	.000	.5356	.7567
	Twig	.0823	.05339	.330	-.0465	.2111

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logNi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	14.502(a)	2	7.251	73.076	.000
Intercept	31.556	1	31.556	318.033	.000
tissue	14.502	2	7.251	73.076	.000
Error	27.485	277	.099		
Total	73.123	280			
Corrected Total	41.987	279			

a R Squared = .345 (Adjusted R Squared = .341)

Post Hoc Tests
Plant Tissue

Multiple Comparisons

Dependent Variable: logNi
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.4196(*)	.04410	.000	-.5259	-.3133
	Leaf	-.5301(*)	.04814	.000	-.6461	-.4141
Twig	Bark	.4196(*)	.04410	.000	.3133	.5259
	Leaf	-.1105	.04600	.051	-.2214	.0004
Leaf	Bark	.5301(*)	.04814	.000	.4141	.6461
	Twig	.1105	.04600	.051	-.0004	.2214

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logPb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.428(a)	2	.214	2.081	.127
Intercept	273.130	1	273.130	2658.637	.000
tissue	.428	2	.214	2.081	.127
Error	26.813	261	.103		
Total	300.034	264			
Corrected Total	27.241	263			

a R Squared = .016 (Adjusted R Squared = .008)

Tests of Between-Subjects Effects

Dependent Variable: logSr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.702(a)	2	3.851	58.317	.000
Intercept	906.357	1	906.357	13725.184	.000
tissue	7.702	2	3.851	58.317	.000
Error	18.424	279	.066		
Total	932.483	282			
Corrected Total	26.126	281			

a R Squared = .295 (Adjusted R Squared = .290)

Post Hoc Tests

Plant Tissue

Multiple Comparisons

Dependent Variable: logSr
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.2253(*)	.03462	.000	-.3088	-.1419
	Leaf	.1786(*)	.04007	.000	.0820	.2751
Twig	Bark	.2253(*)	.03462	.000	.1419	.3088
	Leaf	.4039(*)	.03756	.000	.3133	.4945
Leaf	Bark	-.1786(*)	.04007	.000	-.2751	-.0820
	Twig	-.4039(*)	.03756	.000	-.4945	-.3133

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logTl

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.518(a)	2	8.759	61.269	.000
Intercept	138.005	1	138.005	965.363	.000
tissue	17.518	2	8.759	61.269	.000
Error	38.741	271	.143		
Total	197.829	274			
Corrected Total	56.259	273			

a R Squared = .311 (Adjusted R Squared = .306)

Post Hoc Tests

Plant Tissue

Multiple Comparisons

Dependent Variable: logTl
Tamhane

(I) Plant Tissue	(J) Plant Tissue	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Bark	Twig	-.2526(*)	.04440	.000	-.3598	-.1455
	Leaf	-.6190(*)	.06361	.000	-.7725	-.4656
Twig	Bark	.2526(*)	.04440	.000	.1455	.3598
	Leaf	-.3664(*)	.05738	.000	-.5051	-.2276
Leaf	Bark	.6190(*)	.06361	.000	.4656	.7725
	Twig	.3664(*)	.05738	.000	.2276	.5051

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.022(a)	2	.011	.136	.873
Intercept	330.850	1	330.850	4110.803	.000
tissue	.022	2	.011	.136	.873
Error	22.455	279	.080		
Total	353.327	282			
Corrected Total	22.477	281			

a R Squared = .001 (Adjusted R Squared = -.006)

PART2. Two-way ANOVA Tables
Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logBr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.361(a)	17	.080	3.689	.000
Intercept	22.729	1	22.729	1047.068	.000
species	.404	5	.081	3.720	.005
bedrock	.255	4	.064	2.933	.027
species * bedrock	.212	8	.027	1.222	.300
Error	1.454	67	.022		
Total	62.519	85			
Corrected Total	2.816	84			

a R Squared = .483 (Adjusted R Squared = .352)
b Plant Tissue = Bark

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logBr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.13363	.059825	.304	-.05151	.31878
	S	.10185	.044198	.303	-.04224	.24595
	TG	.15203	.062105	.203	-.04015	.34421
	UB	.35110(*)	.065259	.000	.14648	.55572
LS	Cz	-.13363	.059825	.304	-.31878	.05151
	S	-.03178	.050921	1.000	-.19122	.12765
	TG	.01839	.067057	1.000	-.18537	.22216
	UB	.21746(*)	.069987	.046	.00256	.43237
S	Cz	-.10185	.044198	.303	-.24595	.04224
	LS	.03178	.050921	1.000	-.12765	.19122
	TG	.05018	.053582	.989	-.11837	.21872
	UB	.24925(*)	.057208	.005	.06442	.43408
TG	Cz	-.15203	.062105	.203	-.34421	.04015
	LS	-.01839	.067057	1.000	-.22216	.18537
	S	-.05018	.053582	.989	-.21872	.11837
	UB	.19907	.071947	.099	-.02139	.41953
UB	Cz	-.35110(*)	.065259	.000	-.55572	-.14648
	LS	-.21746(*)	.069987	.046	-.43237	-.00256
	S	-.24925(*)	.057208	.005	-.43408	-.06442
	TG	-.19907	.071947	.099	-.41953	.02139

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logBr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.117(a)	17	.066	2.085	.018
Intercept	29.297	1	29.297	929.512	.000
species	.223	5	.045	1.412	.231
bedrock	.624	4	.156	4.947	.001
species * bedrock	.247	8	.031	.981	.458
Error	2.112	67	.032		
Total	72.782	85			
Corrected Total	3.229	84			

a R Squared = .346 (Adjusted R Squared = .180)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logBr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.17715	.065697	.135	-.03104	.38534
	S	.25847(*)	.059520	.006	.06386	.45308
	TG	.06338	.078760	.996	-.18052	.30728
	UB	.19493	.070090	.110	-.02559	.41546
LS	Cz	-.17715	.065697	.135	-.38534	.03104
	S	.08132	.049738	.698	-.06937	.23200
	TG	-.11377	.071655	.737	-.33394	.10640
	UB	.01778	.061999	1.000	-.17272	.20829
S	Cz	-.25847(*)	.059520	.006	-.45308	-.06386
	LS	-.08132	.049738	.698	-.23200	.06937
	TG	-.19509	.066037	.073	-.40142	.01124
	UB	-.06354	.055411	.953	-.23605	.10898
TG	Cz	-.06338	.078760	.996	-.30728	.18052
	LS	.11377	.071655	.737	-.10640	.33394
	S	.19509	.066037	.073	-.01124	.40142
	UB	.13155	.075703	.629	-.10038	.36348
UB	Cz	-.19493	.070090	.110	-.41546	.02559
	LS	-.01778	.061999	1.000	-.20829	.17272
	S	.06354	.055411	.953	-.10898	.23605
	TG	-.13155	.075703	.629	-.36348	.10038

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logBr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.203(a)	17	.012	.619	.865

Intercept	82.244	1	82.244	4255.105	.000
species	.020	5	.004	.207	.958
bedrock	.091	4	.023	1.177	.329
species * bedrock	.058	8	.007	.377	.929
Error	1.295	67	.019		
Total	221.955	85			
Corrected Total	1.498	84			

a R Squared = .136 (Adjusted R Squared = -.084)
b Plant Tissue = Leaf

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logBr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.04303	.058357	.998	-.14575	.23180
	S	.11369	.053124	.421	-.06700	.29439
	TG	.09756	.065042	.801	-.10653	.30164
	UB	.07498	.058306	.913	-.11417	.26413
LS	Cz	-.04303	.058357	.998	-.23180	.14575
	S	.07066	.037542	.521	-.04412	.18545
	TG	.05453	.053082	.977	-.10789	.21695
	UB	.03196	.044574	.999	-.10440	.16831
S	Cz	-.11369	.053124	.421	-.29439	.06700
	LS	-.07066	.037542	.521	-.18545	.04412
	TG	-.01614	.047269	1.000	-.16420	.13193
	UB	-.03871	.037463	.976	-.15486	.07744
TG	Cz	-.09756	.065042	.801	-.30164	.10653
	LS	-.05453	.053082	.977	-.21695	.10789
	S	.01614	.047269	1.000	-.13193	.16420
	UB	-.02257	.053027	1.000	-.18542	.14027
UB	Cz	-.07498	.058306	.913	-.26413	.11417
	LS	-.03196	.044574	.999	-.16831	.10440
	S	.03871	.037463	.976	-.07744	.15486
	TG	.02257	.053027	1.000	-.14027	.18542

Based on observed means.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logCa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.408(a)	17	.083	.973	.498
Intercept	462.983	1	462.983	5439.706	.000
species	.953	5	.191	2.240	.060
bedrock	.559	4	.140	1.643	.174
species * bedrock	.305	8	.038	.449	.887
Error	5.702	67	.085		
Total	1260.309	85			
Corrected Total	7.110	84			

a R Squared = .198 (Adjusted R Squared = -.006)
b Plant Tissue = Bark

Post Hoc Tests

Bedrock

Multiple Comparisons(a)

Dependent Variable: logCa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.08525	.126481	.999	-.48609	.31559
	S	-.05360	.110493	1.000	-.42345	.31626
	TG	-.18049	.130906	.868	-.59213	.23115
	UB	-.08971	.128040	.999	-.49606	.31664
LS	Cz	.08525	.126481	.999	-.31559	.48609
	S	.03165	.090767	1.000	-.24716	.31047
	TG	-.09524	.114745	.995	-.44402	.25354
	UB	-.00446	.111464	1.000	-.34564	.33671
S	Cz	.05360	.110493	1.000	-.31626	.42345
	LS	-.03165	.090767	1.000	-.31047	.24716
	TG	-.12689	.096838	.897	-.42646	.17268
	UB	-.03612	.092927	1.000	-.32685	.25462
TG	Cz	.18049	.130906	.868	-.23115	.59213
	LS	.09524	.114745	.995	-.25354	.44402
	S	.12689	.096838	.897	-.17268	.42646
	UB	.09078	.116461	.997	-.26532	.44687
UB	Cz	.08971	.128040	.999	-.31664	.49606
	LS	.00446	.111464	1.000	-.33671	.34564
	S	.03612	.092927	1.000	-.25462	.32685
	TG	-.09078	.116461	.997	-.44687	.26532

Based on observed means.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logCa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.614(a)	17	.036	1.666	.072
Intercept	513.633	1	513.633	23718.230	.000
species	.270	5	.054	2.493	.039
bedrock	.275	4	.069	3.172	.019
species * bedrock	.150	8	.019	.864	.551
Error	1.451	67	.022		
Total	1386.882	85			
Corrected Total	2.064	84			

a R Squared = .297 (Adjusted R Squared = .119)
b Plant Tissue = Twig

Post Hoc Tests
Bedrock

Multiple Comparisons(a)

Dependent Variable: logCa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.03021	.062647	1.000	-.17093	.23135
	S	-.01415	.057698	1.000	-.20596	.17766
	TG	-.10191	.067576	.797	-.31446	.11064
	UB	.01973	.069827	1.000	-.19994	.23941
LS	Cz	-.03021	.062647	1.000	-.23135	.17093
	S	-.04436	.043786	.979	-.17699	.08827
	TG	-.13212	.056166	.233	-.30333	.03909
	UB	-.01048	.058856	1.000	-.19249	.17154
S	Cz	.01415	.057698	1.000	-.17766	.20596
	LS	.04436	.043786	.979	-.08827	.17699
	TG	-.08776	.050587	.634	-.24354	.06801
	UB	.03388	.053557	1.000	-.13490	.20267
TG	Cz	.10191	.067576	.797	-.11064	.31446
	LS	.13212	.056166	.233	-.03909	.30333
	S	.08776	.050587	.634	-.06801	.24354
	UB	.12164	.064077	.511	-.07469	.31798
UB	Cz	-.01973	.069827	1.000	-.23941	.19994
	LS	.01048	.058856	1.000	-.17154	.19249
	S	-.03388	.053557	1.000	-.20267	.13490
	TG	-.12164	.064077	.511	-.31798	.07469

Based on observed means.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logCa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.621(a)	17	.037	1.871	.037
Intercept	451.468	1	451.468	23108.940	.000
species	.123	5	.025	1.259	.292
bedrock	.104	4	.026	1.331	.268
species * bedrock	.368	8	.046	2.353	.027
Error	1.309	67	.020		
Total	1214.624	85			
Corrected Total	1.930	84			

a R Squared = .322 (Adjusted R Squared = .150)
b Plant Tissue = Leaf

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logCa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.01206	.052864	1.000	-.17931	.15519
	S	-.06119	.047656	.915	-.21687	.09449
	TG	-.08484	.066893	.914	-.29183	.12215
	UB	-.03531	.063255	1.000	-.23299	.16238
LS	Cz	.01206	.052864	1.000	-.15519	.17931
	S	-.04913	.040303	.929	-.17133	.07308
	TG	-.07278	.061870	.945	-.26382	.11826
	UB	-.02324	.057917	1.000	-.20347	.15699
S	Cz	.06119	.047656	.915	-.09449	.21687
	LS	.04913	.040303	.929	-.07308	.17133
	TG	-.02365	.057484	1.000	-.20456	.15726
	UB	.02588	.053206	1.000	-.14353	.19530
TG	Cz	.08484	.066893	.914	-.12215	.29183
	LS	.07278	.061870	.945	-.11826	.26382
	S	.02365	.057484	1.000	-.15726	.20456
	UB	.04953	.070954	.999	-.16741	.26648
UB	Cz	.03531	.063255	1.000	-.16238	.23299
	LS	.02324	.057917	1.000	-.15699	.20347
	S	-.02588	.053206	1.000	-.19530	.14353
	TG	-.04953	.070954	.999	-.26648	.16741

Based on observed means.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logFe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.849(a)	17	.109	1.221	.273
Intercept	89.252	1	89.252	1002.129	.000
species	.631	5	.126	1.418	.229
bedrock	.264	4	.066	.742	.567
species * bedrock	1.087	8	.136	1.526	.165
Error	5.967	67	.089		
Total	246.548	85			
Corrected Total	7.816	84			

a R Squared = .237 (Adjusted R Squared = .043)
b Plant Tissue = Bark

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logFe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.17736	.106343	.687	-.15382	.50855
	S	.12148	.085654	.859	-.16192	.40487
	TG	.07372	.143279	1.000	-.37194	.51938
	UB	.12423	.118813	.975	-.24715	.49560
LS	Cz	-.17736	.106343	.687	-.50855	.15382
	S	-.05589	.083992	.999	-.31684	.20506
	TG	-.10364	.142291	.998	-.54356	.33627
	UB	-.05314	.117620	1.000	-.41536	.30909
S	Cz	-.12148	.085654	.859	-.40487	.16192
	LS	.05589	.083992	.999	-.20506	.31684
	TG	-.04775	.127572	1.000	-.45749	.36199
	UB	.00275	.099309	1.000	-.31722	.32272
TG	Cz	-.07372	.143279	1.000	-.51938	.37194
	LS	.10364	.142291	.998	-.33627	.54356
	S	.04775	.127572	1.000	-.36199	.45749
	UB	.05050	.151836	1.000	-.41547	.51648
UB	Cz	-.12423	.118813	.975	-.49560	.24715
	LS	.05314	.117620	1.000	-.30909	.41536
	S	-.00275	.099309	1.000	-.32272	.31722
	TG	-.05050	.151836	1.000	-.51648	.41547

Based on observed means.
a Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logFe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.694(a)	17	.100	4.155	.000
Intercept	79.148	1	79.148	3300.781	.000
species	.330	5	.066	2.755	.025
bedrock	.421	4	.105	4.393	.003
species * bedrock	.304	8	.038	1.582	.147
Error	1.607	67	.024		
Total	209.539	85			
Corrected Total	3.300	84			

a R Squared = .513 (Adjusted R Squared = .390)
b Plant Tissue = Twig

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logFe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.23152(*)	.072299	.047	.00235	.46069
	S	-.01789	.035370	1.000	-.12960	.09381
	TG	-.11411	.048586	.246	-.26457	.03634
	UB	-.07278	.062314	.950	-.27189	.12633
LS	Cz	-.23152(*)	.072299	.047	-.46069	-.00235
	S	-.24941(*)	.069502	.023	-.47307	-.02576
	TG	-.34563(*)	.077071	.002	-.58443	-.10683
	UB	-.30430(*)	.086386	.016	-.56869	-.03992
S	Cz	.01789	.035370	1.000	-.09381	.12960
	LS	.24941(*)	.069502	.023	.02576	.47307
	TG	-.09622	.044317	.342	-.23394	.04150
	UB	-.05489	.059046	.990	-.24729	.13750
TG	Cz	.11411	.048586	.246	-.03634	.26457
	LS	.34563(*)	.077071	.002	.10683	.58443
	S	.09622	.044317	.342	-.04150	.23394
	UB	.04133	.067793	1.000	-.16916	.25182
UB	Cz	.07278	.062314	.950	-.12633	.27189
	LS	.30430(*)	.086386	.016	.03992	.56869
	S	.05489	.059046	.990	-.13750	.24729
	TG	-.04133	.067793	1.000	-.25182	.16916

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logFe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.257(a)	17	.074	2.128	.015
Intercept	103.682	1	103.682	2985.332	.000
species	.494	5	.099	2.845	.022
bedrock	.469	4	.117	3.374	.014
species * bedrock	.305	8	.038	1.099	.375
Error	2.327	67	.035		
Total	300.609	85			
Corrected Total	3.583	84			

a R Squared = .351 (Adjusted R Squared = .186)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logFe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.09644	.068524	.851	-.11677	.30965
	S	-.09043	.046513	.489	-.23514	.05428
	TG	.00804	.075590	1.000	-.22857	.24465
	UB	.07337	.067774	.968	-.14050	.28724
LS	Cz	-.09644	.068524	.851	-.30965	.11677
	S	-.18687	.065112	.087	-.38999	.01625
	TG	-.08840	.088261	.980	-.35690	.18009
	UB	-.02308	.081667	1.000	-.27286	.22671
S	Cz	.09043	.046513	.489	-.05428	.23514
	LS	.18687	.065112	.087	-.01625	.38999
	TG	.09847	.072512	.878	-.12999	.32693
	UB	.16379	.064323	.182	-.04030	.36789
TG	Cz	-.00804	.075590	1.000	-.24465	.22857
	LS	.08840	.088261	.980	-.18009	.35690
	S	-.09847	.072512	.878	-.32693	.12999
	UB	.06533	.087680	.998	-.20287	.33352
UB	Cz	-.07337	.067774	.968	-.28724	.14050
	LS	.02308	.081667	1.000	-.22671	.27286
	S	-.16379	.064323	.182	-.36789	.04030
	TG	-.06533	.087680	.998	-.33352	.20287

Based on observed means.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.280(a)	17	.193	2.232	.011
Intercept	253.532	1	253.532	2932.854	.000
species	1.414	5	.283	3.271	.011
bedrock	.797	4	.199	2.304	.067
species * bedrock	.689	8	.086	.996	.447
Error	5.792	67	.086		
Total	666.892	85			
Corrected Total	9.071	84			

a R Squared = .362 (Adjusted R Squared = .200)
b Plant Tissue = Bark

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logK
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.19425	.116588	.697	-.56419	.17569
	S	-.17935	.109442	.721	-.53136	.17266
	TG	.00815	.120010	1.000	-.37001	.38631
	UB	.08859	.136553	.999	-.33836	.51554
LS	Cz	.19425	.116588	.697	-.17569	.56419
	S	.01490	.091894	1.000	-.26092	.29072
	TG	.20240	.104256	.475	-.11445	.51925
	UB	.28284	.122938	.271	-.09896	.66464
S	Cz	.17935	.109442	.721	-.17266	.53136
	LS	-.01490	.091894	1.000	-.29072	.26092
	TG	.18750	.096199	.465	-.10275	.47775
	UB	.26794	.116183	.275	-.09599	.63188
TG	Cz	-.00815	.120010	1.000	-.38631	.37001
	LS	-.20240	.104256	.475	-.51925	.11445
	S	-.18750	.096199	.465	-.47775	.10275
	UB	.08044	.126188	.999	-.30960	.47048
UB	Cz	-.08859	.136553	.999	-.51554	.33836
	LS	-.28284	.122938	.271	-.66464	.09896
	S	-.26794	.116183	.275	-.63188	.09599
	TG	-.08044	.126188	.999	-.47048	.30960

Based on observed means.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.408(a)	17	.024	1.594	.091
Intercept	372.258	1	372.258	24726.769	.000
species	.223	5	.045	2.964	.018
bedrock	.037	4	.009	.608	.659
species * bedrock	.102	8	.013	.843	.568
Error	1.009	67	.015		
Total	967.008	85			
Corrected Total	1.417	84			

a R Squared = .288 (Adjusted R Squared = .107)
b Plant Tissue = Twig

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logK
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.07298	.069208	.974	-.29280	.14683
	S	-.04636	.058533	.997	-.24865	.15592
	TG	-.10133	.064288	.766	-.31103	.10838
	UB	-.03103	.059869	1.000	-.23474	.17269
LS	Cz	.07298	.069208	.974	-.14683	.29280
	S	.02662	.046236	1.000	-.11835	.17159
	TG	-.02834	.053335	1.000	-.19109	.13441
	UB	.04196	.047917	.993	-.10729	.19121
S	Cz	.04636	.058533	.997	-.15592	.24865
	LS	-.02662	.046236	1.000	-.17159	.11835
	TG	-.05496	.038484	.837	-.17339	.06347
	UB	.01534	.030535	1.000	-.07706	.10773
TG	Cz	.10133	.064288	.766	-.10838	.31103
	LS	.02834	.053335	1.000	-.13441	.19109
	S	.05496	.038484	.837	-.06347	.17339
	UB	.07030	.040487	.632	-.05425	.19485
UB	Cz	.03103	.059869	1.000	-.17269	.23474
	LS	-.04196	.047917	.993	-.19121	.10729
	S	-.01534	.030535	1.000	-.10773	.07706
	TG	-.07030	.040487	.632	-.19485	.05425

Based on observed means.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.393(a)	17	.023	2.159	.014
Intercept	434.691	1	434.691	40620.454	.000
species	.059	5	.012	1.108	.365
bedrock	.172	4	.043	4.008	.006
species * bedrock	.135	8	.017	1.582	.147
Error	.717	67	.011		
Total	1158.938	85			
Corrected Total	1.110	84			

a R Squared = .354 (Adjusted R Squared = .190)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logK
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.06639	.042269	.753	-.19773	.06495
	S	-.10272	.035476	.094	-.21604	.01061
	TG	.01805	.040963	1.000	-.10964	.14574
	UB	-.01326	.037632	1.000	-.13287	.10634
LS	Cz	.06639	.042269	.753	-.06495	.19773
	S	-.03632	.036012	.980	-.14636	.07371
	TG	.08444	.041429	.408	-.04145	.21033
	UB	.05313	.038139	.855	-.06382	.17008
S	Cz	.10272	.035476	.094	-.01061	.21604
	LS	.03632	.036012	.980	-.07371	.14636
	TG	.12076(*)	.034470	.016	.01597	.22556
	UB	.08945	.030436	.062	-.00265	.18155
TG	Cz	-.01805	.040963	1.000	-.14574	.10964
	LS	-.08444	.041429	.408	-.21033	.04145
	S	-.12076(*)	.034470	.016	-.22556	-.01597
	UB	-.03131	.036686	.994	-.14362	.08100
UB	Cz	.01326	.037632	1.000	-.10634	.13287
	LS	-.05313	.038139	.855	-.17008	.06382
	S	-.08945	.030436	.062	-.18155	.00265
	TG	.03131	.036686	.994	-.08100	.14362

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Univariate Analysis of Variance

Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logLa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.858(a)	17	.168	1.546	.106
Intercept	55.646	1	55.646	511.610	.000
species	.367	5	.073	.675	.644
bedrock	.762	4	.191	1.752	.149
species * bedrock	.557	8	.070	.640	.741
Error	7.287	67	.109		
Total	145.897	85			
Corrected Total	10.146	84			

a R Squared = .282 (Adjusted R Squared = .099)
b Plant Tissue = Bark

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logLa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.21477	.130307	.698	-.18844	.61797
	S	.08369	.094394	.993	-.22268	.39006
	TG	-.02775	.138117	1.000	-.45551	.40002
	UB	.40216(*)	.107534	.013	.06289	.74143
LS	Cz	-.21477	.130307	.698	-.61797	.18844
	S	-.13107	.112683	.949	-.48428	.22213
	TG	-.24251	.151208	.722	-.70216	.21713
	UB	.18739	.123899	.787	-.19410	.56888
S	Cz	-.08369	.094394	.993	-.39006	.22268
	LS	.13107	.112683	.949	-.22213	.48428
	TG	-.11144	.121631	.990	-.49527	.27239
	UB	.31846(*)	.085330	.010	.05533	.58160
TG	Cz	.02775	.138117	1.000	-.40002	.45551
	LS	.24251	.151208	.722	-.21713	.70216
	S	.11144	.121631	.990	-.27239	.49527
	UB	.42990(*)	.132089	.034	.02135	.83845
UB	Cz	-.40216(*)	.107534	.013	-.74143	-.06289
	LS	-.18739	.123899	.787	-.56888	.19410
	S	-.31846(*)	.085330	.010	-.58160	-.05533
	TG	-.42990(*)	.132089	.034	-.83845	-.02135

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logLa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.220(a)	17	.248	2.002	.023
Intercept	53.232	1	53.232	429.315	.000
species	1.152	5	.230	1.858	.113
bedrock	1.460	4	.365	2.944	.026
species * bedrock	.767	8	.096	.773	.627
Error	8.307	67	.124		
Total	138.684	85			
Corrected Total	12.528	84			

a R Squared = .337 (Adjusted R Squared = .169)
b Plant Tissue = Twig

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logLa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.21355	.179597	.942	-.34884	.77595
	S	-.11518	.101718	.959	-.44137	.21101
	TG	-.18346	.109268	.686	-.52890	.16199
	UB	.12778	.112816	.958	-.22833	.48389
LS	Cz	-.21355	.179597	.942	-.77595	.34884
	S	-.32873	.167298	.492	-.86383	.20637
	TG	-.39701	.171993	.280	-.94101	.14699
	UB	-.08577	.174269	1.000	-.63469	.46315
S	Cz	.11518	.101718	.959	-.21101	.44137
	LS	.32873	.167298	.492	-.20637	.86383
	TG	-.06828	.087596	.997	-.33150	.19494
	UB	.24296	.091984	.130	-.03822	.52414
TG	Cz	.18346	.109268	.686	-.16199	.52890
	LS	.39701	.171993	.280	-.14699	.94101
	S	.06828	.087596	.997	-.19494	.33150
	UB	.31124(*)	.100270	.045	.00398	.61850
UB	Cz	-.12778	.112816	.958	-.48389	.22833
	LS	.08577	.174269	1.000	-.46315	.63469
	S	-.24296	.091984	.130	-.52414	.03822
	TG	-.31124(*)	.100270	.045	-.61850	-.00398

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logLa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.818(a)	17	.283	1.634	.080
Intercept	79.278	1	79.278	457.142	.000
species	1.140	5	.228	1.314	.269
bedrock	2.112	4	.528	3.044	.023
species * bedrock	.960	8	.120	.692	.697
Error	11.619	67	.173		
Total	195.298	85			
Corrected Total	16.437	84			

a R Squared = .293 (Adjusted R Squared = .114)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logLa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.00069	.178039	1.000	-.56159	.56021
	S	-.32877	.155585	.416	-.84087	.18334
	TG	-.26100	.181290	.836	-.83011	.30810
	UB	.09289	.162827	1.000	-.43545	.62123
LS	Cz	.00069	.178039	1.000	-.56021	.56159
	S	-.32808	.135220	.203	-.74136	.08519
	TG	-.26031	.164146	.734	-.75902	.23839
	UB	.09358	.143493	.999	-.34639	.53355
S	Cz	.32877	.155585	.416	-.18334	.84087
	LS	.32808	.135220	.203	-.08519	.74136
	TG	.06777	.139474	1.000	-.36001	.49554
	UB	.42166(*)	.114453	.009	.07515	.76816
TG	Cz	.26100	.181290	.836	-.30810	.83011
	LS	.26031	.164146	.734	-.23839	.75902
	S	-.06777	.139474	1.000	-.49554	.36001
	UB	.35389	.147509	.218	-.09904	.80682
UB	Cz	-.09289	.162827	1.000	-.62123	.43545
	LS	-.09358	.143493	.999	-.53355	.34639
	S	-.42166(*)	.114453	.009	-.76816	-.07515
	TG	-.35389	.147509	.218	-.80682	.09904

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logNa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.300(a)	17	.076	3.870	.000
Intercept	306.809	1	306.809	15532.462	.000
species	.662	5	.132	6.701	.000
bedrock	.326	4	.081	4.125	.005
species * bedrock	.155	8	.019	.983	.457
Error	1.323	67	.020		
Total	800.367	85			
Corrected Total	2.623	84			

a R Squared = .495 (Adjusted R Squared = .367)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logNa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.10549	.054095	.496	-.06590	.27687
	S	.10413	.046860	.368	-.05356	.26181
	TG	.19771(*)	.062626	.044	.00347	.39195
	UB	.26483	.087571	.070	-.01361	.54326
LS	Cz	-.10549	.054095	.496	-.27687	.06590
	S	-.00136	.038440	1.000	-.11987	.11715
	TG	.09222	.056602	.707	-.08113	.26557
	UB	.15934	.083370	.534	-.10971	.42839
S	Cz	-.10413	.046860	.368	-.26181	.05356
	LS	.00136	.038440	1.000	-.11715	.11987
	TG	.09358	.049733	.542	-.06359	.25075
	UB	.16070	.078867	.470	-.10221	.42361
TG	Cz	-.19771(*)	.062626	.044	-.39195	-.00347
	LS	-.09222	.056602	.707	-.26557	.08113
	S	-.09358	.049733	.542	-.25075	.06359
	UB	.06712	.089142	.998	-.21315	.34738
UB	Cz	-.26483	.087571	.070	-.54326	.01361
	LS	-.15934	.083370	.534	-.42839	.10971
	S	-.16070	.078867	.470	-.42361	.10221
	TG	-.06712	.089142	.998	-.34738	.21315

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logNa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.988(a)	17	.058	2.454	.005
Intercept	333.362	1	333.362	14071.679	.000
species	.447	5	.089	3.774	.005
bedrock	.482	4	.120	5.083	.001
species * bedrock	.314	8	.039	1.658	.125
Error	1.587	67	.024		
Total	857.878	85			
Corrected Total	2.576	84			

a R Squared = .384 (Adjusted R Squared = .227)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logNa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.17927	.069754	.183	-.04506	.40361
	S	.18587	.063255	.111	-.02743	.39917
	TG	.09447	.076350	.927	-.14523	.33417
	UB	.06552	.076710	.994	-.17641	.30745
LS	Cz	-.17927	.069754	.183	-.40361	.04506
	S	.00660	.046779	1.000	-.13617	.14937
	TG	-.08480	.063375	.882	-.27825	.10865
	UB	-.11375	.063808	.600	-.31078	.08327
S	Cz	-.18587	.063255	.111	-.39917	.02743
	LS	-.00660	.046779	1.000	-.14937	.13617
	TG	-.09140	.056143	.715	-.26618	.08338
	UB	-.12035	.056631	.384	-.30004	.05934
TG	Cz	-.09447	.076350	.927	-.33417	.14523
	LS	.08480	.063375	.882	-.10865	.27825
	S	.09140	.056143	.715	-.08338	.26618
	UB	-.02895	.070960	1.000	-.24607	.18816
UB	Cz	-.06552	.076710	.994	-.30745	.17641
	LS	.11375	.063808	.600	-.08327	.31078
	S	.12035	.056631	.384	-.05934	.30004
	TG	.02895	.070960	1.000	-.18816	.24607

Based on observed means.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logNa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.431(a)	17	.025	1.876	.036
Intercept	405.787	1	405.787	30035.257	.000
species	.119	5	.024	1.758	.134
bedrock	.098	4	.024	1.809	.137
species * bedrock	.251	8	.031	2.326	.029
Error	.905	67	.014		
Total	1092.191	85			
Corrected Total	1.336	84			

a R Squared = .322 (Adjusted R Squared = .151)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logNa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.09854	.039689	.190	-.02446	.22155
	S	.12026(*)	.032540	.016	.01707	.22345
	TG	.10059	.049745	.435	-.05406	.25524
	UB	.11318	.048818	.273	-.04060	.26697
LS	Cz	-.09854	.039689	.190	-.22155	.02446
	S	.02172	.034800	1.000	-.08482	.12825
	TG	.00205	.051252	1.000	-.15519	.15929
	UB	.01464	.050352	1.000	-.14156	.17083
S	Cz	-.12026(*)	.032540	.016	-.22345	-.01707
	LS	-.02172	.034800	1.000	-.12825	.08482
	TG	-.01967	.045939	1.000	-.16432	.12498
	UB	-.00708	.044934	1.000	-.15113	.13697
TG	Cz	-.10059	.049745	.435	-.25524	.05406
	LS	-.00205	.051252	1.000	-.15929	.15519
	S	.01967	.045939	1.000	-.12498	.16432
	UB	.01259	.058606	1.000	-.16664	.19182
UB	Cz	-.11318	.048818	.273	-.26697	.04060
	LS	-.01464	.050352	1.000	-.17083	.14156
	S	.00708	.044934	1.000	-.13697	.15113
	TG	-.01259	.058606	1.000	-.19182	.16664

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logRb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.512(a)	17	.089	1.432	.150
Intercept	1.890	1	1.890	30.439	.000
species	.645	5	.129	2.078	.079
bedrock	.299	4	.075	1.206	.317
species * bedrock	.758	8	.095	1.526	.165
Error	4.160	67	.062		
Total	12.883	85			
Corrected Total	5.672	84			

a R Squared = .267 (Adjusted R Squared = .080)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logRb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.18699	.084403	.313	-.07419	.44818
	S	.08654	.067824	.912	-.12549	.29858
	TG	.07035	.094619	.998	-.22307	.36378
	UB	.06898	.105531	.999	-.26542	.40337
LS	Cz	-.18699	.084403	.313	-.44818	.07419
	S	-.10045	.077387	.900	-.33724	.13634
	TG	-.11664	.101693	.952	-.42637	.19309
	UB	-.11802	.111918	.973	-.46523	.22920
S	Cz	-.08654	.067824	.912	-.29858	.12549
	LS	.10045	.077387	.900	-.13634	.33724
	TG	-.01619	.088417	1.000	-.29069	.25831
	UB	-.01757	.100009	1.000	-.33807	.30293
TG	Cz	-.07035	.094619	.998	-.36378	.22307
	LS	.11664	.101693	.952	-.19309	.42637
	S	.01619	.088417	1.000	-.25831	.29069
	UB	-.00138	.119810	1.000	-.36947	.36672
UB	Cz	-.06898	.105531	.999	-.40337	.26542
	LS	.11802	.111918	.973	-.22920	.46523
	S	.01757	.100009	1.000	-.30293	.33807
	TG	.00138	.119810	1.000	-.36672	.36947

Based on observed means.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logRb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.128(a)	17	.125	1.691	.066
Intercept	.599	1	.599	8.091	.006
species	.464	5	.093	1.254	.294
bedrock	.953	4	.238	3.218	.018
species * bedrock	.925	8	.116	1.562	.153
Error	4.960	67	.074		
Total	8.258	85			
Corrected Total	7.088	84			

a R Squared = .300 (Adjusted R Squared = .123)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logRb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.18207	.114480	.741	-.17467	.53881
	S	-.09042	.093842	.987	-.39856	.21771
	TG	.00913	.114073	1.000	-.34649	.36475
	UB	-.05710	.116204	1.000	-.42120	.30701
LS	Cz	-.18207	.114480	.741	-.53881	.17467
	S	-.27250	.091288	.064	-.55459	.00960
	TG	-.17295	.111981	.762	-.51311	.16722
	UB	-.23917	.114151	.377	-.58855	.11022
S	Cz	.09042	.093842	.987	-.21771	.39856
	LS	.27250	.091288	.064	-.00960	.55459
	TG	.09955	.090777	.965	-.18080	.37990
	UB	.03333	.093440	1.000	-.26109	.32775
TG	Cz	-.00913	.114073	1.000	-.36475	.34649
	LS	.17295	.111981	.762	-.16722	.51311
	S	-.09955	.090777	.965	-.37990	.18080
	UB	-.06622	.113743	1.000	-.41441	.28197
UB	Cz	.05710	.116204	1.000	-.30701	.42120
	LS	.23917	.114151	.377	-.11022	.58855
	S	-.03333	.093440	1.000	-.32775	.26109
	TG	.06622	.113743	1.000	-.28197	.41441

Based on observed means.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logSc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.

Corrected Model	2.505(a)	17	.147	1.532	.110
Intercept	102.873	1	102.873	1069.323	.000
species	.895	5	.179	1.861	.113
bedrock	.630	4	.157	1.637	.175
species * bedrock	1.173	8	.147	1.524	.166
Error	6.446	67	.096		
Total	279.501	85			
Corrected Total	8.951	84			

a R Squared = .280 (Adjusted R Squared = .097)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logSc
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.25177	.111733	.294	-.09452	.59805
	S	.17018	.085592	.493	-.11069	.45105
	TG	.09683	.145719	.999	-.35721	.55087
	UB	.10099	.125901	.996	-.29346	.49545
LS	Cz	-.25177	.111733	.294	-.59805	.09452
	S	-.08159	.092400	.993	-.37009	.20690
	TG	-.15494	.149819	.976	-.61594	.30607
	UB	-.15077	.130625	.951	-.55294	.25139
S	Cz	-.17018	.085592	.493	-.45105	.11069
	LS	.08159	.092400	.993	-.20690	.37009
	TG	-.07334	.131481	1.000	-.49525	.34856
	UB	-.06918	.109107	1.000	-.42237	.28401
TG	Cz	-.09683	.145719	.999	-.55087	.35721
	LS	.15494	.149819	.976	-.30607	.61594
	S	.07334	.131481	1.000	-.34856	.49525
	UB	.00416	.160662	1.000	-.48785	.49617
UB	Cz	-.10099	.125901	.996	-.49545	.29346
	LS	.15077	.130625	.951	-.25139	.55294
	S	.06918	.109107	1.000	-.28401	.42237
	TG	-.00416	.160662	1.000	-.49617	.48785

Based on observed means.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logSc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.643(a)	17	.097	3.546	.000
Intercept	119.639	1	119.639	4390.243	.000

species	.361	5	.072	2.652	.030
bedrock	.601	4	.150	5.512	.001
species * bedrock	.325	8	.041	1.490	.178
Error	1.826	67	.027		
Total	323.581	85			
Corrected Total	3.469	84			

a R Squared = .474 (Adjusted R Squared = .340)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logSc
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.21259(*)	.055767	.009	.03980	.38539
	S	-.02445	.040830	1.000	-.15218	.10328
	TG	-.10428	.062216	.681	-.29805	.08949
	UB	-.10430	.075626	.872	-.34754	.13894
LS	Cz	-.21259(*)	.055767	.009	-.38539	-.03980
	S	-.23704(*)	.051871	.001	-.39770	-.07638
	TG	-.31687(*)	.069959	.001	-.52982	-.10392
	UB	-.31689(*)	.082114	.009	-.57301	-.06078
S	Cz	.02445	.040830	1.000	-.10328	.15218
	LS	.23704(*)	.051871	.001	.07638	.39770
	TG	-.07983	.058750	.877	-.26405	.10439
	UB	-.07986	.072800	.967	-.31746	.15775
TG	Cz	.10428	.062216	.681	-.08949	.29805
	LS	.31687(*)	.069959	.001	.10392	.52982
	S	.07983	.058750	.877	-.10439	.26405
	UB	-.00002	.086623	1.000	-.26744	.26739
UB	Cz	.10430	.075626	.872	-.13894	.34754
	LS	.31689(*)	.082114	.009	.06078	.57301
	S	.07986	.072800	.967	-.15775	.31746
	TG	.00002	.086623	1.000	-.26739	.26744

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logSc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.327(a)	17	.137	2.333	.007
Intercept	99.537	1	99.537	1696.281	.000

species	.942	5	.188	3.212	.012
bedrock	.857	4	.214	3.651	.009
species * bedrock	.407	8	.051	.866	.549
Error	3.932	67	.059		
Total	247.254	85			
Corrected Total	6.258	84			

a R Squared = .372 (Adjusted R Squared = .212)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logSc
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.18075	.088357	.420	-.09405	.45555
	S	-.08197	.058273	.854	-.26563	.10169
	TG	.09069	.093626	.985	-.20148	.38286
	UB	.15033	.104206	.839	-.18322	.48389
LS	Cz	-.18075	.088357	.420	-.45555	.09405
	S	-.26272(*)	.082323	.045	-.52127	-.00417
	TG	-.09006	.110214	.996	-.42503	.24491
	UB	-.03042	.119332	1.000	-.39814	.33730
S	Cz	.08197	.058273	.854	-.10169	.26563
	LS	.26272(*)	.082323	.045	.00417	.52127
	TG	.17266	.087955	.485	-.10516	.45048
	UB	.23230	.099142	.285	-.09098	.55559
TG	Cz	-.09069	.093626	.985	-.38286	.20148
	LS	.09006	.110214	.996	-.24491	.42503
	S	-.17266	.087955	.485	-.45048	.10516
	UB	.05964	.123285	1.000	-.31890	.43819
UB	Cz	-.15033	.104206	.839	-.48389	.18322
	LS	.03042	.119332	1.000	-.33730	.39814
	S	-.23230	.099142	.285	-.55559	.09098
	TG	-.05964	.123285	1.000	-.43819	.31890

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Univariate Analysis of Variance

Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logSm

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.612(a)	17	.095	1.703	.064
Intercept	99.570	1	99.570	1788.049	.000

species	.210	5	.042	.754	.586
bedrock	.348	4	.087	1.562	.195
species * bedrock	.300	8	.037	.673	.713
Error	3.731	67	.056		
Total	257.784	85			
Corrected Total	5.343	84			

a R Squared = .302 (Adjusted R Squared = .125)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logSm
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.19060	.081254	.252	-.06245	.44364
	S	.03063	.050174	1.000	-.13040	.19167
	TG	.06037	.093392	.999	-.23308	.35382
	UB	.33961(*)	.084848	.008	.07031	.60890
LS	Cz	-.19060	.081254	.252	-.44364	.06245
	S	-.15996	.074508	.371	-.39667	.07674
	TG	-.13023	.108425	.936	-.46049	.20004
	UB	.14901	.101160	.810	-.16081	.45883
S	Cz	-.03063	.050174	1.000	-.19167	.13040
	LS	.15996	.074508	.371	-.07674	.39667
	TG	.02974	.087586	1.000	-.25150	.31097
	UB	.30897(*)	.078412	.012	.05319	.56476
TG	Cz	-.06037	.093392	.999	-.35382	.23308
	LS	.13023	.108425	.936	-.20004	.46049
	S	-.02974	.087586	1.000	-.31097	.25150
	UB	.27924	.111144	.171	-.06066	.61913
UB	Cz	-.33961(*)	.084848	.008	-.60890	-.07031
	LS	-.14901	.101160	.810	-.45883	.16081
	S	-.30897(*)	.078412	.012	-.56476	-.05319
	TG	-.27924	.111144	.171	-.61913	.06066

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logSm

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.081(a)	17	.122	2.271	.009
Intercept	95.899	1	95.899	1778.860	.000
species	.697	5	.139	2.587	.034
bedrock	.439	4	.110	2.035	.099

species * bedrock	.692	8	.087	1.605	.140
Error	3.612	67	.054		
Total	252.841	85			
Corrected Total	5.693	84			

a R Squared = .366 (Adjusted R Squared = .205)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logSm
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.06939	.129607	1.000	-.48023	.34145
	S	-.13696	.063852	.366	-.33802	.06409
	TG	-.13582	.058510	.304	-.32902	.05738
	UB	.02574	.078022	1.000	-.21811	.26958
LS	Cz	.06939	.129607	1.000	-.34145	.48023
	S	-.06757	.124849	1.000	-.46890	.33376
	TG	-.06643	.122203	1.000	-.46433	.33148
	UB	.09513	.132656	.999	-.32124	.51150
S	Cz	.13696	.063852	.366	-.06409	.33802
	LS	.06757	.124849	1.000	-.33376	.46890
	TG	.00114	.047040	1.000	-.13738	.13967
	UB	.16270	.069834	.256	-.05383	.37923
TG	Cz	.13582	.058510	.304	-.05738	.32902
	LS	.06643	.122203	1.000	-.33148	.46433
	S	-.00114	.047040	1.000	-.13967	.13738
	UB	.16156	.064985	.211	-.04666	.36977
UB	Cz	-.02574	.078022	1.000	-.26958	.21811
	LS	-.09513	.132656	.999	-.51150	.32124
	S	-.16270	.069834	.256	-.37923	.05383
	TG	-.16156	.064985	.211	-.36977	.04666

Based on observed means.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logSm

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.887(a)	17	.052	1.307	.216
Intercept	91.882	1	91.882	2302.383	.000
species	.256	5	.051	1.283	.281
bedrock	.298	4	.075	1.869	.126
species * bedrock	.211	8	.026	.661	.724

Error	2.674	67	.040		
Total	233.547	85			
Corrected Total	3.560	84			

a R Squared = .249 (Adjusted R Squared = .058)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logSm
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.00284	.088636	1.000	-.27216	.27785
	S	-.12427	.057104	.373	-.31057	.06204
	TG	-.05973	.071831	.995	-.28271	.16325
	UB	.07499	.070773	.972	-.14660	.29658
LS	Cz	-.00284	.088636	1.000	-.27785	.27216
	S	-.12711	.078728	.732	-.37742	.12320
	TG	-.06258	.089984	.999	-.33850	.21334
	UB	.07215	.089141	.996	-.20240	.34669
S	Cz	.12427	.057104	.373	-.06204	.31057
	LS	.12711	.078728	.732	-.12320	.37742
	TG	.06454	.059174	.966	-.11887	.24794
	UB	.19926(*)	.057884	.026	.01727	.38125
TG	Cz	.05973	.071831	.995	-.16325	.28271
	LS	.06258	.089984	.999	-.21334	.33850
	S	-.06454	.059174	.966	-.24794	.11887
	UB	.13472	.072454	.538	-.08685	.35630
UB	Cz	-.07499	.070773	.972	-.29658	.14660
	LS	-.07215	.089141	.996	-.34669	.20240
	S	-.19926(*)	.057884	.026	-.38125	-.01727
	TG	-.13472	.072454	.538	-.35630	.08685

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Univariate Analysis of Variance
Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logTh

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.781(a)	17	.222	1.933	.030
Intercept	115.250	1	115.250	1001.613	.000
species	.547	5	.109	.951	.454
bedrock	1.234	4	.308	2.680	.039
species * bedrock	1.738	8	.217	1.888	.076

Error	7.709	67	.115		
Total	298.361	85			
Corrected Total	11.491	84			

a R Squared = .329 (Adjusted R Squared = .159)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logTh
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.35378	.132382	.134	-.05989	.76744
	S	.10277	.112111	.991	-.26296	.46850
	TG	-.04339	.162520	1.000	-.54651	.45973
	UB	.13106	.124811	.975	-.26500	.52712
LS	Cz	-.35378	.132382	.134	-.76744	.05989
	S	-.25101	.105548	.226	-.57473	.07270
	TG	-.39717	.158064	.173	-.88249	.08816
	UB	-.22272	.118950	.529	-.58653	.14110
S	Cz	-.10277	.112111	.991	-.46850	.26296
	LS	.25101	.105548	.226	-.07270	.57473
	TG	-.14616	.141521	.977	-.59300	.30068
	UB	.02829	.095881	1.000	-.26618	.32277
TG	Cz	.04339	.162520	1.000	-.45973	.54651
	LS	.39717	.158064	.173	-.08816	.88249
	S	.14616	.141521	.977	-.30068	.59300
	UB	.17445	.151779	.952	-.29630	.64520
UB	Cz	-.13106	.124811	.975	-.52712	.26500
	LS	.22272	.118950	.529	-.14110	.58653
	S	-.02829	.095881	1.000	-.32277	.26618
	TG	-.17445	.151779	.952	-.64520	.29630

Based on observed means.
a Plant Tissue = Bark

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logTh

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.288(a)	17	.135	1.324	.206
Intercept	109.959	1	109.959	1081.507	.000
species	.757	5	.151	1.489	.205
bedrock	.500	4	.125	1.229	.307
species * bedrock	.275	8	.034	.338	.948

Error	6.812	67	.102		
Total	283.676	85			
Corrected Total	9.101	84			

a R Squared = .251 (Adjusted R Squared = .062)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logTh
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.09877	.138829	.999	-.34004	.53758
	S	-.16252	.118007	.882	-.56242	.23738
	TG	-.01857	.147393	1.000	-.47922	.44208
	UB	.13005	.136959	.988	-.30608	.56618
LS	Cz	-.09877	.138829	.999	-.53758	.34004
	S	-.26128	.098229	.133	-.56616	.04359
	TG	-.11734	.132091	.992	-.51926	.28458
	UB	.03128	.120338	1.000	-.33671	.39927
S	Cz	.16252	.118007	.882	-.23738	.56242
	LS	.26128	.098229	.133	-.04359	.56616
	TG	.14395	.110001	.900	-.20125	.48914
	UB	.29257	.095569	.060	-.00820	.59333
TG	Cz	.01857	.147393	1.000	-.44208	.47922
	LS	.11734	.132091	.992	-.28458	.51926
	S	-.14395	.110001	.900	-.48914	.20125
	UB	.14862	.130125	.953	-.24959	.54683
UB	Cz	-.13005	.136959	.988	-.56618	.30608
	LS	-.03128	.120338	1.000	-.39927	.33671
	S	-.29257	.095569	.060	-.59333	.00820
	TG	-.14862	.130125	.953	-.54683	.24959

Based on observed means.
a Plant Tissue = Leaf

Univariate Analysis of Variance

Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logZn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.326(a)	17	.196	1.659	.074
Intercept	4.449	1	4.449	37.726	.000
species	.960	5	.192	1.628	.165
bedrock	.496	4	.124	1.052	.387
species * bedrock	1.901	8	.238	2.015	.058
Error	7.902	67	.118		

Total	19.104	85			
Corrected Total	11.228	84			

a R Squared = .296 (Adjusted R Squared = .118)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logZn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.24569	.137113	.630	-.20833	.69972
	S	.33044	.138729	.269	-.12353	.78442
	TG	.20099	.152815	.898	-.28371	.68569
	UB	.27992	.161809	.649	-.22992	.78976
LS	Cz	-.24569	.137113	.630	-.69972	.20833
	S	.08475	.093326	.990	-.19172	.36122
	TG	-.04470	.113210	1.000	-.39230	.30289
	UB	.03423	.125084	1.000	-.35906	.42751
S	Cz	-.33044	.138729	.269	-.78442	.12353
	LS	-.08475	.093326	.990	-.36122	.19172
	TG	-.12946	.115161	.957	-.47826	.21935
	UB	-.05052	.126853	1.000	-.44474	.34369
TG	Cz	-.20099	.152815	.898	-.68569	.28371
	LS	.04470	.113210	1.000	-.30289	.39230
	S	.12946	.115161	.957	-.21935	.47826
	UB	.07893	.142121	1.000	-.35749	.51535
UB	Cz	-.27992	.161809	.649	-.78976	.22992
	LS	-.03423	.125084	1.000	-.42751	.35906
	S	.05052	.126853	1.000	-.34369	.44474
	TG	-.07893	.142121	1.000	-.51535	.35749

Based on observed means.
a Plant Tissue = Bark

Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logZn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.964(a)	17	.116	1.901	.033
Intercept	24.578	1	24.578	404.477	.000
species	.583	5	.117	1.918	.103
bedrock	.529	4	.132	2.176	.081
species * bedrock	.425	8	.053	.875	.542
Error	4.071	67	.061		
Total	66.136	85			
Corrected Total	6.036	84			

a R Squared = .325 (Adjusted R Squared = .154)

b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logZn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.09147	.095078	.986	-.20820	.39115
	S	.01266	.088210	1.000	-.26892	.29424
	TG	.04007	.096554	1.000	-.26331	.34345
	UB	-.23243	.100361	.272	-.54776	.08290
LS	Cz	-.09147	.095078	.986	-.39115	.20820
	S	-.07881	.077754	.978	-.31247	.15484
	TG	-.05140	.087106	1.000	-.31603	.21323
	UB	-.32390(*)	.091307	.016	-.60411	-.04369
S	Cz	-.01266	.088210	1.000	-.29424	.26892
	LS	.07881	.077754	.978	-.15484	.31247
	TG	.02741	.079552	1.000	-.21227	.26709
	UB	-.24509	.084132	.072	-.50339	.01321
TG	Cz	-.04007	.096554	1.000	-.34345	.26331
	LS	.05140	.087106	1.000	-.21323	.31603
	S	-.02741	.079552	1.000	-.26709	.21227
	UB	-.27250	.092843	.068	-.55707	.01207
UB	Cz	.23243	.100361	.272	-.08290	.54776
	LS	.32390(*)	.091307	.016	.04369	.60411
	S	.24509	.084132	.072	-.01321	.50339
	TG	.27250	.092843	.068	-.01207	.55707

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logZn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.470(a)	17	.028	1.323	.206
Intercept	29.514	1	29.514	1413.878	.000
species	.169	5	.034	1.622	.166
bedrock	.236	4	.059	2.821	.032
species * bedrock	.194	8	.024	1.162	.335
Error	1.399	67	.021		
Total	77.939	85			
Corrected Total	1.868	84			

a R Squared = .251 (Adjusted R Squared = .061)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logZn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.06573	.059781	.965	-.12259	.25405
	S	-.01006	.053629	1.000	-.18390	.16378
	TG	.08700	.058632	.813	-.09852	.27253
	UB	-.02091	.057809	1.000	-.20522	.16340
LS	Cz	-.06573	.059781	.965	-.25405	.12259
	S	-.07580	.047029	.715	-.21831	.06672
	TG	.02127	.052662	1.000	-.13873	.18128
	UB	-.08664	.051745	.674	-.24485	.07157
S	Cz	.01006	.053629	1.000	-.16378	.18390
	LS	.07580	.047029	.715	-.06672	.21831
	TG	.09707	.045558	.345	-.04048	.23461
	UB	-.01085	.044494	1.000	-.14626	.12457
TG	Cz	-.08700	.058632	.813	-.27253	.09852
	LS	-.02127	.052662	1.000	-.18128	.13873
	S	-.09707	.045558	.345	-.23461	.04048
	UB	-.10791	.050412	.348	-.26207	.04624
UB	Cz	.02091	.057809	1.000	-.16340	.20522
	LS	.08664	.051745	.674	-.07157	.24485
	S	.01085	.044494	1.000	-.12457	.14626
	TG	.10791	.050412	.348	-.04624	.26207

Based on observed means.
a Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.082(a)	17	.064	1.703	.064
Intercept	25.982	1	25.982	694.908	.000
species	.123	5	.025	.658	.657
bedrock	.127	4	.032	.852	.498
species * bedrock	.679	8	.085	2.271	.033
Error	2.505	67	.037		
Total	72.644	85			
Corrected Total	3.587	84			

a R Squared = .302 (Adjusted R Squared = .125)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.588(a)	17	.035	1.240	.260
Intercept	30.758	1	30.758	1102.598	.000
species	.105	5	.021	.751	.588
bedrock	.098	4	.024	.878	.482
species * bedrock	.230	8	.029	1.031	.422
Error	1.869	67	.028		
Total	79.611	85			
Corrected Total	2.457	84			

a R Squared = .239 (Adjusted R Squared = .046)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.361(a)	17	.080	1.370	.180
Intercept	88.401	1	88.401	1512.829	.000
species	.499	5	.100	1.708	.145
bedrock	.059	4	.015	.251	.908
species * bedrock	.590	8	.074	1.263	.278
Error	3.915	67	.058		
Total	235.248	85			
Corrected Total	5.276	84			

a R Squared = .258 (Adjusted R Squared = .070)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logCd

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.438(a)	17	.143	1.776	.056
Intercept	28.698	1	28.698	355.298	.000
species	1.537	5	.307	3.806	.005
bedrock	.782	4	.195	2.420	.059
species * bedrock	.480	8	.060	.743	.653
Error	4.442	55	.081		
Total	58.479	73			
Corrected Total	6.881	72			

a R Squared = .354 (Adjusted R Squared = .155)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logCd

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.765(a)	17	.221	1.996	.026
Intercept	52.591	1	52.591	473.879	.000
species	2.039	5	.408	3.674	.006
bedrock	.306	4	.076	.689	.602
species * bedrock	1.905	8	.238	2.146	.045
Error	6.548	59	.111		
Total	115.434	77			
Corrected Total	10.313	76			

a R Squared = .365 (Adjusted R Squared = .182)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logCu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.755(a)	17	.044	1.111	.362
Intercept	.036	1	.036	.910	.343
species	.023	5	.005	.116	.988
bedrock	.124	4	.031	.774	.546
species * bedrock	.219	8	.027	.684	.704
Error	2.679	67	.040		
Total	3.440	85			
Corrected Total	3.435	84			

a R Squared = .220 (Adjusted R Squared = .022)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logCu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.756(a)	17	.044	1.019	.450
Intercept	6.869	1	6.869	157.373	.000
species	.249	5	.050	1.139	.348
bedrock	.128	4	.032	.734	.572
species * bedrock	.564	8	.070	1.615	.137
Error	2.924	67	.044		
Total	19.186	85			
Corrected Total	3.680	84			

a R Squared = .205 (Adjusted R Squared = .004)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logCu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.396(a)	17	.023	.533	.926
Intercept	6.243	1	6.243	142.952	.000
species	.104	5	.021	.477	.792
bedrock	.012	4	.003	.068	.991
species * bedrock	.161	8	.020	.459	.880
Error	2.926	67	.044		
Total	21.617	85			
Corrected Total	3.322	84			

a R Squared = .119 (Adjusted R Squared = -.104)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logGa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.091(a)	15	.206	1.789	.058
Intercept	45.719	1	45.719	396.998	.000
species	.250	4	.063	.543	.705
bedrock	1.967	4	.492	4.271	.004
species * bedrock	1.069	7	.153	1.326	.255
Error	6.795	59	.115		
Total	85.422	75			
Corrected Total	9.885	74			

a R Squared = .313 (Adjusted R Squared = .138)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logGa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.556(a)	16	.222	1.980	.029
Intercept	32.740	1	32.740	291.717	.000
species	1.611	4	.403	3.588	.011
bedrock	2.233	4	.558	4.973	.002
species * bedrock	.808	8	.101	.899	.523
Error	7.071	63	.112		
Total	59.672	80			
Corrected Total	10.626	79			

a R Squared = .335 (Adjusted R Squared = .166)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logGa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.467(a)	16	.217	2.777	.002
Intercept	26.460	1	26.460	339.191	.000
species	.469	5	.094	1.204	.317
bedrock	1.744	4	.436	5.590	.001
species * bedrock	.233	7	.033	.427	.882
Error	5.071	65	.078		
Total	64.629	82			
Corrected Total	8.537	81			

a R Squared = .406 (Adjusted R Squared = .260)
b Plant Tissue = Leaf

Post Hoc Tests

Multiple Comparisons(a)

Dependent Variable: logGa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.2561	.11170	.280	-.0931	.6053
	S	-.1887	.09228	.463	-.4948	.1175
	TG	.0557	.11847	1.000	-.3135	.4250
	UB	.2321	.12422	.553	-.1611	.6253
LS	Cz	-.2561	.11170	.280	-.6053	.0931
	S	-.4448(*)	.08616	.000	-.7116	-.1780
	TG	-.2004	.11377	.610	-.5478	.1470
	UB	-.0240	.11974	1.000	-.3982	.3502
S	Cz	.1887	.09228	.463	-.1175	.4948
	LS	.4448(*)	.08616	.000	.1780	.7116
	TG	.2444	.09477	.167	-.0544	.5433
	UB	.4208(*)	.10186	.010	.0841	.7574

TG	Cz	-.0557	.11847	1.000	-.4250	.3135
	LS	.2004	.11377	.610	-.1470	.5478
	S	-.2444	.09477	.167	-.5433	.0544
	UB	.1764	.12608	.855	-.2157	.5685
UB	Cz	-.2321	.12422	.553	-.6253	.1611
	LS	.0240	.11974	1.000	-.3502	.3982
	S	-.4208(*)	.10186	.010	-.7574	-.0841
	TG	-.1764	.12608	.855	-.5685	.2157

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logLi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.947(a)	17	.232	1.731	.060
Intercept	35.535	1	35.535	264.977	.000
species	.777	5	.155	1.159	.339
bedrock	1.261	4	.315	2.351	.064
species * bedrock	.339	8	.042	.316	.957
Error	8.449	63	.134		
Total	96.094	81			
Corrected Total	12.396	80			

a R Squared = .318 (Adjusted R Squared = .134)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logLi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.001(a)	17	.177	1.201	.292
Intercept	20.829	1	20.829	141.658	.000
species	.729	5	.146	.991	.431
bedrock	.235	4	.059	.399	.809
species * bedrock	.258	8	.032	.219	.986
Error	8.822	60	.147		
Total	69.396	78			
Corrected Total	11.824	77			

a R Squared = .254 (Adjusted R Squared = .042)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logLi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.968(a)	17	.586	4.845	.000
Intercept	2.983	1	2.983	24.650	.000
species	1.840	5	.368	3.041	.016
bedrock	.910	4	.228	1.880	.125
species * bedrock	1.191	8	.149	1.230	.296
Error	7.866	65	.121		
Total	22.821	83			
Corrected Total	17.834	82			

a R Squared = .559 (Adjusted R Squared = .444)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logMn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.056(a)	17	.180	2.058	.019
Intercept	22.129	1	22.129	253.331	.000
species	.961	5	.192	2.200	.064
bedrock	.893	4	.223	2.557	.047
species * bedrock	.264	8	.033	.378	.929
Error	5.852	67	.087		
Total	57.287	85			
Corrected Total	8.908	84			

a R Squared = .343 (Adjusted R Squared = .176)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logMn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.1776	.11755	.790	-.5419	.1866
	S	-.1243	.08847	.865	-.4174	.1688
	TG	-.2080	.13643	.782	-.6308	.2148
	UB	-.4970(*)	.10682	.002	-.8329	-.1610
LS	Cz	.1776	.11755	.790	-.1866	.5419
	S	.0533	.09605	1.000	-.2482	.3549
	TG	-.0303	.14146	1.000	-.4621	.4015
	UB	-.3193	.11318	.087	-.6658	.0271
S	Cz	.1243	.08847	.865	-.1688	.4174
	LS	-.0533	.09605	1.000	-.3549	.2482
	TG	-.0837	.11841	.999	-.4617	.2943
	UB	-.3727(*)	.08258	.002	-.6324	-.1129

TG	Cz	.2080	.13643	.782	-.2148	.6308
	LS	.0303	.14146	1.000	-.4015	.4621
	S	.0837	.11841	.999	-.2943	.4617
	UB	-.2890	.13268	.333	-.6988	.1208
UB	Cz	.4970(*)	.10682	.002	.1610	.8329
	LS	.3193	.11318	.087	-.0271	.6658
	S	.3727(*)	.08258	.002	.1129	.6324
	TG	.2890	.13268	.333	-.1208	.6988

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logMn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.041(a)	17	.238	1.606	.087
Intercept	55.402	1	55.402	374.442	.000
species	.769	5	.154	1.039	.402
bedrock	1.619	4	.405	2.735	.036
species * bedrock	.617	8	.077	.521	.837
Error	9.913	67	.148		
Total	160.464	85			
Corrected Total	13.954	84			

a R Squared = .290 (Adjusted R Squared = .109)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logMn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.3179	.17328	.592	-.8818	.2459
	S	-.3996	.15739	.237	-.9422	.1430
	TG	-.2963	.19532	.791	-.9095	.3169
	UB	-.6468(*)	.17632	.020	-1.2179	-.0757
LS	Cz	.3179	.17328	.592	-.2459	.8818
	S	-.0816	.10538	.997	-.4058	.2425
	TG	.0216	.15647	1.000	-.4581	.5014
	UB	-.3289	.13198	.179	-.7331	.0754
S	Cz	.3996	.15739	.237	-.1430	.9422
	LS	.0816	.10538	.997	-.2425	.4058
	TG	.1032	.13867	.998	-.3349	.5413
	UB	-.2473	.11030	.310	-.5939	.0994
TG	Cz	.2963	.19532	.791	-.3169	.9095

	LS	-.0216	.15647	1.000	-.5014	.4581
	S	-.1032	.13867	.998	-.5413	.3349
	UB	-.3505	.15983	.320	-.8410	.1400
UB	Cz	.6468(*)	.17632	.020	.0757	1.2179
	LS	.3289	.13198	.179	-.0754	.7331
	S	.2473	.11030	.310	-.0994	.5939
	TG	.3505	.15983	.320	-.1400	.8410

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logMn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.413(a)	17	.142	1.820	.043
Intercept	61.567	1	61.567	789.340	.000
species	.336	5	.067	.861	.512
bedrock	.884	4	.221	2.835	.031
species * bedrock	.477	8	.060	.765	.634
Error	5.226	67	.078		
Total	174.814	85			
Corrected Total	7.638	84			

a R Squared = .316 (Adjusted R Squared = .142)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logNi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.590(a)	17	.211	3.606	.000
Intercept	10.421	1	10.421	177.972	.000
species	.561	5	.112	1.918	.103
bedrock	.787	4	.197	3.361	.015
species * bedrock	1.501	8	.188	3.205	.004
Error	3.806	65	.059		
Total	40.062	83			
Corrected Total	7.396	82			

a R Squared = .485 (Adjusted R Squared = .351)
b Plant Tissue = Bark

Multiple Comparisons(a)

Dependent Variable: logNi
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-	Std. Error	Sig.	95% Confidence Interval

		J)			Lower Bound	Upper Bound
Cz	LS	.0087	.12115	1.000	-.3690	.3864
	S	-.0253	.09616	1.000	-.3413	.2908
	TG	-.0249	.10964	1.000	-.3704	.3206
	UB	-.4024(*)	.10930	.016	-.7486	-.0561
LS	Cz	-.0087	.12115	1.000	-.3864	.3690
	S	-.0340	.09810	1.000	-.3413	.2733
	TG	-.0336	.11135	1.000	-.3748	.3076
	UB	-.4111(*)	.11101	.011	-.7528	-.0694
S	Cz	.0253	.09616	1.000	-.2908	.3413
	LS	.0340	.09810	1.000	-.2733	.3413
	TG	.0004	.08347	1.000	-.2545	.2553
	UB	-.3771(*)	.08301	.001	-.6339	-.1202
TG	Cz	.0249	.10964	1.000	-.3206	.3704
	LS	.0336	.11135	1.000	-.3076	.3748
	S	-.0004	.08347	1.000	-.2553	.2545
	UB	-.3775(*)	.09832	.007	-.6782	-.0768
UB	Cz	.4024(*)	.10930	.016	.0561	.7486
	LS	.4111(*)	.11101	.011	.0694	.7528
	S	.3771(*)	.08301	.001	.1202	.6339
	TG	.3775(*)	.09832	.007	.0768	.6782

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logNi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.949(a)	17	.173	2.854	.001
Intercept	.692	1	.692	11.390	.001
species	.204	5	.041	.672	.646
bedrock	.614	4	.154	2.527	.049
species * bedrock	1.008	8	.126	2.074	.051
Error	4.072	67	.061		
Total	10.977	85			
Corrected Total	7.021	84			

a R Squared = .420 (Adjusted R Squared = .273)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logNi
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-	Std. Error	Sig.	95% Confidence Interval

		J)			Lower Bound	Upper Bound
Cz	LS	-.0523	.11872	1.000	-.4357	.3310
	S	-.1017	.10559	.988	-.4664	.2631
	TG	-.0821	.12099	.999	-.4700	.3059
	UB	-.4524(*)	.13535	.032	-.8779	-.0270
LS	Cz	.0523	.11872	1.000	-.3310	.4357
	S	-.0493	.07406	.999	-.2788	.1801
	TG	-.0297	.09473	1.000	-.3176	.2581
	UB	-.4001(*)	.11250	.017	-.7495	-.0507
S	Cz	.1017	.10559	.988	-.2631	.4664
	LS	.0493	.07406	.999	-.1801	.2788
	TG	.0196	.07765	1.000	-.2221	.2613
	UB	-.3507(*)	.09854	.026	-.6709	-.0306
TG	Cz	.0821	.12099	.999	-.3059	.4700
	LS	.0297	.09473	1.000	-.2581	.3176
	S	-.0196	.07765	1.000	-.2613	.2221
	UB	-.3704(*)	.11489	.037	-.7258	-.0150
UB	Cz	.4524(*)	.13535	.032	.0270	.8779
	LS	.4001(*)	.11250	.017	.0507	.7495
	S	.3507(*)	.09854	.026	.0306	.6709
	TG	.3704(*)	.11489	.037	.0150	.7258

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logNi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.923(a)	17	.231	2.611	.003
Intercept	8.62E-005	1	8.62E-005	.001	.975
species	.942	5	.188	2.132	.072
bedrock	1.127	4	.282	3.187	.019
species * bedrock	1.286	8	.161	1.819	.089
Error	5.922	67	.088		
Total	10.568	85			
Corrected Total	9.845	84			

a R Squared = .398 (Adjusted R Squared = .246)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logPb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.112(a)	16	.257	2.640	.004

Intercept	42.820	1	42.820	439.768	.000
species	.427	4	.107	1.096	.367
bedrock	.631	4	.158	1.619	.182
species * bedrock	.648	8	.081	.831	.579
Error	5.647	58	.097		
Total	92.548	75			
Corrected Total	9.760	74			

a R Squared = .421 (Adjusted R Squared = .262)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logPb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.399(a)	17	.200	3.276	.000
Intercept	34.577	1	34.577	566.413	.000
species	.120	5	.024	.393	.852
bedrock	.793	4	.198	3.246	.017
species * bedrock	.483	8	.060	.988	.453
Error	4.090	67	.061		
Total	90.587	85			
Corrected Total	7.490	84			

a R Squared = .454 (Adjusted R Squared = .315)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logPb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.3754	.12010	.062	-.0127	.7635
	S	.2250	.10894	.466	-.1458	.5959
	TG	.1999	.11547	.668	-.1800	.5797
	UB	.6402(*)	.11588	.001	.2590	1.0214
LS	Cz	-.3754	.12010	.062	-.7635	.0127
	S	-.1504	.07737	.478	-.3872	.0865
	TG	-.1755	.08632	.413	-.4382	.0872
	UB	.2648	.08688	.051	-.0009	.5305
S	Cz	-.2250	.10894	.466	-.5959	.1458
	LS	.1504	.07737	.478	-.0865	.3872
	TG	-.0251	.06997	1.000	-.2369	.1866
	UB	.4152(*)	.07065	.000	.1985	.6319
TG	Cz	-.1999	.11547	.668	-.5797	.1800
	LS	.1755	.08632	.413	-.0872	.4382
	S	.0251	.06997	1.000	-.1866	.2369
	UB	.4403(*)	.08036	.000	.1944	.6862

UB	Cz	-.6402(*)	.11588	.001	-1.0214	-.2590
	LS	-.2648	.08688	.051	-.5305	.0009
	S	-.4152(*)	.07065	.000	-.6319	-.1985
	TG	-.4403(*)	.08036	.000	-.6862	-.1944

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logPb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.645(a)	17	.097	.972	.500
Intercept	36.931	1	36.931	371.029	.000
species	.299	5	.060	.600	.700
bedrock	.408	4	.102	1.024	.403
species * bedrock	.491	8	.061	.616	.761
Error	5.873	59	.100		
Total	91.772	77			
Corrected Total	7.517	76			

a R Squared = .219 (Adjusted R Squared = -.006)
b Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logSr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.568(a)	17	.092	1.468	.134
Intercept	91.884	1	91.884	1462.913	.000
species	.665	5	.133	2.118	.074
bedrock	.632	4	.158	2.516	.049
species * bedrock	.665	8	.083	1.323	.247
Error	4.208	67	.063		
Total	273.258	85			
Corrected Total	5.776	84			

a R Squared = .271 (Adjusted R Squared = .087)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logSr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.598(a)	17	.094	2.493	.004
Intercept	119.726	1	119.726	3175.928	.000

species	.383	5	.077	2.029	.086
bedrock	.752	4	.188	4.985	.001
species * bedrock	.421	8	.053	1.397	.214
Error	2.526	67	.038		
Total	349.580	85			
Corrected Total	4.124	84			

a R Squared = .387 (Adjusted R Squared = .232)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logSr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0972	.07397	.901	-.1399	.3342
	S	-.0944	.07279	.907	-.3269	.1381
	TG	-.0125	.08060	1.000	-.2653	.2402
	UB	.1430	.08397	.666	-.1205	.4065
LS	Cz	-.0972	.07397	.901	-.3342	.1399
	S	-.1916(*)	.05838	.022	-.3653	-.0178
	TG	-.1097	.06787	.714	-.3168	.0973
	UB	.0458	.07184	.999	-.1768	.2685
S	Cz	.0944	.07279	.907	-.1381	.3269
	LS	.1916(*)	.05838	.022	.0178	.3653
	TG	.0819	.06657	.925	-.1191	.2829
	UB	.2374(*)	.07062	.025	.0200	.4549
TG	Cz	.0125	.08060	1.000	-.2402	.2653
	LS	.1097	.06787	.714	-.0973	.3168
	S	-.0819	.06657	.925	-.2829	.1191
	UB	.1556	.07864	.455	-.0855	.3966
UB	Cz	-.1430	.08397	.666	-.4065	.1205
	LS	-.0458	.07184	.999	-.2685	.1768
	S	-.2374(*)	.07062	.025	-.4549	-.0200

	TG	-.1556	.07864	.455	-.3966	.0855

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logSr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.377(a)	17	.199	3.368	.000
Intercept	73.409	1	73.409	1244.655	.000
species	.287	5	.057	.973	.441
bedrock	1.342	4	.335	5.687	.001
species * bedrock	1.005	8	.126	2.130	.045
Error	3.952	67	.059		
Total	229.688	85			
Corrected Total	7.329	84			

a R Squared = .461 (Adjusted R Squared = .324)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logSr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.1011	.08114	.925	-.1562	.3584
	S	-.1833	.08009	.286	-.4351	.0685
	TG	-.0021	.10159	1.000	-.3165	.3122
	UB	.2523	.09712	.156	-.0512	.5559
LS	Cz	-.1011	.08114	.925	-.3584	.1562
	S	-.2845(*)	.06889	.002	-.4893	-.0796
	TG	-.1033	.09301	.962	-.3903	.1838
	UB	.1512	.08811	.653	-.1231	.4256
S	Cz	.1833	.08009	.286	-.0685	.4351
	LS	.2845(*)	.06889	.002	.0796	.4893
	TG	.1812	.09210	.464	-.1017	.4641
	UB	.4357(*)	.08714	.000	.1659	.7054
TG	Cz	.0021	.10159	1.000	-.3122	.3165
	LS	.1033	.09301	.962	-.1838	.3903
	S	-.1812	.09210	.464	-.4641	.1017
	UB	.2545	.10724	.226	-.0734	.5824
UB	Cz	-.2523	.09712	.156	-.5559	.0512
	LS	-.1512	.08811	.653	-.4256	.1231

	S	-.4357(*)	.08714	.000	-.7054	-.1659
	TG	-.2545	.10724	.226	-.5824	.0734

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logTl

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.392(a)	17	.082	1.017	.454
Intercept	5.080	1	5.080	63.104	.000
species	.687	5	.137	1.706	.147
bedrock	.394	4	.098	1.223	.311
species * bedrock	.540	8	.068	.839	.573
Error	4.749	59	.080		
Total	17.333	77			
Corrected Total	6.142	76			

a R Squared = .227 (Adjusted R Squared = .004)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logTl

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.279(a)	17	.075	1.274	.236
Intercept	14.082	1	14.082	238.446	.000
species	.316	5	.063	1.070	.385
bedrock	.210	4	.052	.887	.477
species * bedrock	.371	8	.046	.786	.616
Error	3.957	67	.059		
Total	43.430	85			
Corrected Total	5.236	84			

a R Squared = .244 (Adjusted R Squared = .053)
b Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

Dependent Variable: logTl

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.636(a)	17	.626	4.178	.000
Intercept	27.248	1	27.248	181.960	.000
species	1.433	5	.287	1.913	.104
bedrock	2.989	4	.747	4.990	.001
species * bedrock	.987	8	.123	.824	.584
Error	10.033	67	.150		
Total	121.905	85			

Corrected Total	20.669	84			

a R Squared = .515 (Adjusted R Squared = .391)
b Plant Tissue = Leaf

Multiple Comparisons(a)

Dependent Variable: logTl
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.4483	.17393	.159	-.0928	.9894
	S	.0146	.12985	1.000	-.4373	.4665
	TG	.4985	.17189	.081	-.0369	1.0339
	UB	.8684(*)	.18275	.001	.2971	1.4398
LS	Cz	-.4483	.17393	.159	-.9894	.0928
	S	-.4338(*)	.12936	.037	-.8486	-.0189
	TG	.0502	.17152	1.000	-.4709	.5712
	UB	.4201	.18240	.261	-.1391	.9793
S	Cz	-.0146	.12985	1.000	-.4665	.4373
	LS	.4338(*)	.12936	.037	.0189	.8486
	TG	.4839(*)	.12660	.013	.0785	.8894
	UB	.8539(*)	.14099	.000	.3881	1.3196
TG	Cz	-.4985	.17189	.081	-1.0339	.0369
	LS	-.0502	.17152	1.000	-.5712	.4709
	S	-.4839(*)	.12660	.013	-.8894	-.0785
	UB	.3699	.18045	.407	-.1837	.9236
UB	Cz	-.8684(*)	.18275	.001	-1.4398	-.2971
	LS	-.4201	.18240	.261	-.9793	.1391
	S	-.8539(*)	.14099	.000	-1.3196	-.3881
	TG	-.3699	.18045	.407	-.9236	.1837

Based on observed means.
* The mean difference is significant at the .05 level.

a Plant Tissue = Leaf

Tests of Between-Subjects Effects(b)

Dependent Variable: logV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.302(a)	17	.135	1.505	.120
Intercept	40.386	1	40.386	448.748	.000
species	.614	5	.123	1.365	.249
bedrock	.303	4	.076	.842	.503
species * bedrock	.964	8	.121	1.339	.240
Error	6.030	67	.090		
Total	106.392	85			
Corrected Total	8.332	84			

a R Squared = .276 (Adjusted R Squared = .093)
b Plant Tissue = Bark

Tests of Between-Subjects Effects(b)

Dependent Variable: logV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.772(a)	17	.104	2.124	.015
Intercept	41.061	1	41.061	836.608	.000
species	.366	5	.073	1.491	.204
bedrock	.574	4	.143	2.923	.027
species * bedrock	.662	8	.083	1.686	.118
Error	3.288	67	.049		
Total	103.011	85			
Corrected Total	5.060	84			

a R Squared = .350 (Adjusted R Squared = .185)
b Plant Tissue = Twig

Multiple Comparisons(a)

Dependent Variable: logV
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.1812	.10534	.653	-.1489	.5112
	S	-.0944	.08387	.964	-.3837	.1949
	TG	-.0639	.10074	1.000	-.3824	.2546
	UB	-.0076	.11280	1.000	-.3608	.3455

LS	Cz	-.1812	.10534	.653	-.5112	.1489
	S	-.2756(*)	.07553	.017	-.5148	-.0364
	TG	-.2451	.09392	.136	-.5306	.0405
	UB	-.1888	.10675	.607	-.5167	.1391
S	Cz	.0944	.08387	.964	-.1949	.3837
	LS	.2756(*)	.07553	.017	.0364	.5148
	TG	.0305	.06899	1.000	-.1862	.2473
	UB	.0868	.08564	.981	-.1933	.3669
TG	Cz	.0639	.10074	1.000	-.2546	.3824
	LS	.2451	.09392	.136	-.0405	.5306
	S	-.0305	.06899	1.000	-.2473	.1862
	UB	.0563	.10223	1.000	-.2593	.3718
UB	Cz	.0076	.11280	1.000	-.3455	.3608
	LS	.1888	.10675	.607	-.1391	.5167
	S	-.0868	.08564	.981	-.3669	.1933
	TG	-.0563	.10223	1.000	-.3718	.2593

Based on observed means.
* The mean difference is significant at the .05 level.
a Plant Tissue = Twig

Tests of Between-Subjects Effects(b)

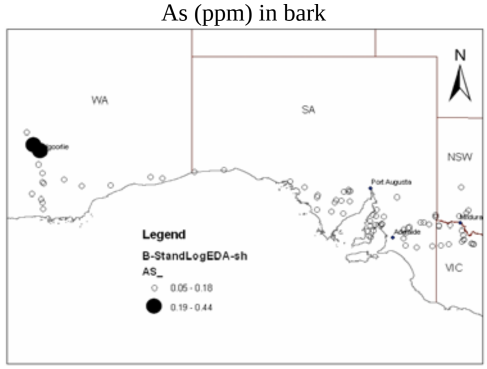
Dependent Variable: logV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.270(a)	17	.192	2.711	.002
Intercept	42.980	1	42.980	605.680	.000
species	1.229	5	.246	3.464	.008
bedrock	.475	4	.119	1.675	.166
species * bedrock	.508	8	.064	.895	.525
Error	4.754	67	.071		
Total	104.787	85			
Corrected Total	8.024	84			

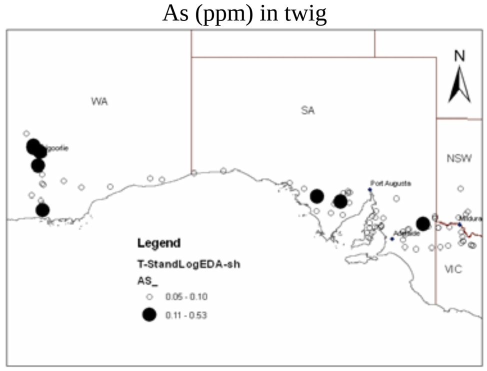
a R Squared = .408 (Adjusted R Squared = .257)
b Plant Tissue = Leaf

APPENDIX D: BIOGEOCHEMICAL RECONNASSIANCE MAPS

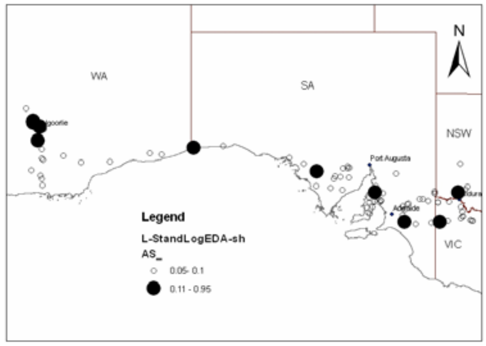
As (ppm) in bark



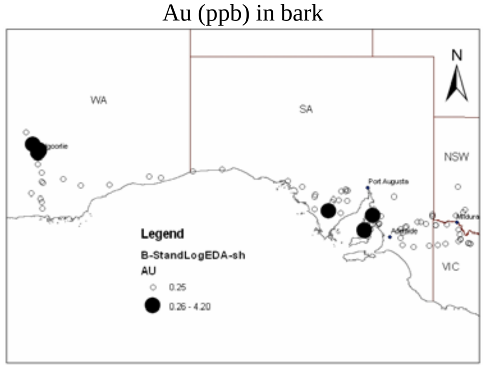
As (ppm) in twig



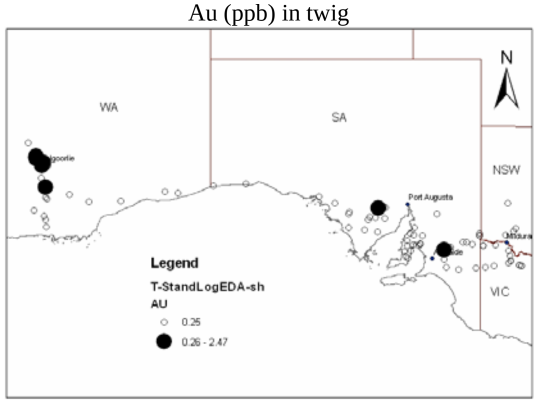
As (ppm) in leaf



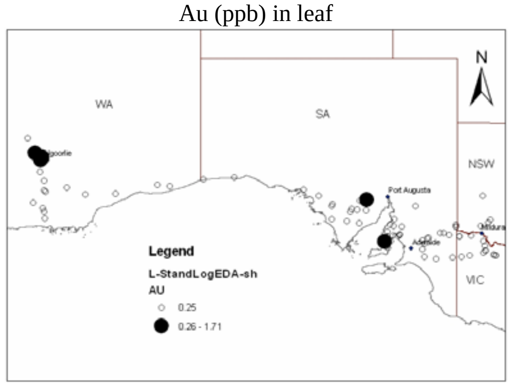
Au (ppb) in bark



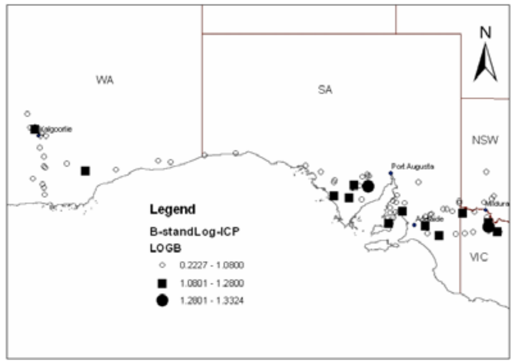
Au (ppb) in twig



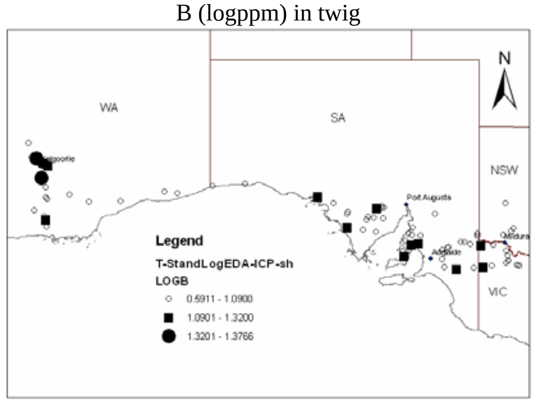
Au (ppb) in leaf



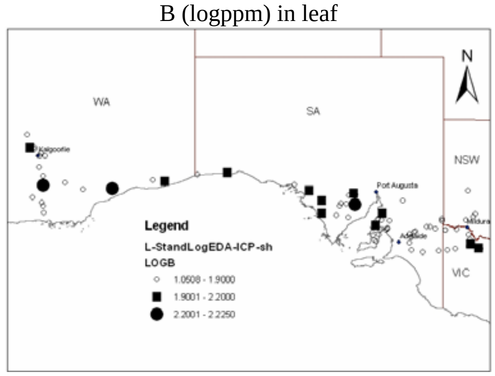
B (logppm) in bark



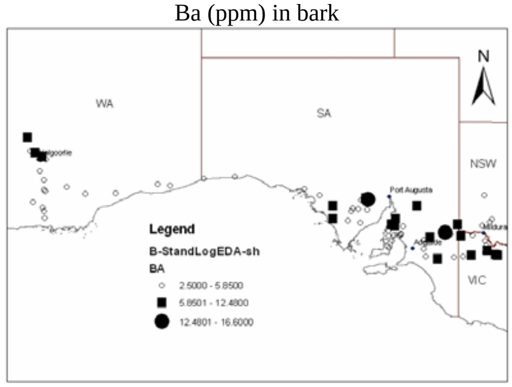
B (logppm) in twig



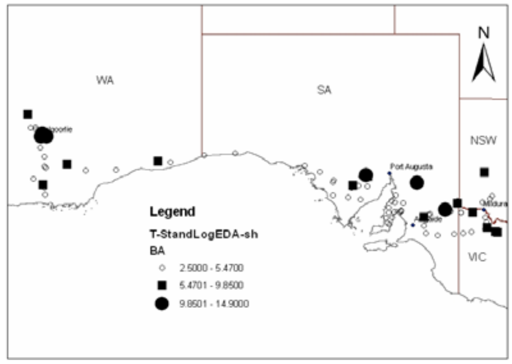
B (logppm) in leaf



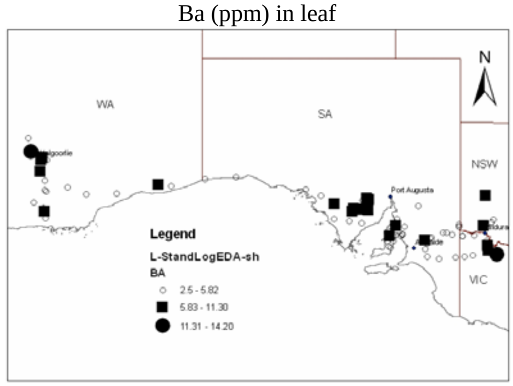
Ba (ppm) in bark



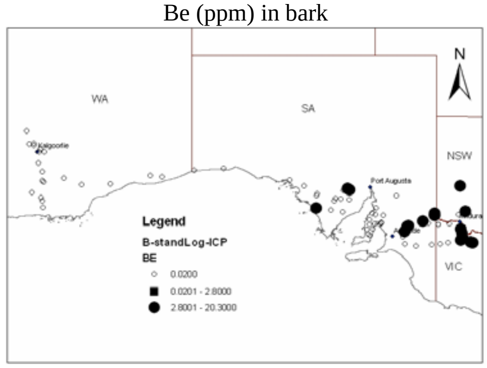
Ba (ppm) in twig



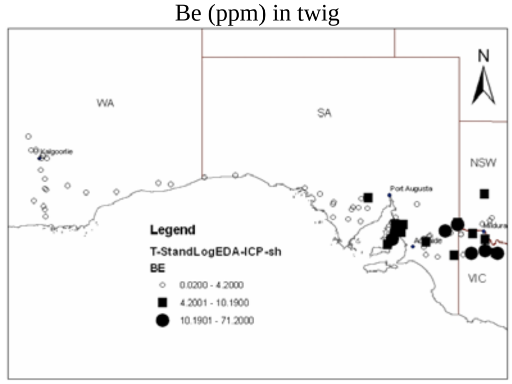
Ba (ppm) in leaf



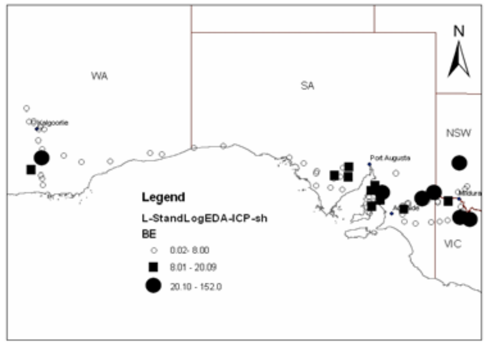
Be (ppm) in bark



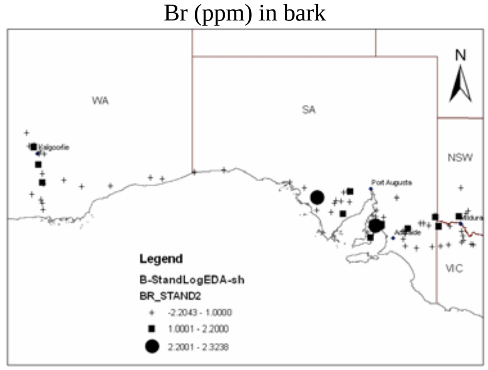
Be (ppm) in twig



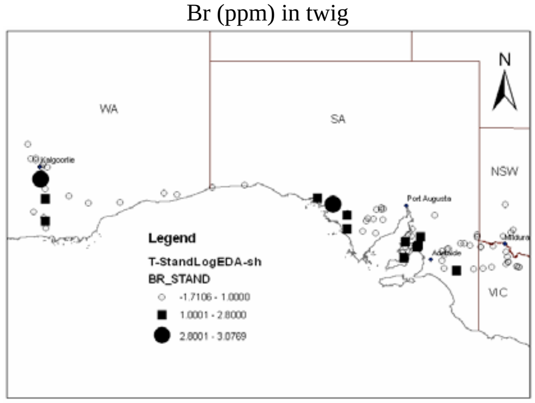
Be (ppm) in leaf



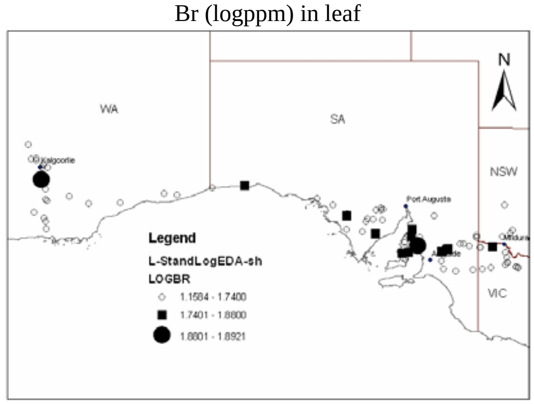
Br (ppm) in bark



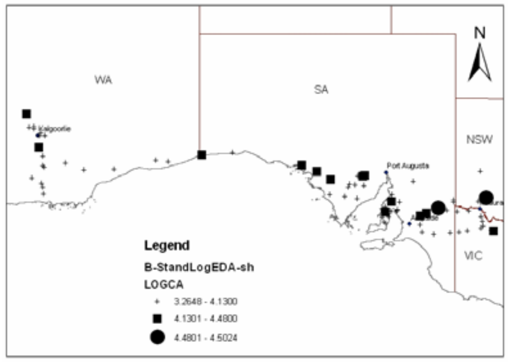
Br (ppm) in twig



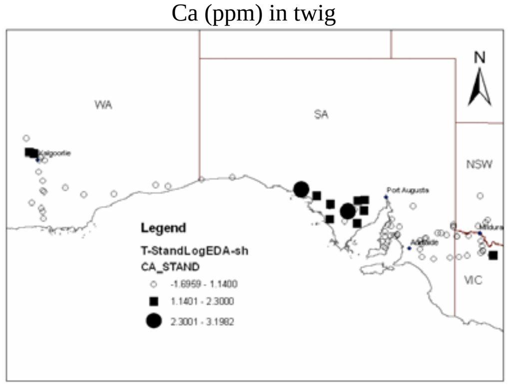
Br (logppm) in leaf



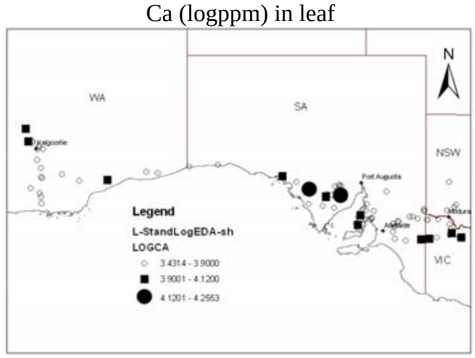
Ca (logppm) in bark



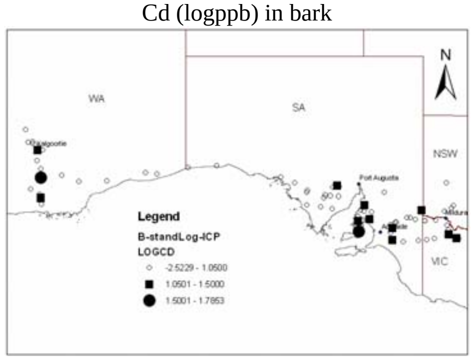
Ca (ppm) in twig



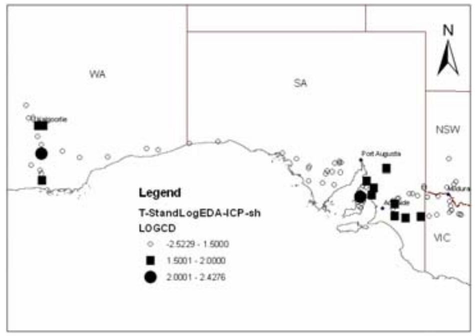
Ca (logppm) in leaf



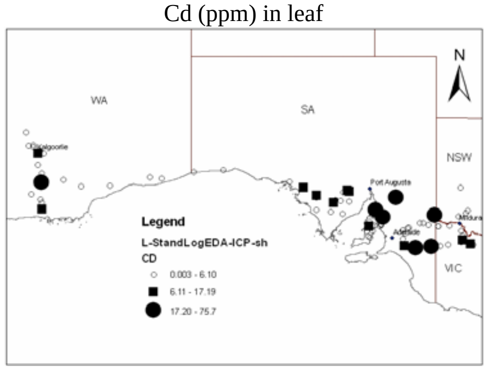
Cd (logppb) in bark



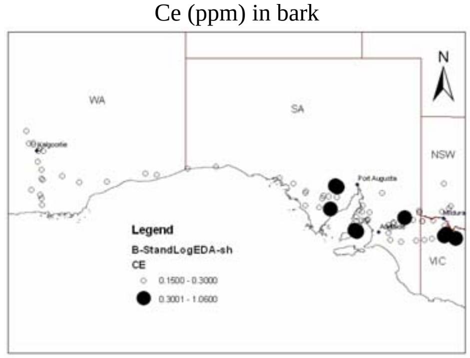
Cd (logppb) in twig



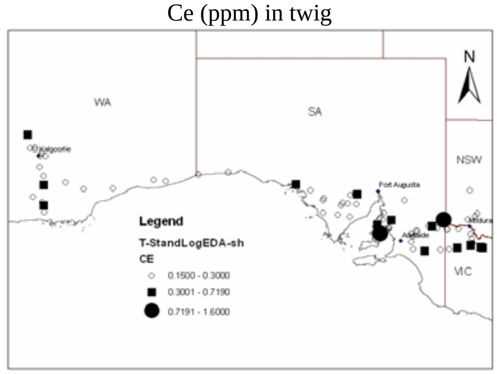
Cd (ppm) in leaf



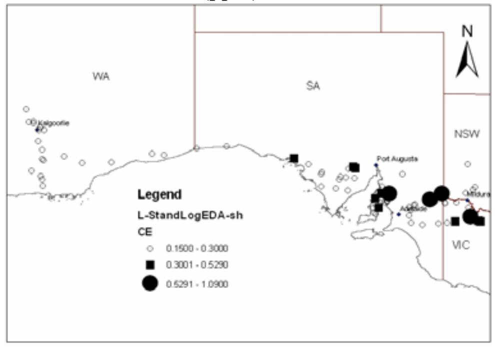
Ce (ppm) in bark



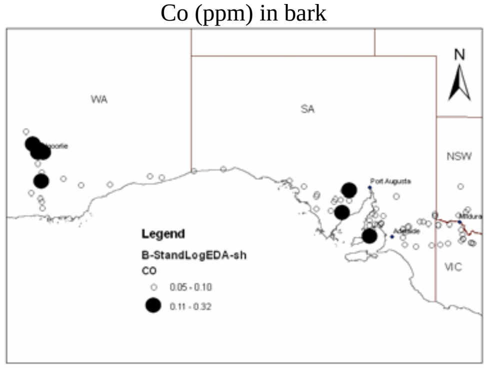
Ce (ppm) in twig



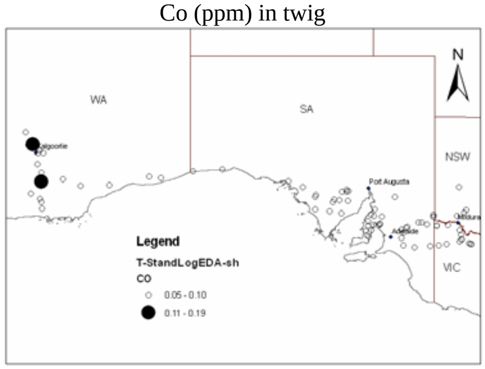
Ce (ppm) in leaf



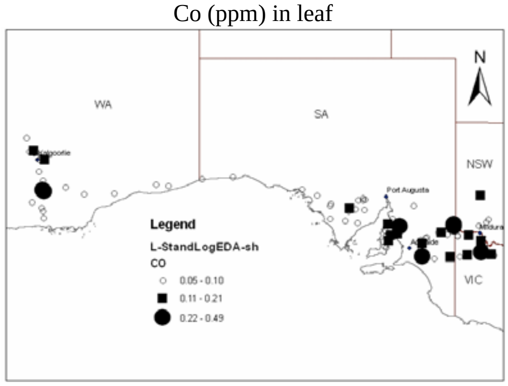
Co (ppm) in bark



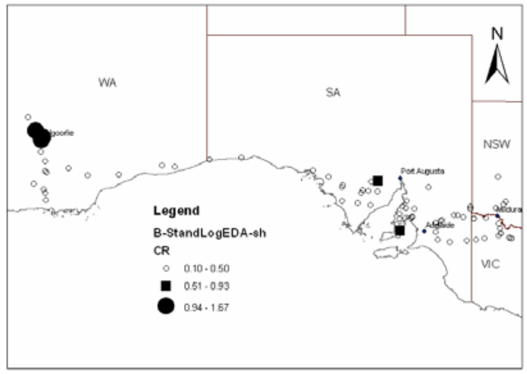
Co (ppm) in twig



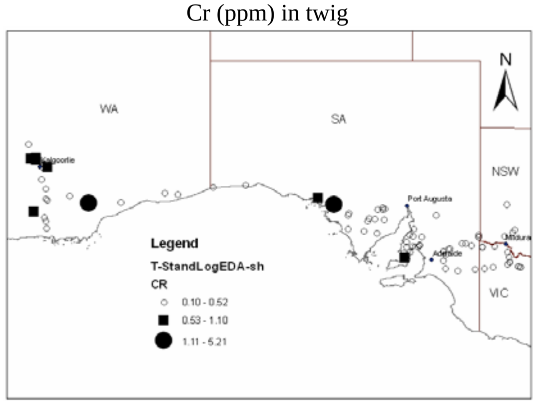
Co (ppm) in leaf



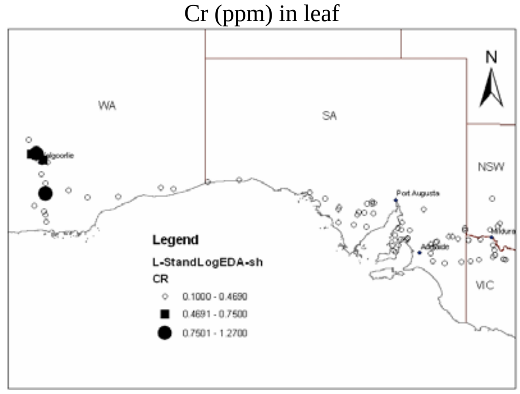
Cr (ppm) in bark



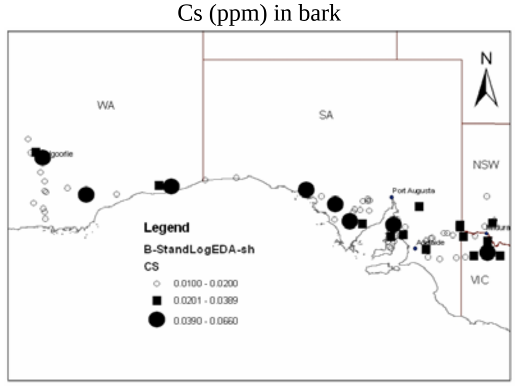
Cr (ppm) in twig



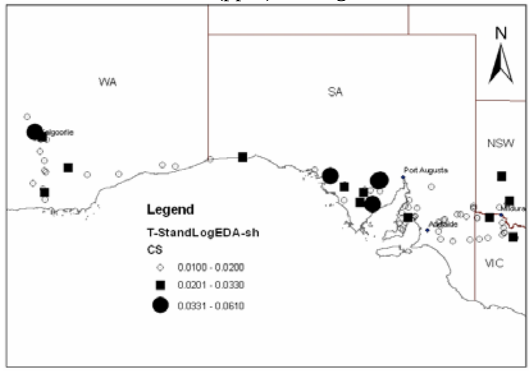
Cr (ppm) in leaf



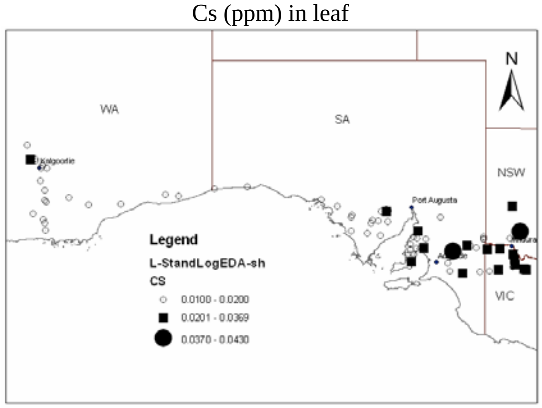
Cs (ppm) in bark



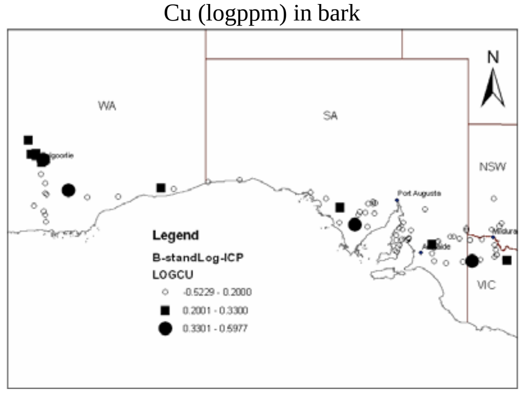
Cs (ppm) in twig



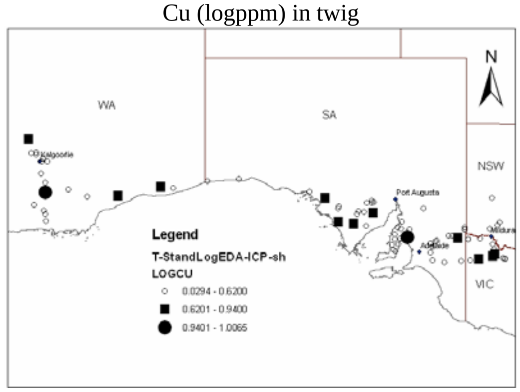
Cs (ppm) in leaf



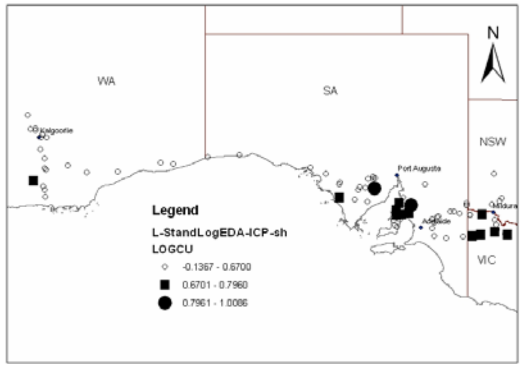
Cu (logppm) in bark



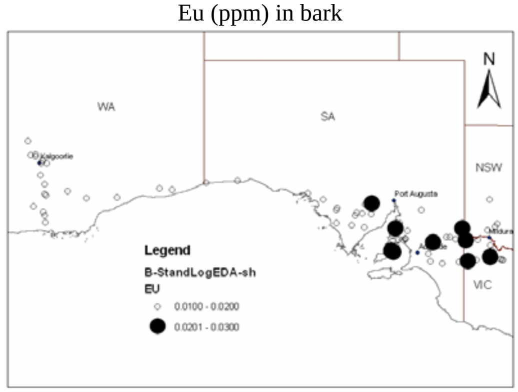
Cu (logppm) in twig



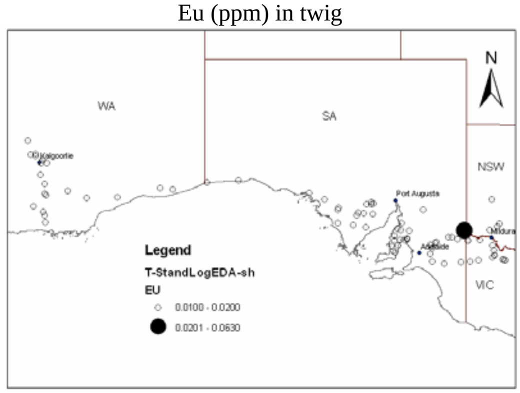
Cu (logppm) in leaf



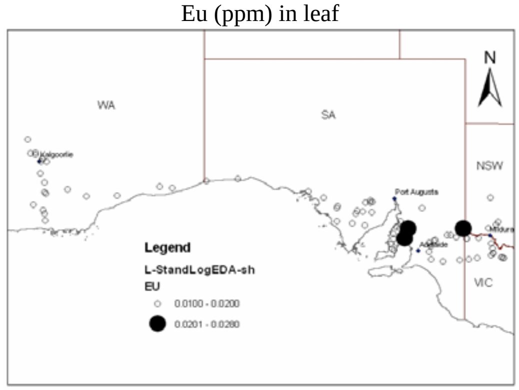
Eu (ppm) in bark



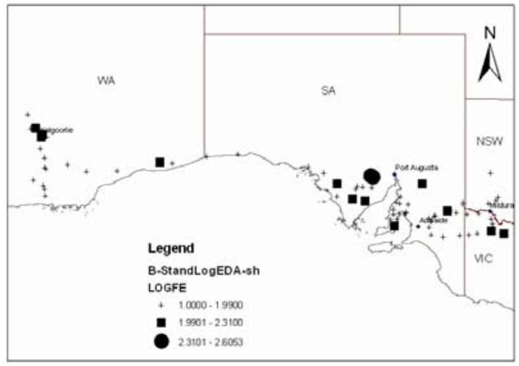
Eu (ppm) in twig



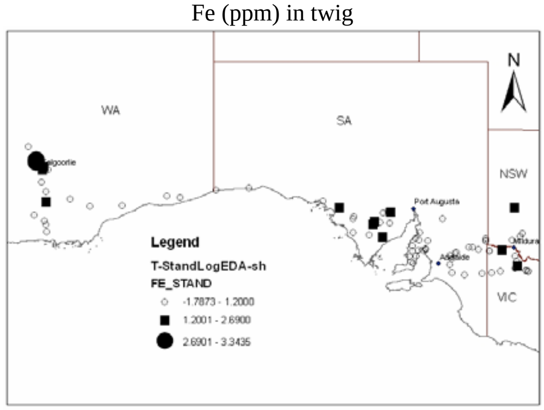
Eu (ppm) in leaf



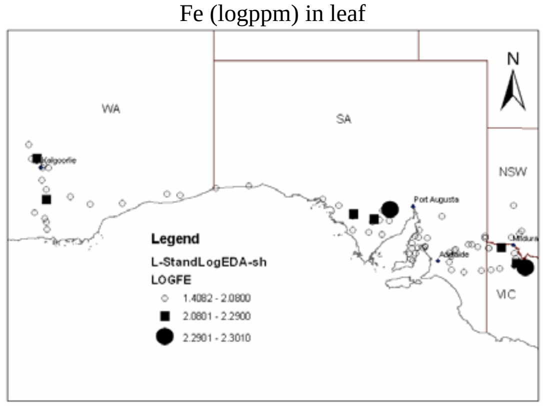
Fe (logppm) in bark



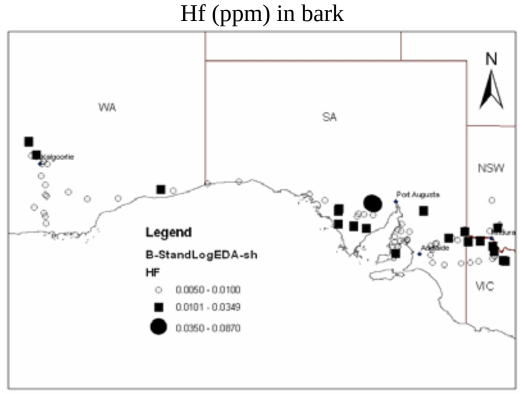
Fe (ppm) in twig



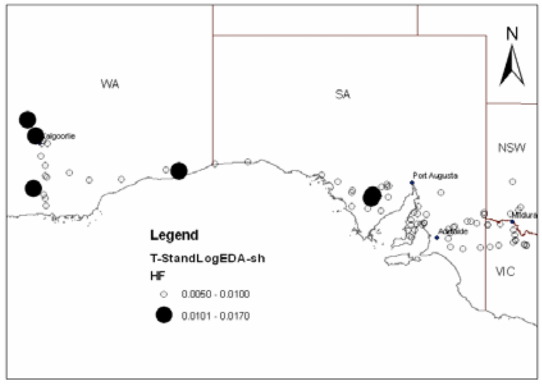
Fe (logppm) in leaf



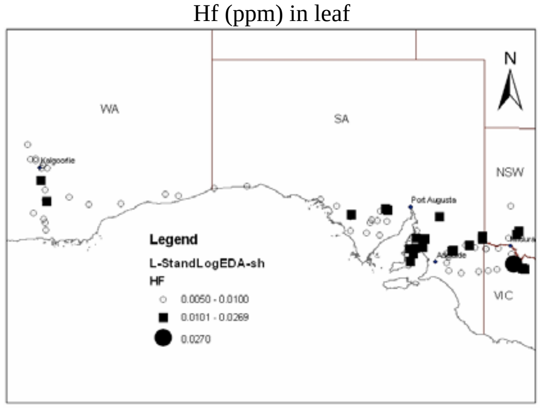
Hf (ppm) in bark



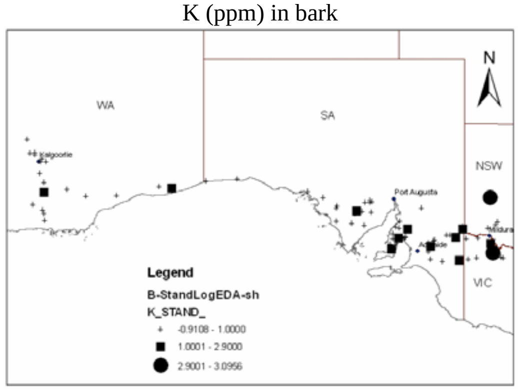
Hf (ppm) in twig



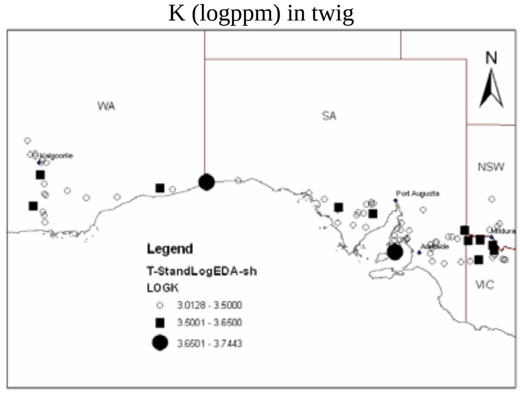
Hf (ppm) in leaf



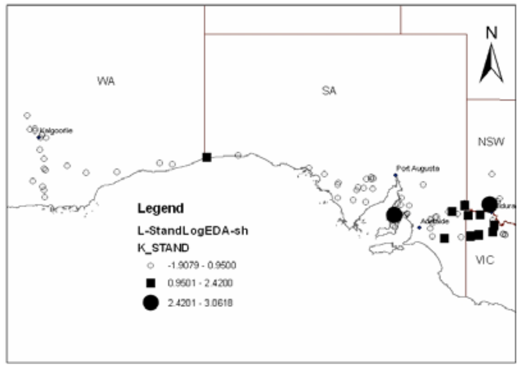
K (ppm) in bark



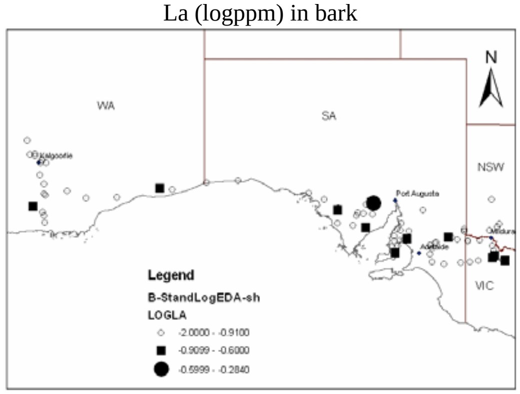
K (logppm) in twig



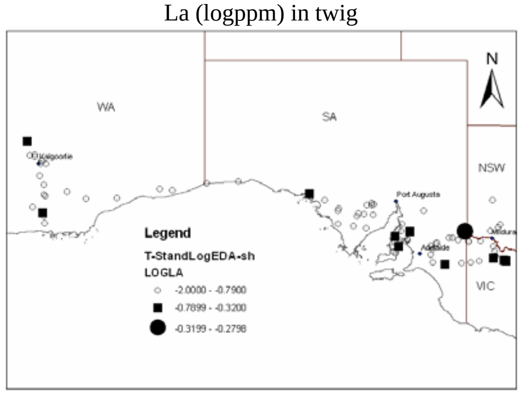
K in leaf



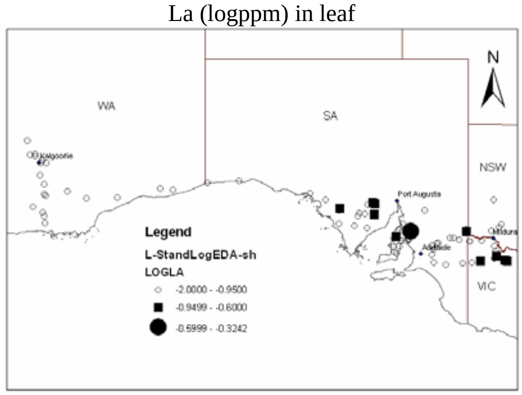
La (logppm) in bark



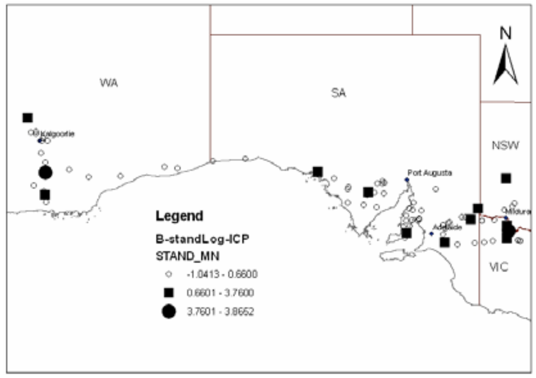
La (logppm) in twig



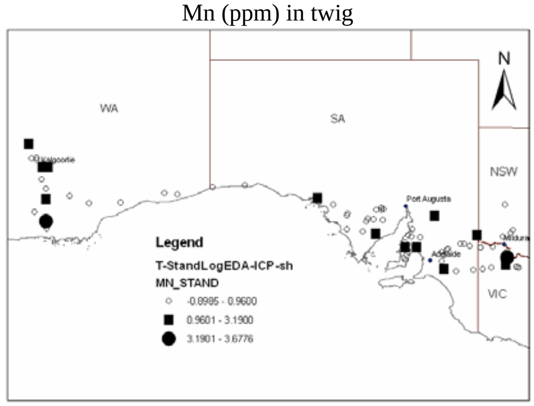
La (logppm) in leaf



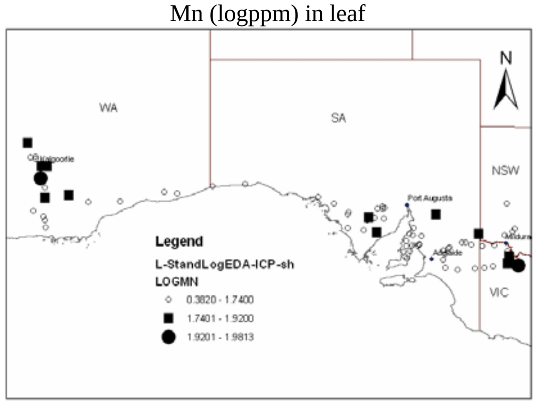
Mn (ppm) in bark



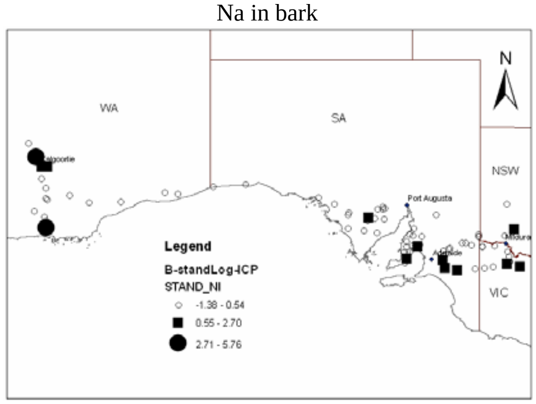
Mn (ppm) in twig



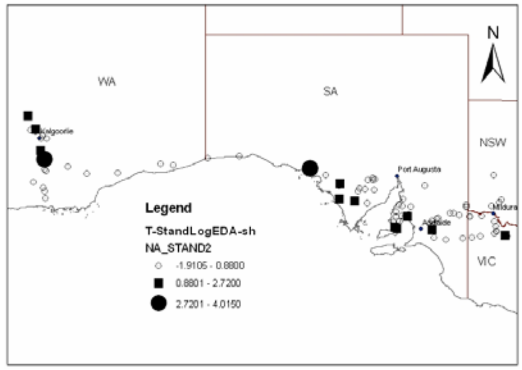
Mn (logppm) in leaf



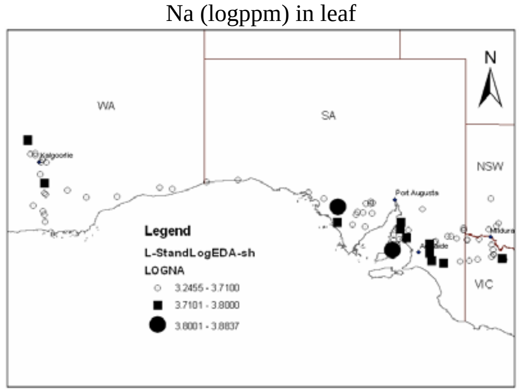
Na in bark



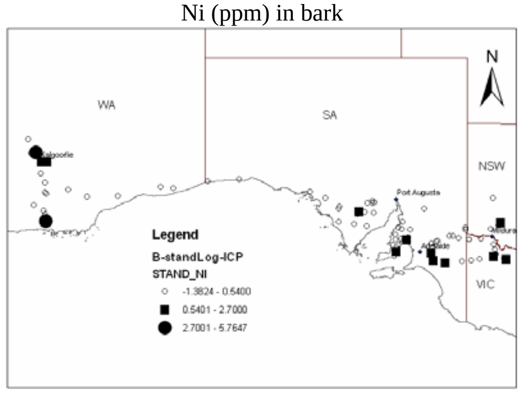
Na in twig



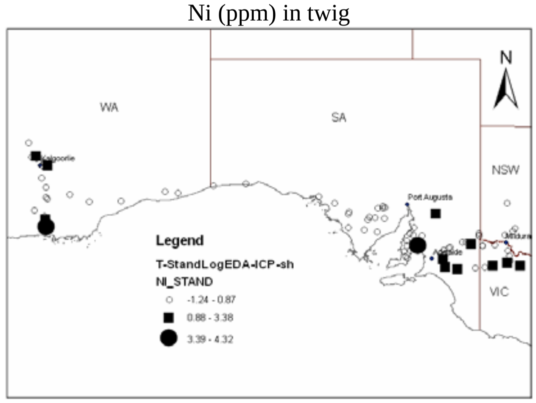
Na (logppm) in leaf



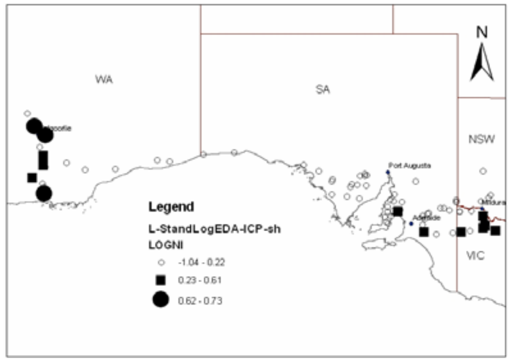
Ni (ppm) in bark



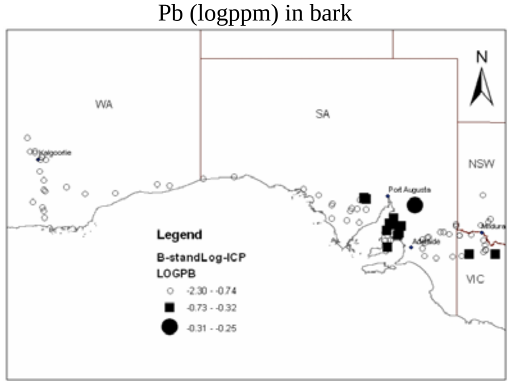
Ni (ppm) in twig



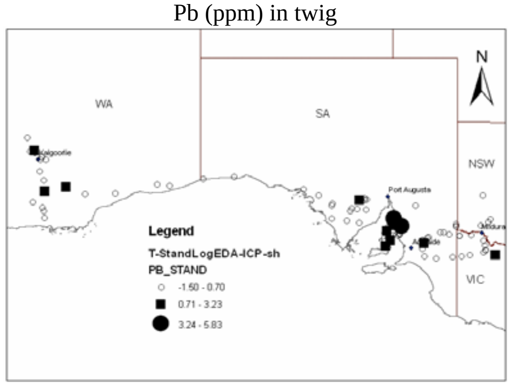
Ni (logppm) in leaf



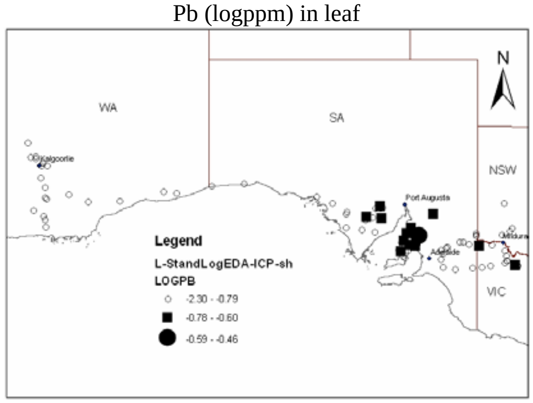
Pb (logppm) in bark



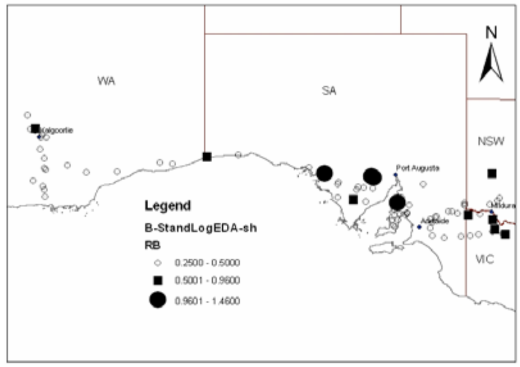
Pb (ppm) in twig



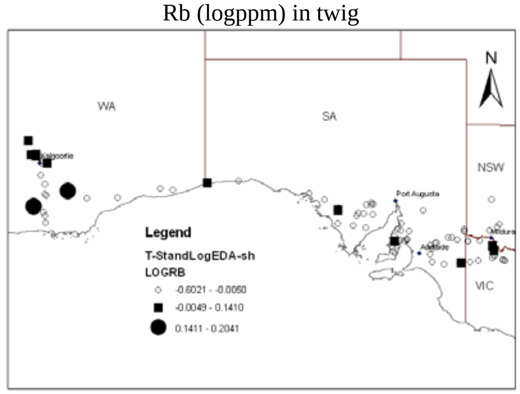
Pb (logppm) in leaf



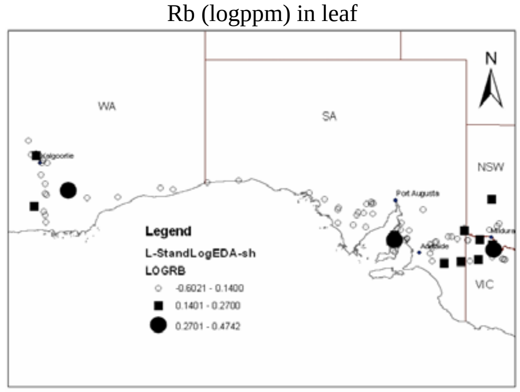
Rb (ppm) in bark



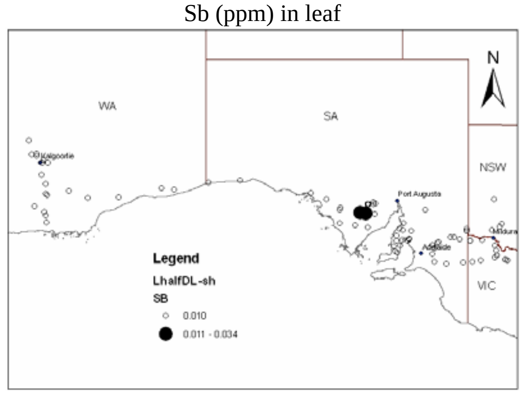
Rb (logppm) in twig



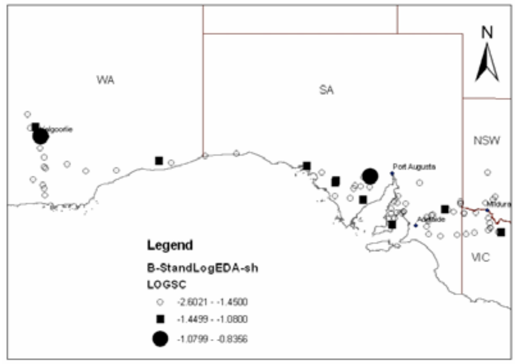
Rb (logppm) in leaf



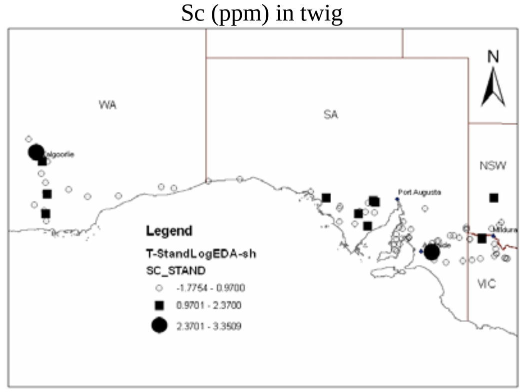
Sb (ppm) in leaf



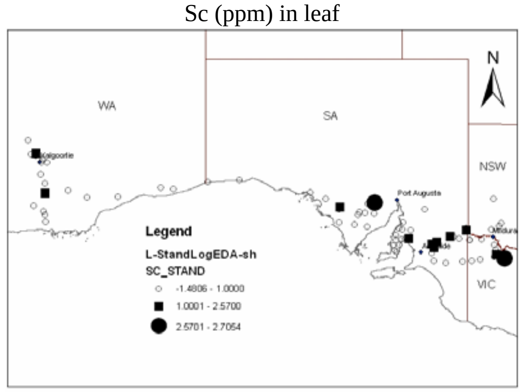
Sc (logppm) in bark



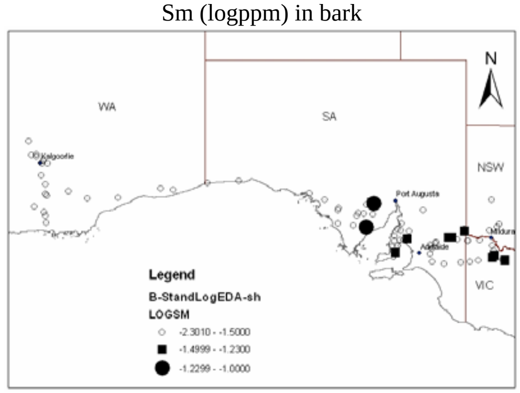
Sc (ppm) in twig



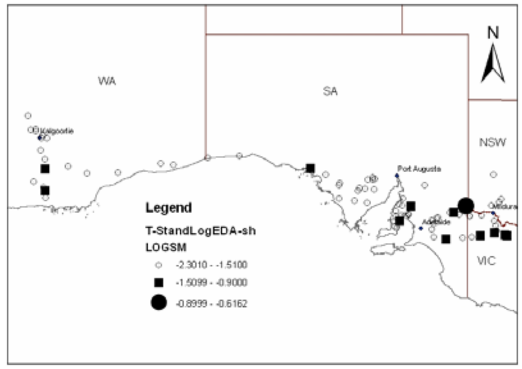
Sc (ppm) in leaf



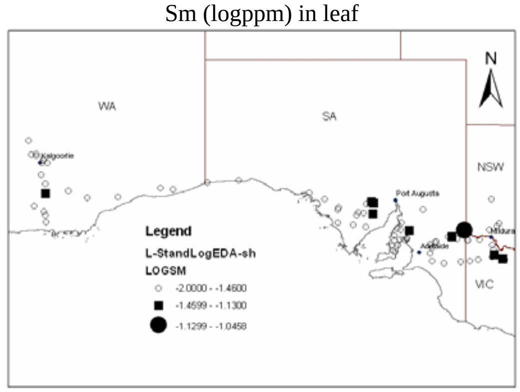
Sm (logppm) in bark



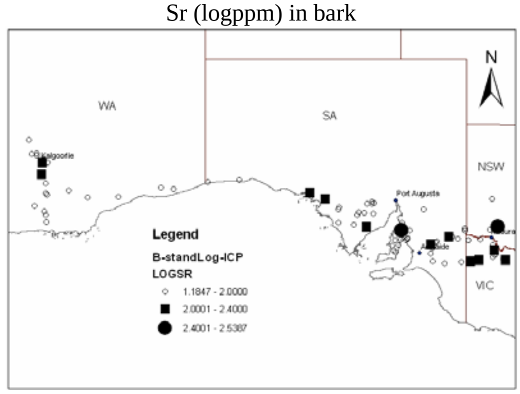
Sm (ppm) in twig



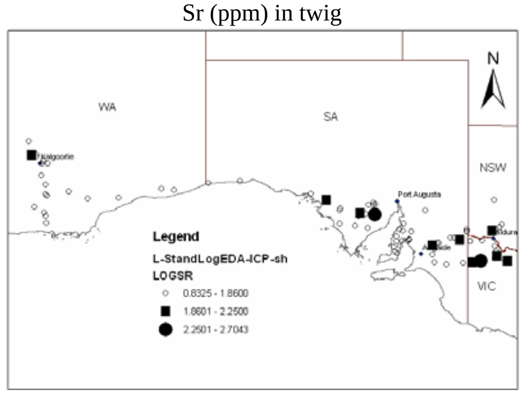
Sm (logppm) in leaf



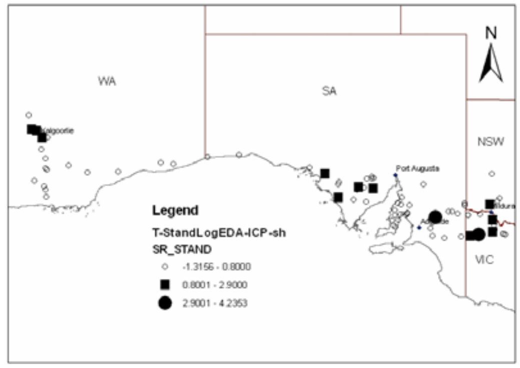
Sr (logppm) in bark



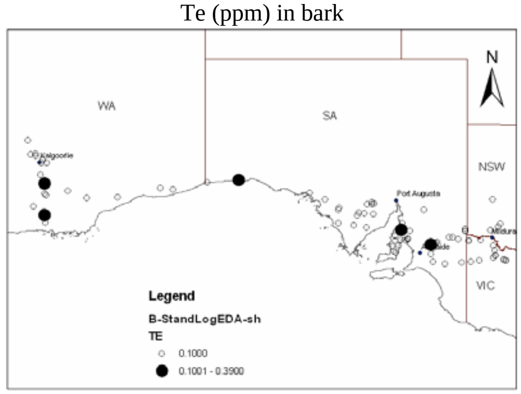
Sr (ppm) in twig



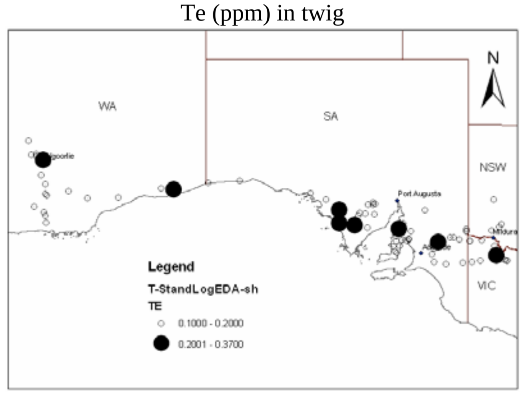
Sr (ppm) in leaf



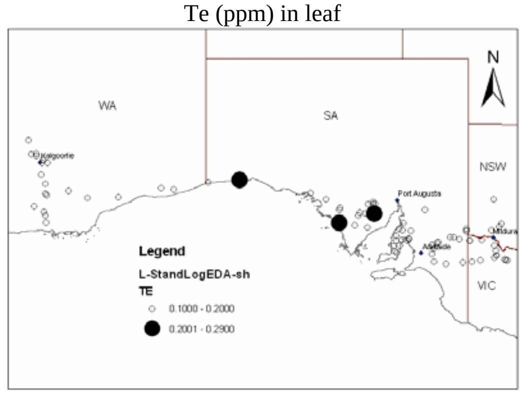
Te (ppm) in bark



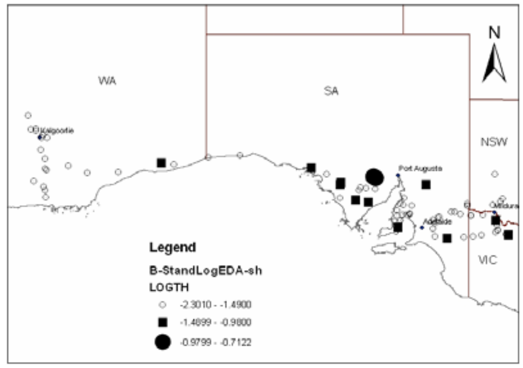
Te (ppm) in twig



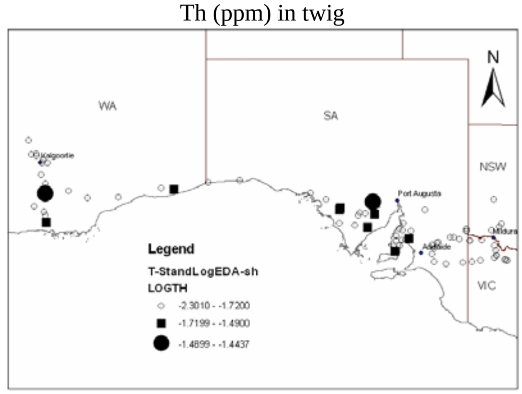
Te (ppm) in leaf



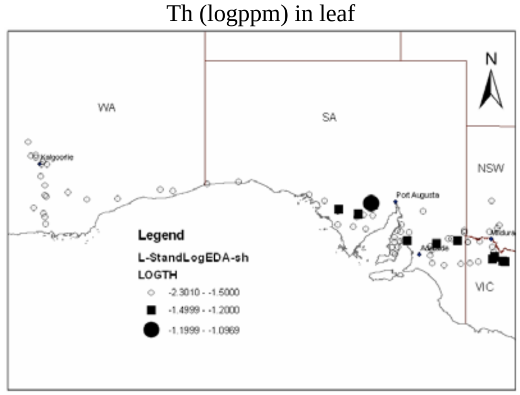
Th (logppm) in bark



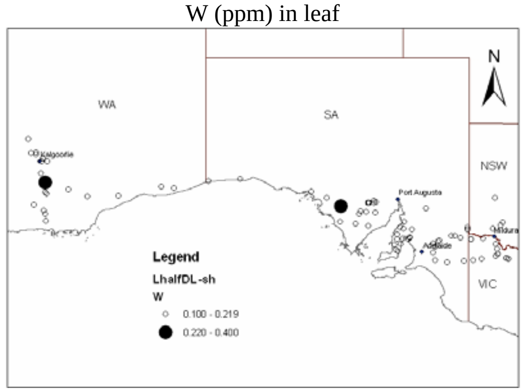
Th (ppm) in twig



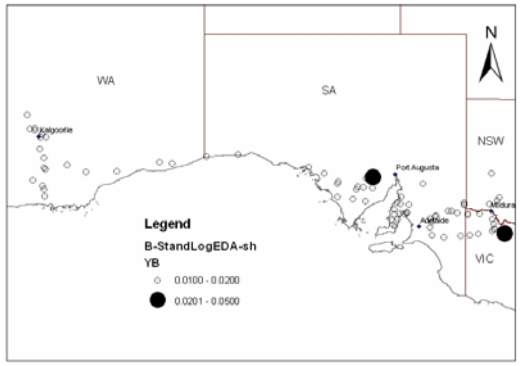
Th (logppm) in leaf



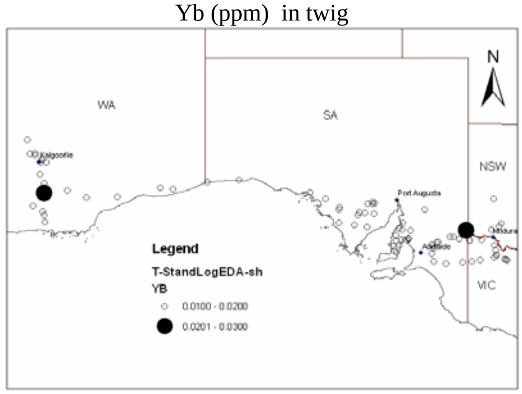
W (ppm) in leaf



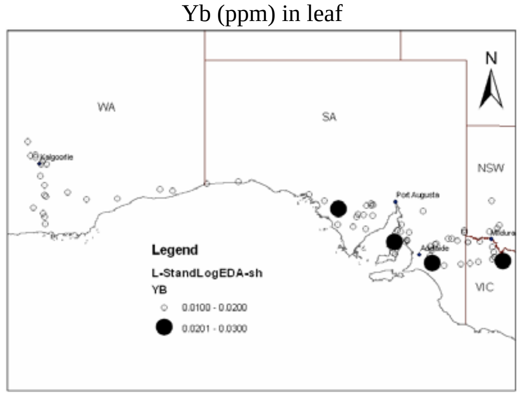
Yb (ppm) in bark



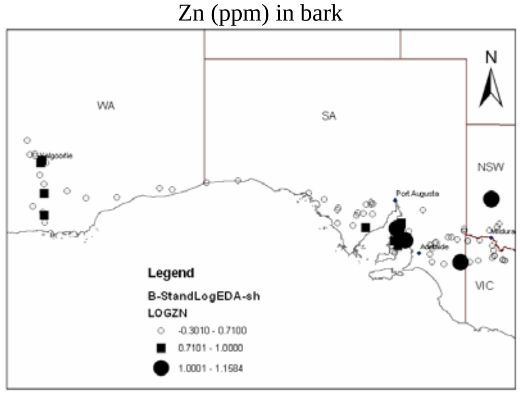
Yb (ppm) in twig



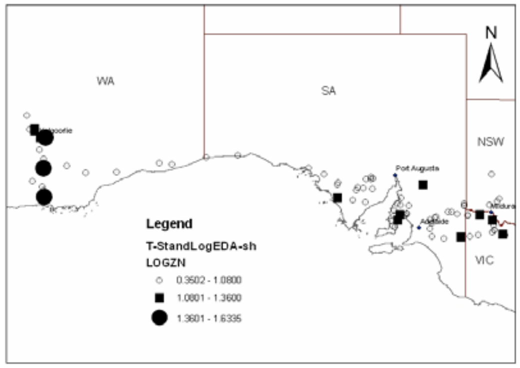
Yb (ppm) in leaf



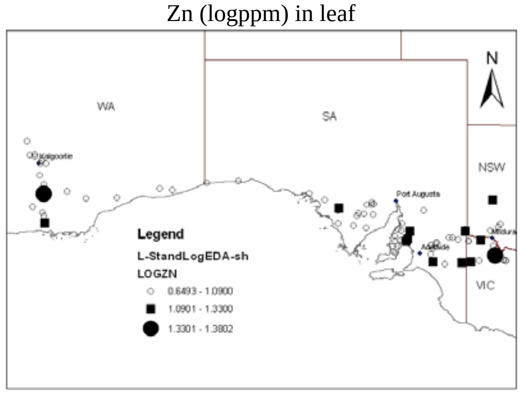
Zn (ppm) in bark



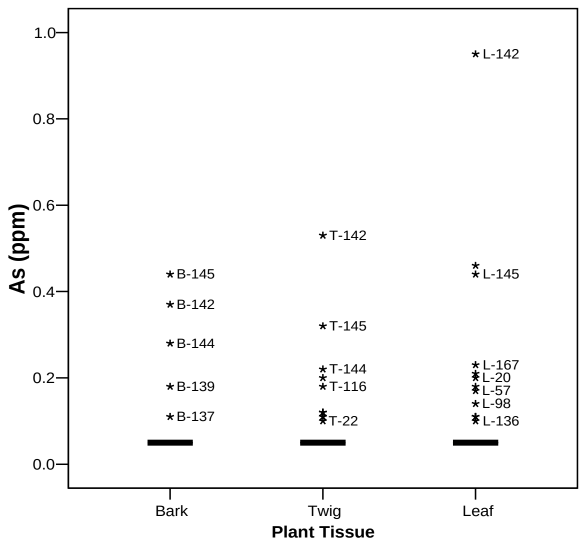
Zn (logppm) in twig

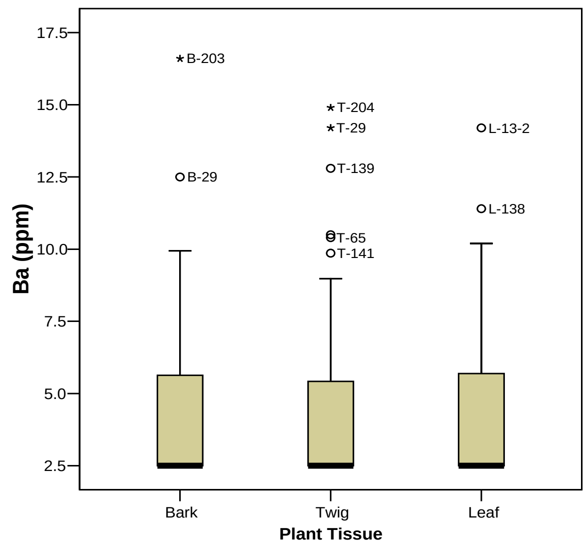


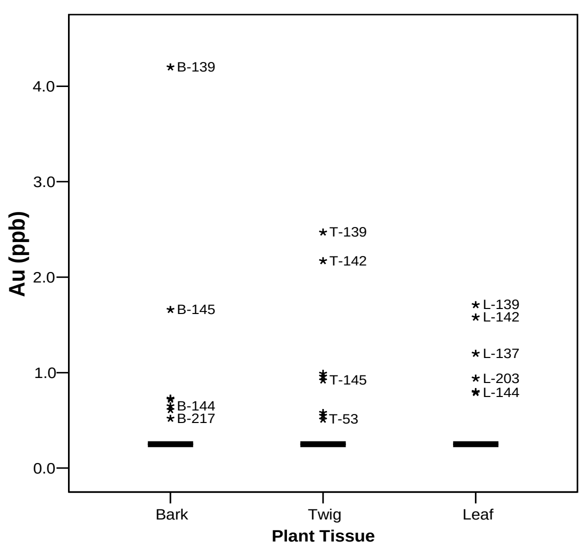
Zn (logppm) in leaf

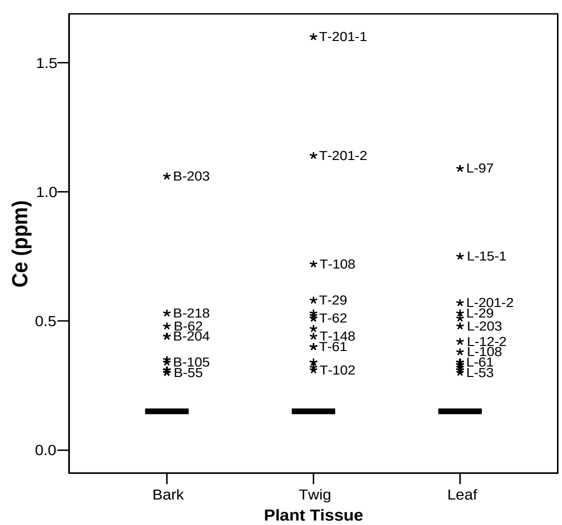


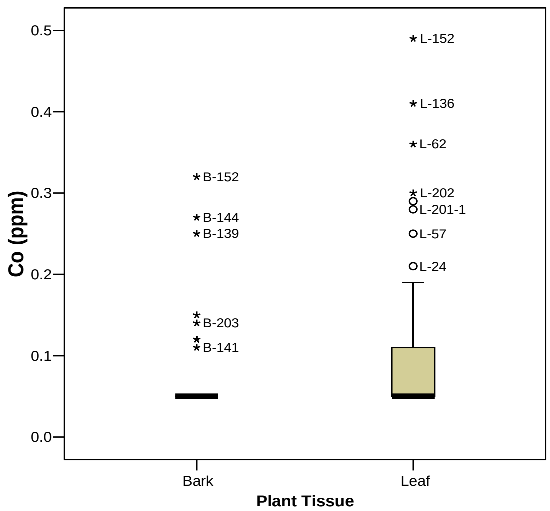
APPENDIX F: EXPLORATORY DATA ANALYSIS RESULTS (EDA) AND CUMULATIVE FREQUENCY CURVES-VEGETATION



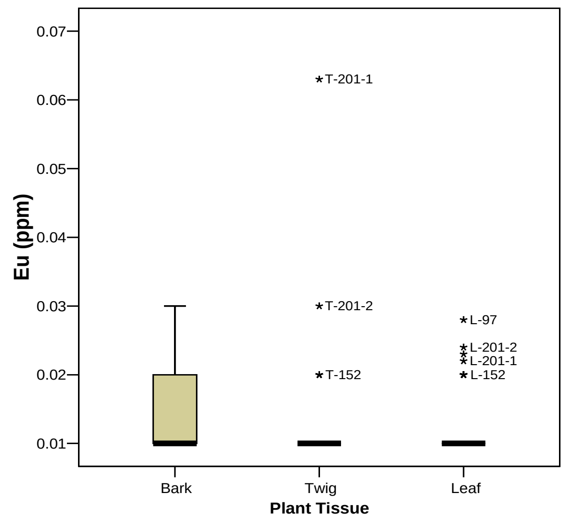




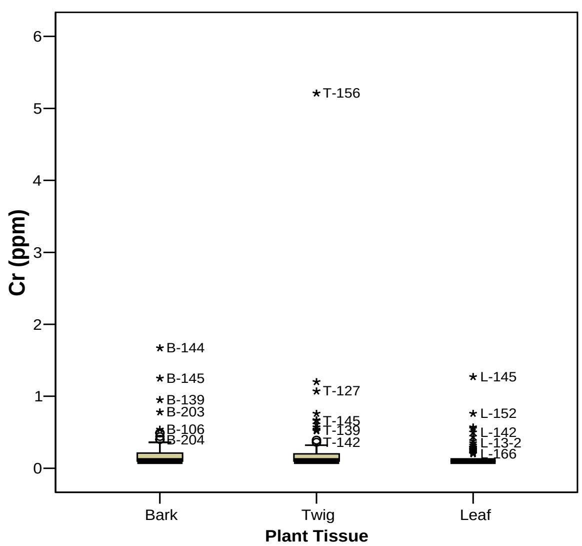




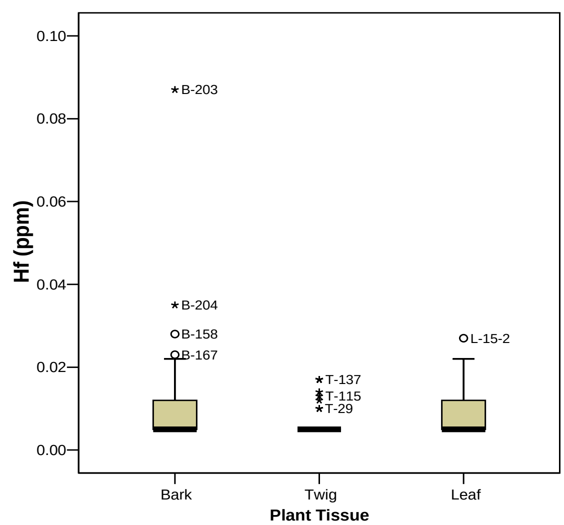
Co (ppm)
0.0
0.1
0.2
0.3
0.4
0.5
B-152
B-144
B-139
B-203
B-141
L-152
L-136
L-62
L-202
L-201-1
L-57
L-24
Bark
Leaf
Plant Tissue



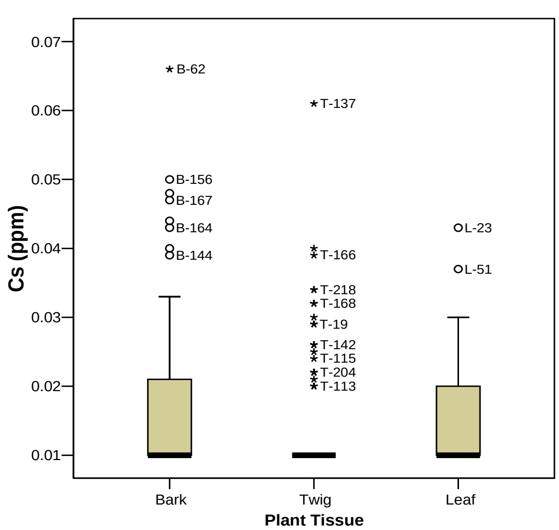
Eu (ppm)
0.01
0.02
0.03
0.04
0.05
0.06
0.07
T-201-1
T-201-2
T-152
L-97
L-201-2
L-201-1
L-152
Bark
Twig
Leaf
Plant Tissue



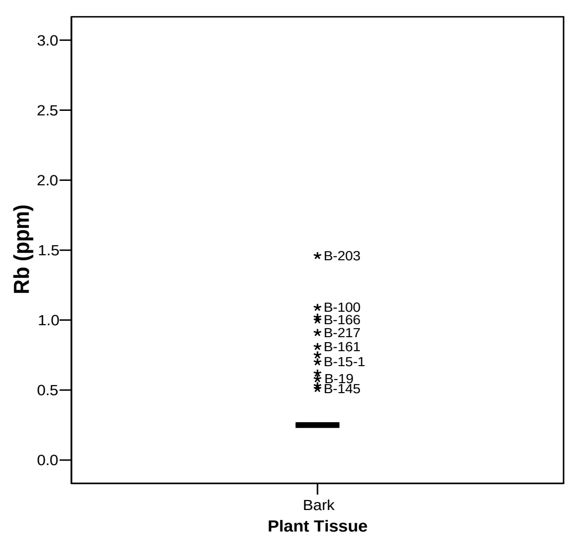
Cr (ppm)
0
1
2
3
4
5
6
T-156
B-144
B-145
B-139
B-203
B-106
B-204
T-127
T-145
T-139
T-142
L-145
L-152
L-142
L-13-2
L-166
Bark
Twig
Leaf
Plant Tissue



Hf (ppm)
0.00
0.02
0.04
0.06
0.08
0.10
B-203
B-204
B-158
B-167
T-137
T-115
T-29
L-15-2
Bark
Twig
Leaf
Plant Tissue



Cs (ppm)
0.01
0.02
0.03
0.04
0.05
0.06
0.07
B-62
B-156
B-167
B-164
B-144
T-137
T-166
T-218
T-168
T-19
T-142
T-115
T-204
T-113
L-23
L-51
Bark
Twig
Leaf
Plant Tissue



Rb (ppm)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
B-203
B-100
B-166
B-217
B-161
B-15-1
B-19
B-145
Bark
Plant Tissue

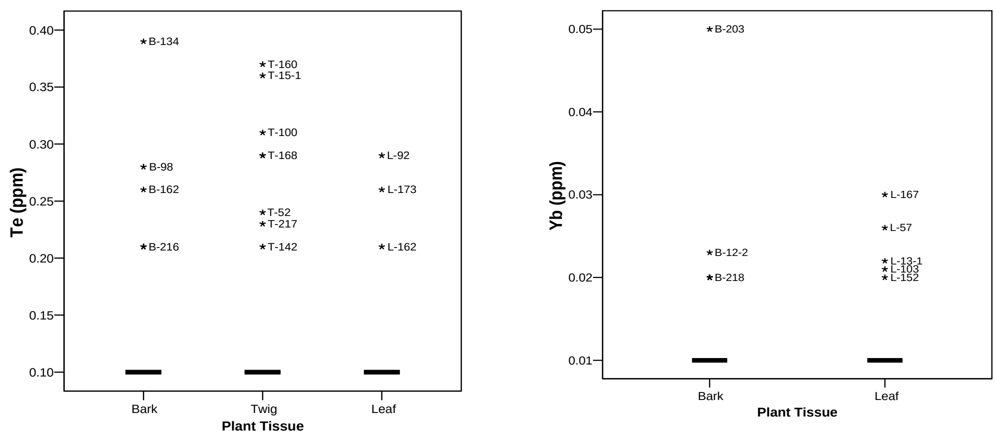
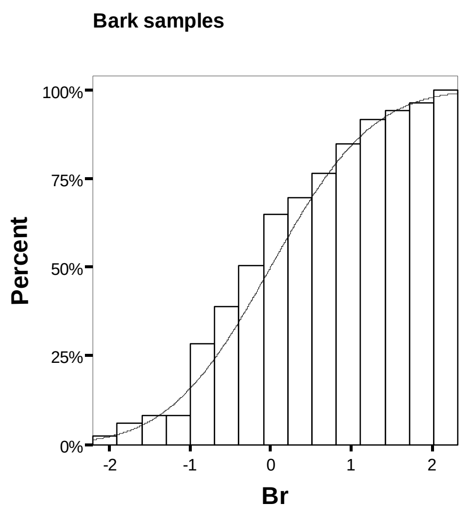
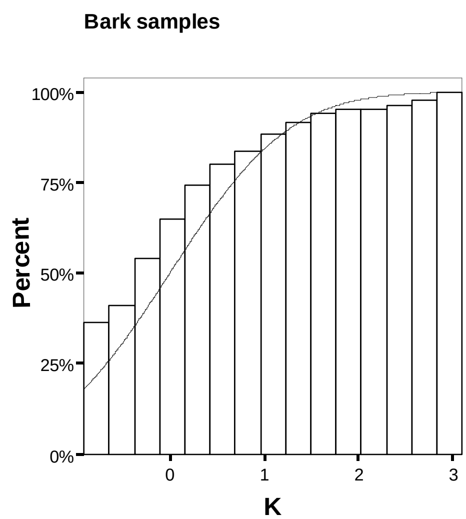
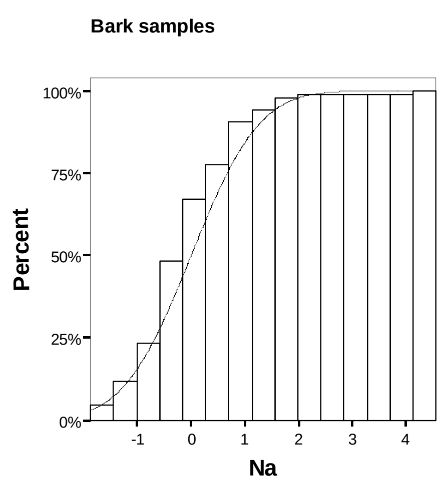


Figure F-1: Boxplots produced by EDA analysis of biosamples for As, Au, Ba, Ce, Co (for bark and leaf samples), Cr, Cs, Hf, Rb (only for bark), Te and Yb (for bark and leaf samples)

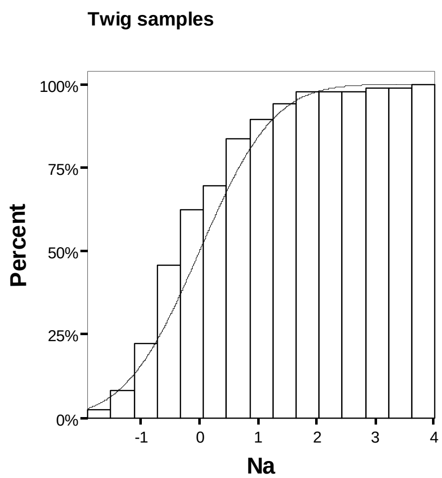
BARK:



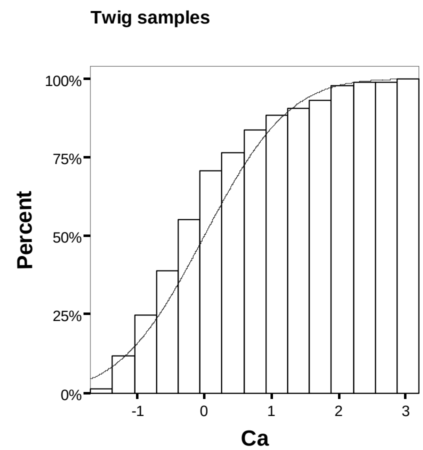




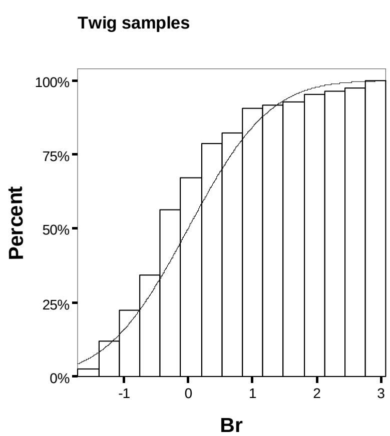
TWIG



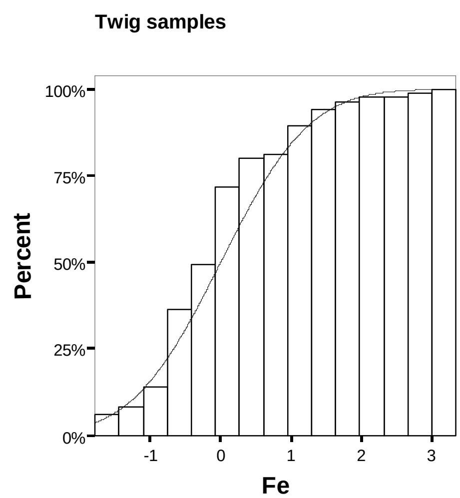
Twig samples
100%
75%
50%
25%
0%
Percent
-1
0
1
2
3
4
Na



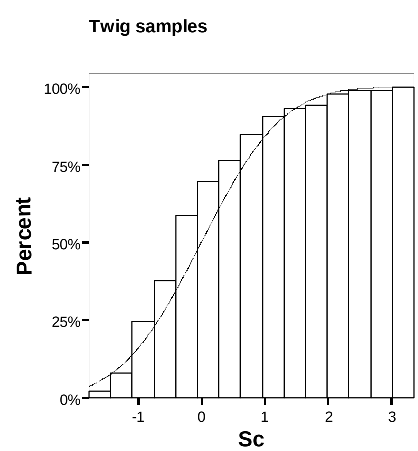
Twig samples
100%
75%
50%
25%
0%
Percent
-1
0
1
2
3
Ca



Twig samples
100%
75%
50%
25%
0%
Percent
-1
0
1
2
3
Br

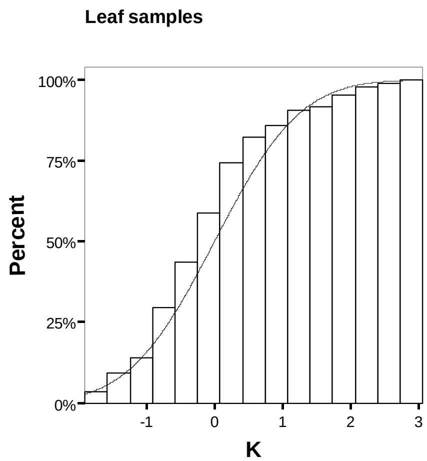


Twig samples
100%
75%
50%
25%
0%
Percent
-1
0
1
2
3
Fe



Twig samples
100%
75%
50%
25%
0%
Percent
-1
0
1
2
3
Sc

Leaf



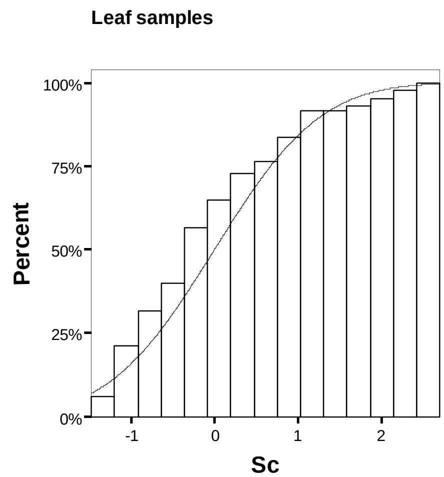
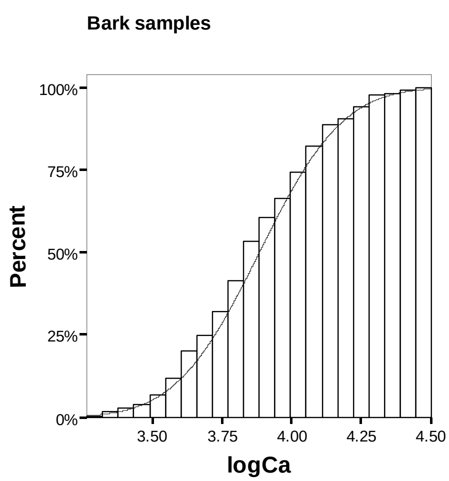
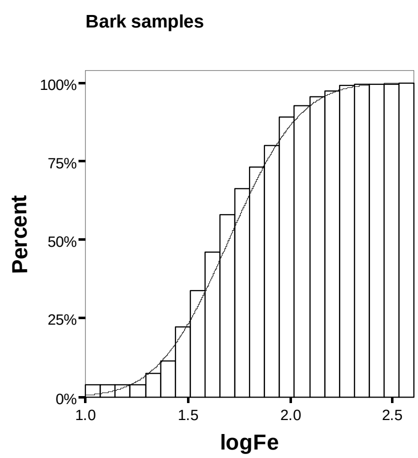


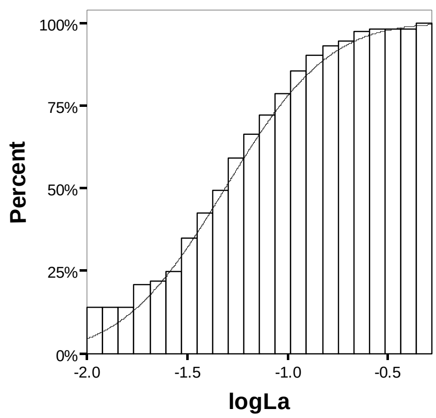
Figure F-2: Cumulative frequency chart for standardized data among biosamples for Br, K and Na (in bark samples), Br, Ca, Fe, Na and Sc (in twig samples) and K and Sc (in leaf samples)

LogBark:

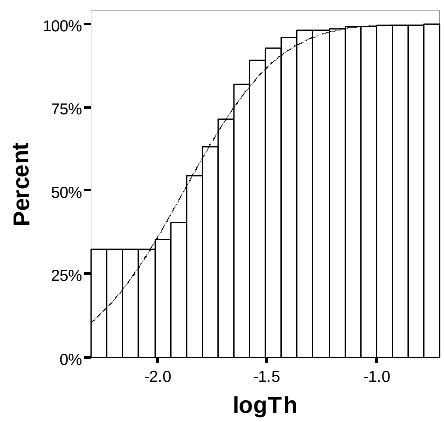




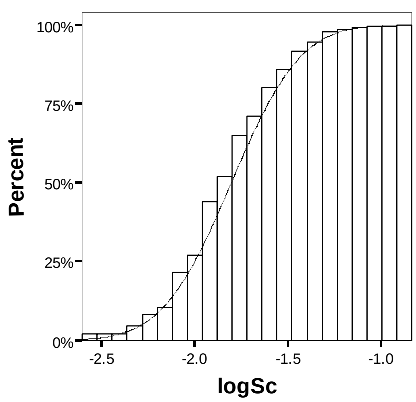
Bark samples



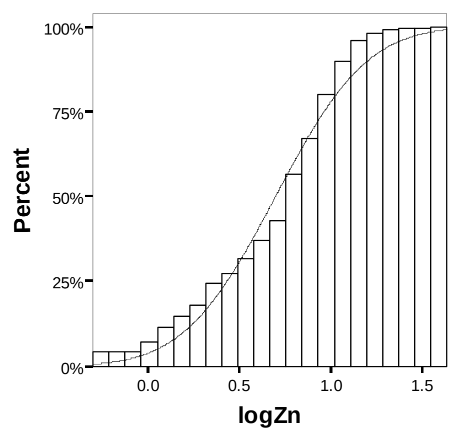
Bark samples



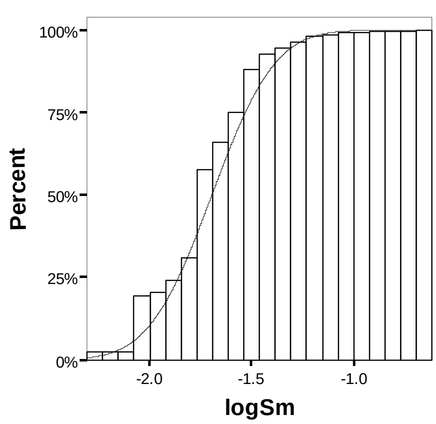
Bark samples



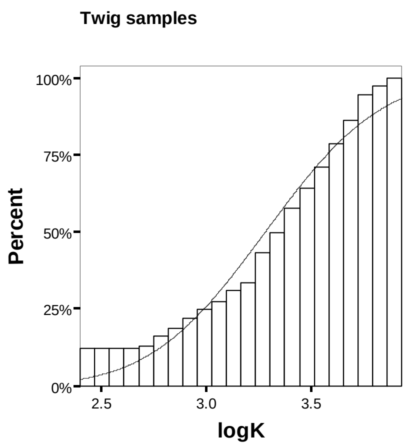
Bark samples

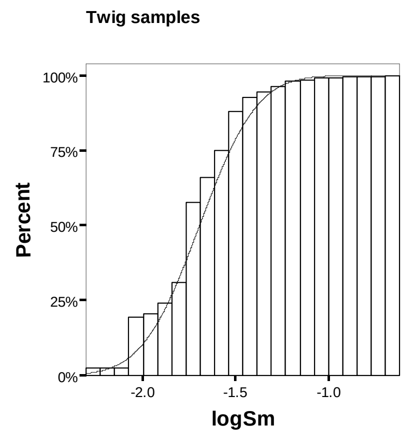


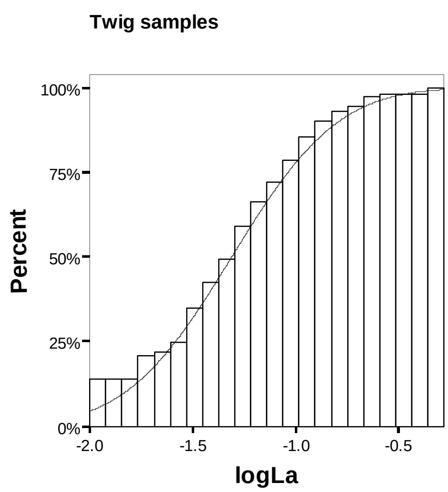
Bark samples

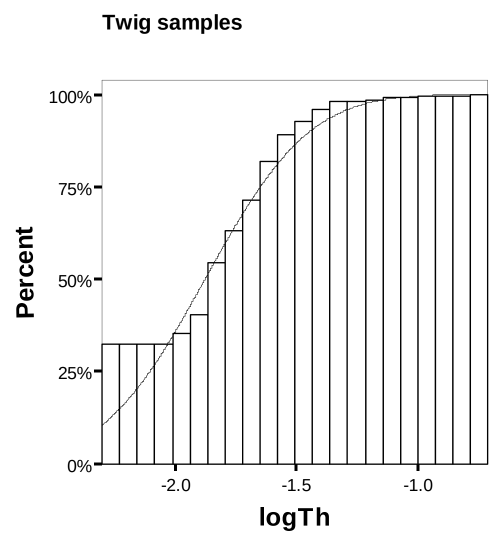


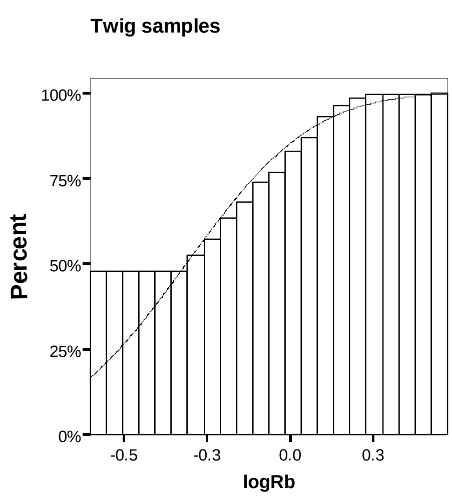
LogTwig:

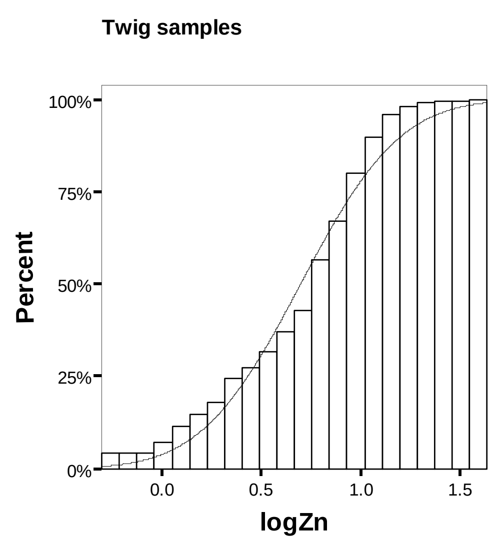

Twig samples
100%
75%
50%
25%
0%
Percent
2.5
3.0
3.5
logK


Twig samples
100%
75%
50%
25%
0%
Percent
-2.0
-1.5
-1.0
logSm

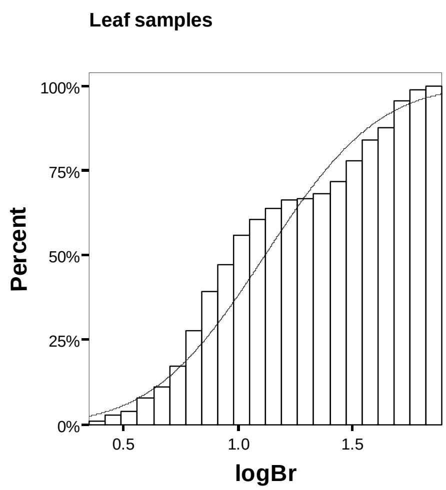

Twig samples
100%
75%
50%
25%
0%
Percent
-2.0
-1.5
-1.0
-0.5
logLa

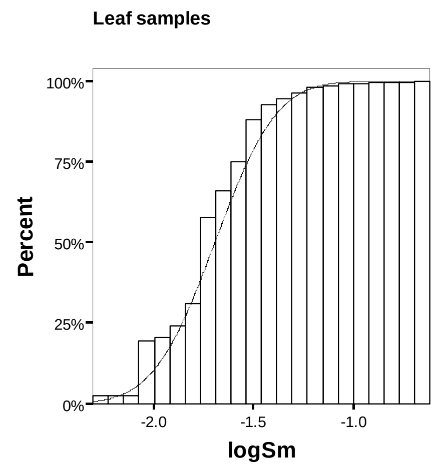

Twig samples
100%
75%
50%
25%
0%
Percent
-2.0
-1.5
-1.0
logTh

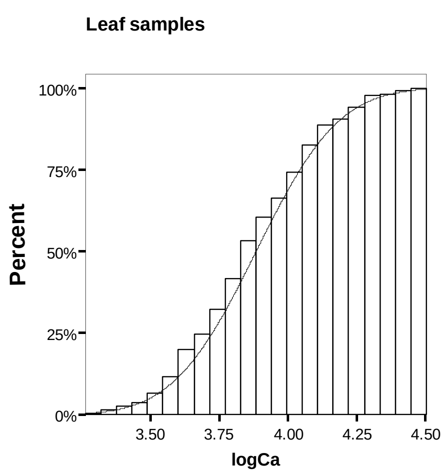

Twig samples
100%
75%
50%
25%
0%
Percent
-0.5
-0.3
0.0
0.3
logRb

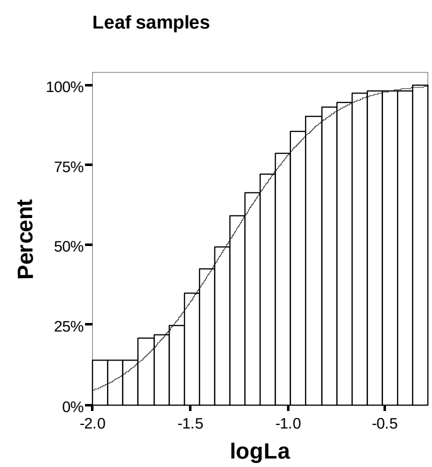

Twig samples
100%
75%
50%
25%
0%
Percent
0.0
0.5
1.0
1.5
logZn

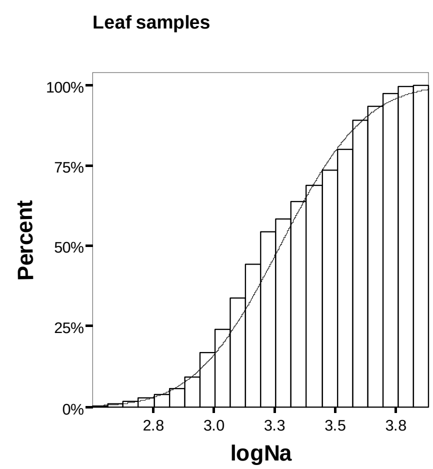
LogLeaf:


Leaf samples
100%
75%
50%
25%
0%
Percent
0.5
1.0
1.5
logBr


Leaf samples
100%
75%
50%
25%
0%
Percent
-2.0
-1.5
-1.0
logSm


Leaf samples
100%
75%
50%
25%
0%
Percent
3.50
3.75
4.00
4.25
4.50
logCa


Leaf samples
100%
75%
50%
25%
0%
Percent
-2.0
-1.5
-1.0
-0.5
logLa


Leaf samples
100%
75%
50%
25%
0%
Percent
2.8
3.0
3.3
3.5
3.8
logNa

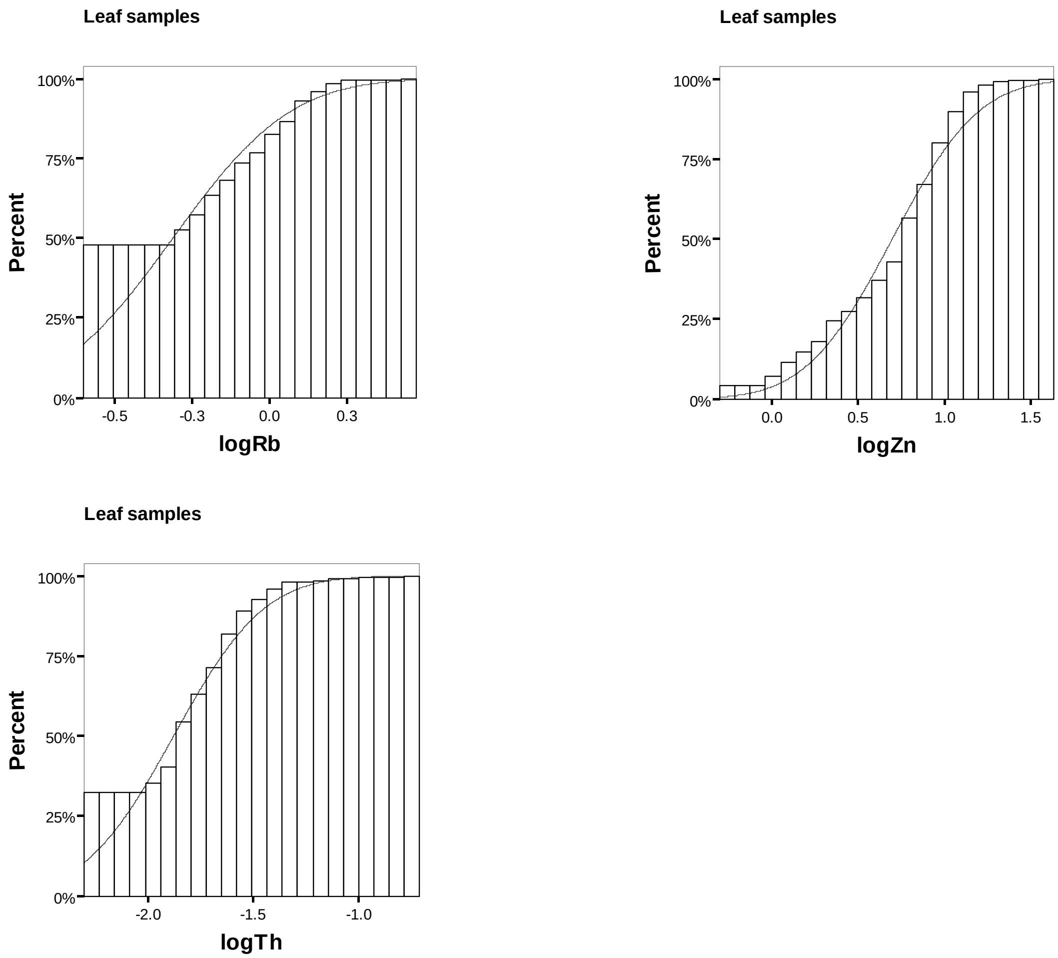


Figure F-3: Cumulative frequency chart for logtransformed data among biosamples for Ca, Fe, La, Sc, Sm, Th and Zn (in bark), K, La, Rb, Sm, Th and Zn (in twig) and Br, Ca, Fe, La, Na, Rb, Sm, Th and Zn (in leaf).

APPENDIX H: RESULTS OF ANALYSIS OF VARIANCE- SOIL

Tests of Between-Subjects Effects

Dependent Variable: logAs

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.089(a)	4	1.022	10.550	.000
Intercept	14.676	1	14.676	151.476	.000
bedrock	4.089	4	1.022	10.550	.000
Error	7.169	74	.097		
Total	25.957	79			
Corrected Total	11.258	78			

a R Squared = .363 (Adjusted R Squared = .329)

Post Hoc Tests
Bedrock

Multiple Comparisons

Dependent Variable: logAs
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.0251	.10752	1.000	-.3582	.3079
	S	.0279	.08415	1.000	-.2435	.2994
	G	.0020	.10914	1.000	-.3391	.3430
	UB	-.6049(*)	.15181	.009	-1.0890	-.1207
LS	Cz	.0251	.10752	1.000	-.3079	.3582
	S	.0531	.09182	1.000	-.2313	.3375
	G	.0271	.11516	1.000	-.3253	.3795
	UB	-.5797(*)	.15619	.014	-1.0708	-.0887
S	Cz	-.0279	.08415	1.000	-.2994	.2435
	LS	-.0531	.09182	1.000	-.3375	.2313
	G	-.0260	.09371	1.000	-.3219	.2700
	UB	-.6328(*)	.14113	.005	-1.0965	-.1691
G	Cz	-.0020	.10914	1.000	-.3430	.3391
	LS	-.0271	.11516	1.000	-.3795	.3253
	S	.0260	.09371	1.000	-.2700	.3219
	UB	-.6068(*)	.15731	.010	-1.1015	-.1122
UB	Cz	.6049(*)	.15181	.009	.1207	1.0890
	LS	.5797(*)	.15619	.014	.0887	1.0708
	S	.6328(*)	.14113	.005	.1691	1.0965
	G	.6068(*)	.15731	.010	.1122	1.1015

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logBa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.070(a)	4	.018	.422	.792
Intercept	336.950	1	336.950	8086.721	.000
bedrock	.070	4	.018	.422	.792
Error	3.000	72	.042		
Total	385.600	77			
Corrected Total	3.070	76			

a R Squared = .023 (Adjusted R Squared = -.031)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logBa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0204	.07017	1.000	-.2025	.2433
	S	-.0037	.06541	1.000	-.2140	.2066
	G	-.0551	.09284	1.000	-.3456	.2354
	UB	-.0595	.07097	.995	-.2864	.1674
LS	Cz	-.0204	.07017	1.000	-.2433	.2025
	S	-.0240	.05944	1.000	-.2028	.1547
	G	-.0755	.08873	.994	-.3521	.2011
	UB	-.0798	.06551	.931	-.2813	.1216
S	Cz	.0037	.06541	1.000	-.2066	.2140
	LS	.0240	.05944	1.000	-.1547	.2028
	G	-.0514	.08502	1.000	-.3192	.2163
	UB	-.0558	.06038	.989	-.2407	.1292
G	Cz	.0551	.09284	1.000	-.2354	.3456
	LS	.0755	.08873	.994	-.2011	.3521
	S	.0514	.08502	1.000	-.2163	.3192
	UB	-.0044	.08937	1.000	-.2834	.2747
UB	Cz	.0595	.07097	.995	-.1674	.2864
	LS	.0798	.06551	.931	-.1216	.2813
	S	.0558	.06038	.989	-.1292	.2407
	G	.0044	.08937	1.000	-.2747	.2834

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logBe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.370(a)	4	.092	2.590	.043
Intercept	30.787	1	30.787	862.588	.000
bedrock	.370	4	.092	2.590	.043
Error	2.713	76	.036		
Total	36.269	81			
Corrected Total	3.082	80			

a R Squared = .120 (Adjusted R Squared = .074)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logBe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.08868	.057616	.779	-.09351	.27087
	S	-.04898	.057080	.994	-.22778	.12983
	G	-.03229	.078390	1.000	-.27523	.21066
	UB	.11818	.071149	.694	-.10425	.34061
LS	Cz	-.08868	.057616	.779	-.27087	.09351
	S	-.13766	.050071	.089	-.28688	.01156
	G	-.12097	.073444	.701	-.34934	.10740
	UB	.02950	.065659	1.000	-.17560	.23460
S	Cz	.04898	.057080	.994	-.12983	.22778
	LS	.13766	.050071	.089	-.01156	.28688
	G	.01669	.073024	1.000	-.20976	.24313
	UB	.16716	.065189	.163	-.03546	.36978
G	Cz	.03229	.078390	1.000	-.21066	.27523
	LS	.12097	.073444	.701	-.10740	.34934
	S	-.01669	.073024	1.000	-.24313	.20976
	UB	.15047	.084478	.596	-.10795	.40889
UB	Cz	-.11818	.071149	.694	-.34061	.10425
	LS	-.02950	.065659	1.000	-.23460	.17560
	S	-.16716	.065189	.163	-.36978	.03546
	G	-.15047	.084478	.596	-.40889	.10795

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logBr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.039(a)	4	.510	2.753	.034
Intercept	76.302	1	76.302	412.225	.000
bedrock	2.039	4	.510	2.753	.034
Error	14.067	76	.185		
Total	96.112	81			
Corrected Total	16.106	80			

a R Squared = .127 (Adjusted R Squared = .081)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logBr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.1074	.14940	.999	-.3615	.5763
	S	.3989(*)	.11411	.013	.0572	.7406
	G	.3416	.13055	.147	-.0647	.7479
	UB	.4484(*)	.10797	.005	.1109	.7859
LS	Cz	-.1074	.14940	.999	-.5763	.3615
	S	.2915	.16094	.571	-.1986	.7816
	G	.2342	.17299	.874	-.2926	.7611
	UB	.3410	.15665	.335	-.1436	.8256
S	Cz	-.3989(*)	.11411	.013	-.7406	-.0572
	LS	-.2915	.16094	.571	-.7816	.1986
	G	-.0573	.14362	1.000	-.4892	.3747
	UB	.0495	.12345	1.000	-.3190	.4180
G	Cz	-.3416	.13055	.147	-.7479	.0647
	LS	-.2342	.17299	.874	-.7611	.2926
	S	.0573	.14362	1.000	-.3747	.4892
	UB	.1068	.13879	.997	-.3192	.5327
UB	Cz	-.4484(*)	.10797	.005	-.7859	-.1109
	LS	-.3410	.15665	.335	-.8256	.1436
	S	-.0495	.12345	1.000	-.4180	.3190
	G	-.1068	.13879	.997	-.5327	.3192

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logCa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.277(a)	4	.569	1.918	.116
Intercept	7.147	1	7.147	24.079	.000
bedrock	2.277	4	.569	1.918	.116
Error	21.666	73	.297		
Total	30.182	78			
Corrected Total	23.943	77			

a R Squared = .095 (Adjusted R Squared = .046)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0702	.22653	1.000	-.6328	.7733
	S	.4240	.15726	.131	-.0711	.9191
	G	.3584	.20453	.626	-.2778	.9945
	UB	.4075	.17406	.259	-.1387	.9538
LS	Cz	-.0702	.22653	1.000	-.7733	.6328
	S	.3538	.21074	.681	-.3042	1.0118
	G	.2882	.24802	.948	-.4685	1.0448
	UB	.3373	.22356	.791	-.3537	1.0283
S	Cz	-.4240	.15726	.131	-.9191	.0711
	LS	-.3538	.21074	.681	-1.0118	.3042
	G	-.0657	.18689	1.000	-.6465	.5152
	UB	-.0165	.15296	1.000	-.4833	.4504
G	Cz	-.3584	.20453	.626	-.9945	.2778
	LS	-.2882	.24802	.948	-1.0448	.4685
	S	.0657	.18689	1.000	-.5152	.6465
	UB	.0492	.20124	1.000	-.5719	.6703
UB	Cz	-.4075	.17406	.259	-.9538	.1387
	LS	-.3373	.22356	.791	-1.0283	.3537
	S	.0165	.15296	1.000	-.4504	.4833
	G	-.0492	.20124	1.000	-.6703	.5719

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logCd

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	1.746(a)	4	.437	3.908	.006
Intercept	107.294	1	107.294	960.533	.000
bedrock	1.746	4	.437	3.908	.006
Error	8.489	76	.112		
Total	140.096	81			
Corrected Total	10.236	80			

a R Squared = .171 (Adjusted R Squared = .127)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCd
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.14537	.111032	.900	-.20423	.49496
	S	.41159(*)	.112450	.013	.06365	.75953
	G	.31580	.126313	.184	-.07576	.70737
	UB	.13876	.113977	.934	-.22035	.49788
LS	Cz	-.14537	.111032	.900	-.49496	.20423
	S	.26622	.102088	.123	-.03735	.56980
	G	.17044	.117184	.820	-.18764	.52851
	UB	-.00660	.103768	1.000	-.32444	.31123
S	Cz	-.41159(*)	.112450	.013	-.75953	-.06365
	LS	-.26622	.102088	.123	-.56980	.03735
	G	-.09578	.118528	.996	-.45327	.26170
	UB	-.27283	.105284	.133	-.58901	.04335
G	Cz	-.31580	.126313	.184	-.70737	.07576
	LS	-.17044	.117184	.820	-.52851	.18764
	S	.09578	.118528	.996	-.26170	.45327
	UB	-.17704	.119978	.808	-.54444	.19035
UB	Cz	-.13876	.113977	.934	-.49788	.22035
	LS	.00660	.103768	1.000	-.31123	.32444
	S	.27283	.105284	.133	-.04335	.58901
	G	.17704	.119978	.808	-.19035	.54444

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logCe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.235(a)	4	.059	1.132	.348
Intercept	134.508	1	134.508	2594.624	.000
bedrock	.235	4	.059	1.132	.348
Error	3.940	76	.052		
Total	153.306	81			
Corrected Total	4.175	80			

a R Squared = .056 (Adjusted R Squared = .007)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0415	.07782	1.000	-.2249	.3079
	S	.0422	.08780	1.000	-.2371	.3216
	G	-.1025	.10567	.985	-.4304	.2253
	UB	-.0103	.07960	1.000	-.2786	.2581
LS	Cz	-.0415	.07782	1.000	-.3079	.2249
	S	.0008	.05752	1.000	-.1698	.1713
	G	-.1440	.08226	.640	-.4065	.1184
	UB	-.0517	.04401	.944	-.1869	.0834
S	Cz	-.0422	.08780	1.000	-.3216	.2371
	LS	-.0008	.05752	1.000	-.1713	.1698
	G	-.1448	.09176	.742	-.4255	.1360
	UB	-.0525	.05991	.992	-.2302	.1252
G	Cz	.1025	.10567	.985	-.2253	.4304
	LS	.1440	.08226	.640	-.1184	.4065
	S	.1448	.09176	.742	-.1360	.4255
	UB	.0923	.08395	.965	-.1734	.3579
UB	Cz	.0103	.07960	1.000	-.2581	.2786
	LS	.0517	.04401	.944	-.0834	.1869
	S	.0525	.05991	.992	-.1252	.2302
	G	-.0923	.08395	.965	-.3579	.1734

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logCo

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.746(a)	4	1.437	23.778	.000
Intercept	39.910	1	39.910	660.591	.000
bedrock	5.746	4	1.437	23.778	.000
Error	4.592	76	.060		
Total	50.418	81			
Corrected Total	10.338	80			

a R Squared = .556 (Adjusted R Squared = .532)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCo
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0558	.07900	.999	-.2012	.3129
	S	.0972	.08594	.958	-.1713	.3657
	G	-.0067	.09276	1.000	-.2961	.2826
	UB	-.6661(*)	.09898	.000	-.9756	-.3566
LS	Cz	-.0558	.07900	.999	-.3129	.2012
	S	.0414	.06744	1.000	-.1582	.2409
	G	-.0625	.07594	.996	-.2965	.1715
	UB	-.7220(*)	.08342	.000	-.9854	-.4586
S	Cz	-.0972	.08594	.958	-.3657	.1713
	LS	-.0414	.06744	1.000	-.2409	.1582
	G	-.1039	.08313	.917	-.3536	.1459
	UB	-.7633(*)	.09002	.000	-1.0393	-.4873
G	Cz	.0067	.09276	1.000	-.2826	.2961
	LS	.0625	.07594	.996	-.1715	.2965
	S	.1039	.08313	.917	-.1459	.3536
	UB	-.6594(*)	.09655	.000	-.9558	-.3631
UB	Cz	.6661(*)	.09898	.000	.3566	.9756
	LS	.7220(*)	.08342	.000	.4586	.9854
	S	.7633(*)	.09002	.000	.4873	1.0393
	G	.6594(*)	.09655	.000	.3631	.9558

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logCr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	17.345(a)	4	4.336	57.713	.000
Intercept	193.139	1	193.139	2570.509	.000
bedrock	17.345	4	4.336	57.713	.000
Error	5.710	76	.075		
Total	225.515	81			
Corrected Total	23.056	80			

a R Squared = .752 (Adjusted R Squared = .739)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.0970	.07112	.873	-.3180	.1239
	S	-.0193	.06514	1.000	-.2209	.1824
	G	-.2082	.09202	.291	-.4942	.0778
	UB	-1.3207(*)	.13171	.000	-1.7488	-.8926
LS	Cz	.0970	.07112	.873	-.1239	.3180
	S	.0778	.06633	.943	-.1216	.2772
	G	-.1112	.09286	.938	-.3970	.1747
	UB	-1.2237(*)	.13230	.000	-1.6519	-.7955
S	Cz	.0193	.06514	1.000	-.1824	.2209
	LS	-.0778	.06633	.943	-.2772	.1216
	G	-.1889	.08836	.360	-.4629	.0851
	UB	-1.3015(*)	.12918	.000	-1.7247	-.8782
G	Cz	.2082	.09202	.291	-.0778	.4942
	LS	.1112	.09286	.938	-.1747	.3970
	S	.1889	.08836	.360	-.0851	.4629
	UB	-1.1125(*)	.14461	.000	-1.5651	-.6599
UB	Cz	1.3207(*)	.13171	.000	.8926	1.7488
	LS	1.2237(*)	.13230	.000	.7955	1.6519
	S	1.3015(*)	.12918	.000	.8782	1.7247
	G	1.1125(*)	.14461	.000	.6599	1.5651

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logCs

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.162(a)	4	.041	1.134	.347
Intercept	1.377	1	1.377	38.497	.000
bedrock	.162	4	.041	1.134	.347
Error	2.539	71	.036		
Total	4.289	76			
Corrected Total	2.701	75			

a R Squared = .060 (Adjusted R Squared = .007)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCs
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0209	.07340	1.000	-.2285	.2703
	S	-.0538	.07803	.999	-.3080	.2005
	G	-.1169	.08807	.893	-.3954	.1617
	UB	-.0772	.08711	.993	-.3540	.1997
LS	Cz	-.0209	.07340	1.000	-.2703	.2285
	S	-.0747	.04866	.760	-.2191	.0697
	G	-.1378	.06352	.361	-.3403	.0647
	UB	-.0981	.06218	.761	-.2981	.1020
S	Cz	.0538	.07803	.999	-.2005	.3080
	LS	.0747	.04866	.760	-.0697	.2191
	G	-.0631	.06883	.990	-.2754	.1492
	UB	-.0234	.06759	1.000	-.2330	.1862
G	Cz	.1169	.08807	.893	-.1617	.3954
	LS	.1378	.06352	.361	-.0647	.3403
	S	.0631	.06883	.990	-.1492	.2754
	UB	.0397	.07897	1.000	-.2047	.2840
UB	Cz	.0772	.08711	.993	-.1997	.3540
	LS	.0981	.06218	.761	-.1020	.2981
	S	.0234	.06759	1.000	-.1862	.2330
	G	-.0397	.07897	1.000	-.2840	.2047

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logCu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.484(a)	4	1.121	12.398	.000
Intercept	37.159	1	37.159	410.955	.000
bedrock	4.484	4	1.121	12.398	.000
Error	6.872	76	.090		
Total	49.088	81			
Corrected Total	11.356	80			

a R Squared = .395 (Adjusted R Squared = .363)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logCu
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.02564	.104032	1.000	-.36425	.31298
	S	.06828	.107791	1.000	-.27466	.41122
	G	-.00634	.127336	1.000	-.40192	.38923
	UB	-.61197(*)	.118776	.001	-.98615	-.23779
LS	Cz	.02564	.104032	1.000	-.31298	.36425
	S	.09392	.081706	.949	-.14839	.33623
	G	.01929	.106168	1.000	-.30955	.34813
	UB	-.58633(*)	.095733	.000	-.88421	-.28845
S	Cz	-.06828	.107791	1.000	-.41122	.27466
	LS	-.09392	.081706	.949	-.33623	.14839
	G	-.07462	.109854	.999	-.40982	.26057
	UB	-.68025(*)	.099805	.000	-.98489	-.37560
G	Cz	.00634	.127336	1.000	-.38923	.40192
	LS	-.01929	.106168	1.000	-.34813	.30955
	S	.07462	.109854	.999	-.26057	.40982
	UB	-.60562(*)	.120651	.000	-.97467	-.23658
UB	Cz	.61197(*)	.118776	.001	.23779	.98615
	LS	.58633(*)	.095733	.000	.28845	.88421
	S	.68025(*)	.099805	.000	.37560	.98489
	G	.60562(*)	.120651	.000	.23658	.97467

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logEu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.322(a)	4	.080	2.892	.028
Intercept	6.126	1	6.126	220.157	.000
bedrock	.322	4	.080	2.892	.028
Error	1.892	68	.028		
Total	8.824	73			
Corrected Total	2.214	72			

a R Squared = .145 (Adjusted R Squared = .095)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logEu
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.1251	.06384	.509	-.0835	.3338
	S	.0073	.06444	1.000	-.2014	.2159
	G	-.0106	.07525	1.000	-.2461	.2250
	UB	-.0898	.07542	.942	-.3266	.1470
LS	Cz	-.1251	.06384	.509	-.3338	.0835
	S	-.1179	.04696	.159	-.2588	.0231
	G	-.1357	.06096	.311	-.3252	.0538
	UB	-.2149(*)	.06117	.021	-.4067	-.0232
S	Cz	-.0073	.06444	1.000	-.2159	.2014
	LS	.1179	.04696	.159	-.0231	.2588
	G	-.0178	.06158	1.000	-.2077	.1720
	UB	-.0970	.06179	.753	-.2891	.0950
G	Cz	.0106	.07525	1.000	-.2250	.2461
	LS	.1357	.06096	.311	-.0538	.3252
	S	.0178	.06158	1.000	-.1720	.2077
	UB	-.0792	.07300	.967	-.3033	.1448
UB	Cz	.0898	.07542	.942	-.1470	.3266
	LS	.2149(*)	.06117	.021	.0232	.4067
	S	.0970	.06179	.753	-.0950	.2891
	G	.0792	.07300	.967	-.1448	.3033

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logFe

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.660(a)	4	1.165	22.293	.000
Intercept	2.257	1	2.257	43.184	.000
bedrock	4.660	4	1.165	22.293	.000
Error	3.972	76	.052		
Total	10.347	81			
Corrected Total	8.633	80			

a R Squared = .540 (Adjusted R Squared = .516)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logFe
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0293	.06594	1.000	-.1859	.2444
	S	.0316	.07547	1.000	-.2012	.2644
	G	-.1149	.09382	.930	-.4053	.1755
	UB	-.6425(*)	.07508	.000	-.8793	-.4058
LS	Cz	-.0293	.06594	1.000	-.2444	.1859
	S	.0024	.06036	1.000	-.1762	.1809
	G	-.1442	.08216	.631	-.4032	.1149
	UB	-.6718(*)	.05987	.000	-.8581	-.4855
S	Cz	-.0316	.07547	1.000	-.2644	.2012
	LS	-.0024	.06036	1.000	-.1809	.1762
	G	-.1465	.08999	.706	-.4212	.1281
	UB	-.6742(*)	.07022	.000	-.8846	-.4638
G	Cz	.1149	.09382	.930	-.1755	.4053
	LS	.1442	.08216	.631	-.1149	.4032
	S	.1465	.08999	.706	-.1281	.4212
	UB	-.5276(*)	.08966	.000	-.8043	-.2509
UB	Cz	.6425(*)	.07508	.000	.4058	.8793
	LS	.6718(*)	.05987	.000	.4855	.8581
	S	.6742(*)	.07022	.000	.4638	.8846
	G	.5276(*)	.08966	.000	.2509	.8043

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logGa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.135(a)	4	.034	1.032	.396
Intercept	25.552	1	25.552	779.880	.000
bedrock	.135	4	.034	1.032	.396
Error	2.490	76	.033		
Total	30.705	81			
Corrected Total	2.625	80			

a R Squared = .052 (Adjusted R Squared = .002)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logGa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.01096	.043872	1.000	-.12652	.14844
	S	.01174	.052012	1.000	-.14454	.16802
	G	-.06958	.069366	.981	-.28686	.14770
	UB	-.08312	.048762	.663	-.23556	.06932
LS	Cz	-.01096	.043872	1.000	-.14844	.12652
	S	.00078	.049710	1.000	-.14627	.14784
	G	-.08054	.067657	.942	-.29316	.13209
	UB	-.09408	.046298	.422	-.23672	.04857
S	Cz	-.01174	.052012	1.000	-.16802	.14454
	LS	-.00078	.049710	1.000	-.14784	.14627
	G	-.08132	.073198	.961	-.30492	.14227
	UB	-.09486	.054074	.602	-.25613	.06641
G	Cz	.06958	.069366	.981	-.14770	.28686
	LS	.08054	.067657	.942	-.13209	.29316
	S	.08132	.073198	.961	-.14227	.30492
	UB	-.01354	.070925	1.000	-.23374	.20666
UB	Cz	.08312	.048762	.663	-.06932	.23556
	LS	.09408	.046298	.422	-.04857	.23672
	S	.09486	.054074	.602	-.06641	.25613
	G	.01354	.070925	1.000	-.20666	.23374

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logHf

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.173(a)	4	.043	1.525	.203
Intercept	30.996	1	30.996	1095.530	.000
bedrock	.173	4	.043	1.525	.203
Error	2.150	76	.028		
Total	38.037	81			
Corrected Total	2.323	80			

a R Squared = .074 (Adjusted R Squared = .026)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logHf
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.0490	.05188	.988	-.2100	.1120
	S	-.0689	.04543	.777	-.2054	.0677
	G	-.1060	.05224	.429	-.2682	.0561
	UB	.0338	.05586	1.000	-.1430	.2105
LS	Cz	.0490	.05188	.988	-.1120	.2100
	S	-.0199	.05558	1.000	-.1871	.1474
	G	-.0570	.06127	.988	-.2432	.1291
	UB	.0828	.06438	.906	-.1147	.2802
S	Cz	.0689	.04543	.777	-.0677	.2054
	LS	.0199	.05558	1.000	-.1474	.1871
	G	-.0372	.05591	.999	-.2055	.1312
	UB	.1026	.05930	.635	-.0793	.2845
G	Cz	.1060	.05224	.429	-.0561	.2682
	LS	.0570	.06127	.988	-.1291	.2432
	S	.0372	.05591	.999	-.1312	.2055
	UB	.1398	.06467	.337	-.0585	.3380
UB	Cz	-.0338	.05586	1.000	-.2105	.1430
	LS	-.0828	.06438	.906	-.2802	.1147
	S	-.1026	.05930	.635	-.2845	.0793
	G	-.1398	.06467	.337	-.3380	.0585

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logK

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.071(a)	4	.018	.262	.901
Intercept	2.918	1	2.918	43.039	.000
bedrock	.071	4	.018	.262	.901
Error	5.153	76	.068		
Total	8.654	81			
Corrected Total	5.224	80			

a R Squared = .014 (Adjusted R Squared = -.038)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logK
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0042	.08823	1.000	-.2822	.2905
	S	.0397	.09338	1.000	-.2542	.3336
	G	-.0389	.11434	1.000	-.3929	.3151
	UB	.0375	.08490	1.000	-.2436	.3187
LS	Cz	-.0042	.08823	1.000	-.2905	.2822
	S	.0355	.07296	1.000	-.1806	.2517
	G	-.0431	.09836	1.000	-.3496	.2634
	UB	.0334	.06173	1.000	-.1555	.2222
S	Cz	-.0397	.09338	1.000	-.3336	.2542
	LS	-.0355	.07296	1.000	-.2517	.1806
	G	-.0786	.10301	.998	-.3938	.2365
	UB	-.0022	.06889	1.000	-.2066	.2023
G	Cz	.0389	.11434	1.000	-.3151	.3929
	LS	.0431	.09836	1.000	-.2634	.3496
	S	.0786	.10301	.998	-.2365	.3938
	UB	.0765	.09539	.997	-.2240	.3770
UB	Cz	-.0375	.08490	1.000	-.3187	.2436
	LS	-.0334	.06173	1.000	-.2222	.1555
	S	.0022	.06889	1.000	-.2023	.2066
	G	-.0765	.09539	.997	-.3770	.2240

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logLa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.280(a)	4	.070	1.307	.275
Intercept	81.302	1	81.302	1515.140	.000
bedrock	.280	4	.070	1.307	.275
Error	4.078	76	.054		
Total	93.954	81			
Corrected Total	4.359	80			

a R Squared = .064 (Adjusted R Squared = .015)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logLa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0425	.07523	1.000	-.2148	.2997
	S	.0539	.08626	1.000	-.2186	.3264
	G	-.1079	.10590	.979	-.4358	.2201
	UB	-.0045	.07859	1.000	-.2660	.2569
LS	Cz	-.0425	.07523	1.000	-.2997	.2148
	S	.0114	.05789	1.000	-.1604	.1832
	G	-.1504	.08441	.620	-.4205	.1198
	UB	-.0470	.04568	.977	-.1881	.0940
S	Cz	-.0539	.08626	1.000	-.3264	.2186
	LS	-.0114	.05789	1.000	-.1832	.1604
	G	-.1618	.09437	.646	-.4509	.1273
	UB	-.0584	.06219	.987	-.2430	.1262
G	Cz	.1079	.10590	.979	-.2201	.4358
	LS	.1504	.08441	.620	-.1198	.4205
	S	.1618	.09437	.646	-.1273	.4509
	UB	.1033	.08742	.945	-.1725	.3792
UB	Cz	.0045	.07859	1.000	-.2569	.2660
	LS	.0470	.04568	.977	-.0940	.1881
	S	.0584	.06219	.987	-.1262	.2430
	G	-.1033	.08742	.945	-.3792	.1725

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logLi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.167(a)	4	.042	1.358	.257
Intercept	36.155	1	36.155	1172.353	.000
bedrock	.167	4	.042	1.358	.257
Error	2.344	76	.031		
Total	43.838	81			
Corrected Total	2.511	80			

a R Squared = .067 (Adjusted R Squared = .018)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logLi
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Cz	LS	.06000	.040059	.798	-.06399	.18399
	S	-.03476	.044878	.997	-.16888	.09936
	G	-.05905	.064336	.990	-.26281	.14472
	UB	.04709	.053397	.993	-.12280	.21697
LS	Cz	-.06000	.040059	.798	-.18399	.06399
	S	-.09476	.047776	.427	-.23627	.04675
	G	-.11905	.066390	.599	-.32648	.08839
	UB	-.01291	.055855	1.000	-.18732	.16149
S	Cz	.03476	.044878	.997	-.09936	.16888
	LS	.09476	.047776	.427	-.04675	.23627
	G	-.02428	.069404	1.000	-.23726	.18869
	UB	.08185	.059406	.862	-.09928	.26297
G	Cz	.05905	.064336	.990	-.14472	.26281
	LS	.11905	.066390	.599	-.08839	.32648
	S	.02428	.069404	1.000	-.18869	.23726
	UB	.10613	.075194	.845	-.12426	.33652
UB	Cz	-.04709	.053397	.993	-.21697	.12280
	LS	.01291	.055855	1.000	-.16149	.18732
	S	-.08185	.059406	.862	-.26297	.09928
	G	-.10613	.075194	.845	-.33652	.12426

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logLu

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.218(a)	4	.055	2.439	.056
Intercept	38.580	1	38.580	1723.602	.000
bedrock	.218	4	.055	2.439	.056
Error	1.477	66	.022		
Total	43.167	71			
Corrected Total	1.696	70			

a R Squared = .129 (Adjusted R Squared = .076)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logLu
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0496	.05847	.995	-.1496	.2487
	S	-.0592	.05931	.983	-.2586	.1402
	G	-.0945	.08259	.955	-.3541	.1651
	UB	-.0996	.06041	.729	-.3015	.1023
LS	Cz	-.0496	.05847	.995	-.2487	.1496
	S	-.1087	.03872	.080	-.2249	.0074
	G	-.1440	.06930	.427	-.3686	.0805
	UB	-.1492(*)	.04039	.011	-.2735	-.0248
S	Cz	.0592	.05931	.983	-.1402	.2586
	LS	.1087	.03872	.080	-.0074	.2249
	G	-.0353	.07001	1.000	-.2606	.1900
	UB	-.0404	.04159	.984	-.1663	.0855
G	Cz	.0945	.08259	.955	-.1651	.3541
	LS	.1440	.06930	.427	-.0805	.3686
	S	.0353	.07001	1.000	-.1900	.2606
	UB	-.0051	.07094	1.000	-.2327	.2224
UB	Cz	.0996	.06041	.729	-.1023	.3015
	LS	.1492(*)	.04039	.011	.0248	.2735
	S	.0404	.04159	.984	-.0855	.1663
	G	.0051	.07094	1.000	-.2224	.2327

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logMn

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.200(a)	4	.550	7.664	.000
Intercept	278.811	1	278.811	3885.749	.000
bedrock	2.200	4	.550	7.664	.000
Error	5.453	76	.072		
Total	315.963	81			
Corrected Total	7.653	80			

a R Squared = .287 (Adjusted R Squared = .250)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logMn
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.11630	.087628	.894	-.39477	.16218
	S	-.04510	.090797	1.000	-.32724	.23704
	G	.02654	.109082	1.000	-.31105	.36413
	UB	-.46960(*)	.087122	.000	-.74794	-.19126
LS	Cz	.11630	.087628	.894	-.16218	.39477
	S	.07120	.078362	.990	-.16137	.30376
	G	.14283	.098972	.829	-.16258	.44825
	UB	-.35330(*)	.074072	.001	-.57986	-.12675
S	Cz	.04510	.090797	1.000	-.23704	.32724
	LS	-.07120	.078362	.990	-.30376	.16137
	G	.07164	.101788	.999	-.23818	.38146
	UB	-.42450(*)	.077795	.000	-.65655	-.19245
G	Cz	-.02654	.109082	1.000	-.36413	.31105
	LS	-.14283	.098972	.829	-.44825	.16258
	S	-.07164	.101788	.999	-.38146	.23818
	UB	-.49614(*)	.098524	.000	-.80114	-.19114
UB	Cz	.46960(*)	.087122	.000	.19126	.74794
	LS	.35330(*)	.074072	.001	.12675	.57986
	S	.42450(*)	.077795	.000	.19245	.65655
	G	.49614(*)	.098524	.000	.19114	.80114

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logNa

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.520(a)	4	.630	6.137	.000
Intercept	44.338	1	44.338	431.805	.000
bedrock	2.520	4	.630	6.137	.000
Error	7.804	76	.103		
Total	63.874	81			
Corrected Total	10.324	80			

a R Squared = .244 (Adjusted R Squared = .204)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logNa
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.1274	.10305	.927	-.4507	.1958
	S	.0545	.09672	1.000	-.2502	.3591
	G	-.1043	.13393	.997	-.5193	.3106
	UB	-.4660(*)	.11950	.008	-.8394	-.0925
LS	Cz	.1274	.10305	.927	-.1958	.4507
	S	.1819	.08893	.394	-.0850	.4488
	G	.0231	.12842	1.000	-.3736	.4198
	UB	-.3385	.11328	.064	-.6891	.0121
S	Cz	-.0545	.09672	1.000	-.3591	.2502
	LS	-.1819	.08893	.394	-.4488	.0850
	G	-.1588	.12339	.907	-.5424	.2248
	UB	-.5204(*)	.10756	.001	-.8548	-.1861
G	Cz	.1043	.13393	.997	-.3106	.5193
	LS	-.0231	.12842	1.000	-.4198	.3736
	S	.1588	.12339	.907	-.2248	.5424
	UB	-.3616	.14195	.159	-.7961	.0729
UB	Cz	.4660(*)	.11950	.008	.0925	.8394
	LS	.3385	.11328	.064	-.0121	.6891
	S	.5204(*)	.10756	.001	.1861	.8548
	G	.3616	.14195	.159	-.0729	.7961

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logNi

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9.068(a)	4	2.267	32.822	.000
Intercept	58.793	1	58.793	851.161	.000
bedrock	9.068	4	2.267	32.822	.000
Error	5.250	76	.069		
Total	74.707	81			
Corrected Total	14.318	80			

a R Squared = .633 (Adjusted R Squared = .614)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logNi
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.13404	.051441	.152	-.29447	.02640
	S	-.02972	.046015	.999	-.16716	.10773
	G	-.16137	.076807	.404	-.40718	.08444
	UB	-.97490(*)	.131557	.000	-1.41717	-.53263
LS	Cz	.13404	.051441	.152	-.02640	.29447
	S	.10432	.058325	.579	-.07067	.27931
	G	-.02734	.084757	1.000	-.28932	.23465
	UB	-.84087(*)	.136351	.000	-1.28826	-.39347
S	Cz	.02972	.046015	.999	-.10773	.16716
	LS	-.10432	.058325	.579	-.27931	.07067
	G	-.13166	.081578	.724	-.38540	.12209
	UB	-.94519(*)	.134398	.000	-1.38994	-.50043
G	Cz	.16137	.076807	.404	-.08444	.40718
	LS	.02734	.084757	1.000	-.23465	.28932
	S	.13166	.081578	.724	-.12209	.38540
	UB	-.81353(*)	.147799	.000	-1.28077	-.34629
UB	Cz	.97490(*)	.131557	.000	.53263	1.41717
	LS	.84087(*)	.136351	.000	.39347	1.28826
	S	.94519(*)	.134398	.000	.50043	1.38994
	G	.81353(*)	.147799	.000	.34629	1.28077

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logPb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.545(a)	4	.136	1.982	.106
Intercept	50.412	1	50.412	732.727	.000
bedrock	.545	4	.136	1.982	.106
Error	5.229	76	.069		
Total	60.382	81			
Corrected Total	5.774	80			

a R Squared = .094 (Adjusted R Squared = .047)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logPb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.26615	.108430	.272	-.10853	.64083
	S	.18219	.118087	.786	-.20209	.56647
	G	.07828	.117185	.999	-.30664	.46319
	UB	.18405	.119901	.791	-.20647	.57456
LS	Cz	-.26615	.108430	.272	-.64083	.10853
	S	-.08396	.070104	.934	-.29156	.12365
	G	-.18787	.068573	.109	-.39932	.02357
	UB	-.08210	.073117	.960	-.31243	.14823
S	Cz	-.18219	.118087	.786	-.56647	.20209
	LS	.08396	.070104	.934	-.12365	.29156
	G	-.10391	.083005	.915	-.35074	.14291
	UB	.00186	.086797	1.000	-.25922	.26293
G	Cz	-.07828	.117185	.999	-.46319	.30664
	LS	.18787	.068573	.109	-.02357	.39932
	S	.10391	.083005	.915	-.14291	.35074
	UB	.10577	.085566	.925	-.15650	.36804
UB	Cz	-.18405	.119901	.791	-.57456	.20647
	LS	.08210	.073117	.960	-.14823	.31243
	S	-.00186	.086797	1.000	-.26293	.25922
	G	-.10577	.085566	.925	-.36804	.15650

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logRb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.253(a)	4	.063	1.181	.326
Intercept	159.761	1	159.761	2985.142	.000
bedrock	.253	4	.063	1.181	.326
Error	3.960	74	.054		
Total	182.498	79			
Corrected Total	4.213	78			

a R Squared = .060 (Adjusted R Squared = .009)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logRb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0688	.07353	.989	-.1607	.2982
	S	.0023	.06972	1.000	-.2143	.2190
	G	-.1116	.10202	.966	-.4291	.2059
	UB	-.0087	.06563	1.000	-.2198	.2024
LS	Cz	-.0688	.07353	.989	-.2982	.1607
	S	-.0664	.06728	.982	-.2680	.1351
	G	-.1803	.10036	.592	-.4917	.1310
	UB	-.0775	.06303	.927	-.2713	.1164
S	Cz	-.0023	.06972	1.000	-.2190	.2143
	LS	.0664	.06728	.982	-.1351	.2680
	G	-.1139	.09761	.948	-.4180	.1902
	UB	-.0110	.05854	1.000	-.1861	.1640
G	Cz	.1116	.10202	.966	-.2059	.4291
	LS	.1803	.10036	.592	-.1310	.4917
	S	.1139	.09761	.948	-.1902	.4180
	UB	.1029	.09473	.968	-.1969	.4026
UB	Cz	.0087	.06563	1.000	-.2024	.2198
	LS	.0775	.06303	.927	-.1164	.2713
	S	.0110	.05854	1.000	-.1640	.1861
	G	-.1029	.09473	.968	-.4026	.1969

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logSb

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	2.143(a)	4	.536	11.677	.000
Intercept	16.772	1	16.772	365.649	.000
bedrock	2.143	4	.536	11.677	.000
Error	3.073	67	.046		
Total	24.924	72			
Corrected Total	5.216	71			

a R Squared = .411 (Adjusted R Squared = .376)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logSb
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.0139	.07537	1.000	-.2663	.2386
	S	-.0431	.07318	1.000	-.2925	.2062
	G	.0275	.08960	1.000	-.2588	.3138
	UB	-.4762(*)	.13053	.019	-.8932	-.0593
LS	Cz	.0139	.07537	1.000	-.2386	.2663
	S	-.0293	.04309	.999	-.1600	.1015
	G	.0413	.06730	1.000	-.1803	.2630
	UB	-.4624(*)	.11635	.016	-.8538	-.0709
S	Cz	.0431	.07318	1.000	-.2062	.2925
	LS	.0293	.04309	.999	-.1015	.1600
	G	.0706	.06484	.970	-.1465	.2878
	UB	-.4331(*)	.11495	.025	-.8232	-.0430
G	Cz	-.0275	.08960	1.000	-.3138	.2588
	LS	-.0413	.06730	1.000	-.2630	.1803
	S	-.0706	.06484	.970	-.2878	.1465
	UB	-.5037(*)	.12604	.010	-.9107	-.0967
UB	Cz	.4762(*)	.13053	.019	.0593	.8932
	LS	.4624(*)	.11635	.016	.0709	.8538
	S	.4331(*)	.11495	.025	.0430	.8232
	G	.5037(*)	.12604	.010	.0967	.9107

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logSc

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.242(a)	4	1.061	21.645	.000
Intercept	39.717	1	39.717	810.583	.000
bedrock	4.242	4	1.061	21.645	.000
Error	3.724	76	.049		
Total	48.665	81			
Corrected Total	7.966	80			

a R Squared = .533 (Adjusted R Squared = .508)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logSc
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0562	.06553	.994	-.1572	.2696
	S	.0590	.07450	.997	-.1709	.2890
	G	-.1043	.08527	.930	-.3683	.1598
	UB	-.5877(*)	.07982	.000	-.8376	-.3377
LS	Cz	-.0562	.06553	.994	-.2696	.1572
	S	.0029	.05977	1.000	-.1740	.1797
	G	-.1605	.07276	.325	-.3875	.0666
	UB	-.6439(*)	.06629	.000	-.8523	-.4354
S	Cz	-.0590	.07450	.997	-.2890	.1709
	LS	-.0029	.05977	1.000	-.1797	.1740
	G	-.1633	.08093	.418	-.4079	.0812
	UB	-.6467(*)	.07517	.000	-.8742	-.4193
G	Cz	.1043	.08527	.930	-.1598	.3683
	LS	.1605	.07276	.325	-.0666	.3875
	S	.1633	.08093	.418	-.0812	.4079
	UB	-.4834(*)	.08586	.000	-.7460	-.2208
UB	Cz	.5877(*)	.07982	.000	.3377	.8376
	LS	.6439(*)	.06629	.000	.4354	.8523
	S	.6467(*)	.07517	.000	.4193	.8742
	G	.4834(*)	.08586	.000	.2208	.7460

Based on observed means.
* The mean difference is significant at the .05 level.

Univariate Analysis of Variance

Tests of Between-Subjects Effects

Dependent Variable: logSm

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.186(a)	4	.047	.980	.423
Intercept	8.054	1	8.054	169.439	.000
bedrock	.186	4	.047	.980	.423
Error	3.613	76	.048		
Total	12.335	81			
Corrected Total	3.799	80			

a R Squared = .049 (Adjusted R Squared = -.001)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logSm
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.0699	.07496	.990	-.1897	.3294
	S	.0598	.08651	.999	-.2145	.3341
	G	-.0534	.09887	1.000	-.3612	.2545
	UB	-.0192	.07695	1.000	-.2805	.2421
LS	Cz	-.0699	.07496	.990	-.3294	.1897
	S	-.0100	.05582	1.000	-.1760	.1559
	G	-.1232	.07354	.693	-.3583	.1118
	UB	-.0891	.03941	.286	-.2104	.0323
S	Cz	-.0598	.08651	.999	-.3341	.2145
	LS	.0100	.05582	1.000	-.1559	.1760
	G	-.1132	.08528	.886	-.3720	.1456
	UB	-.0790	.05846	.870	-.2525	.0945
G	Cz	.0534	.09887	1.000	-.2545	.3612
	LS	.1232	.07354	.693	-.1118	.3583
	S	.1132	.08528	.886	-.1456	.3720
	UB	.0342	.07557	1.000	-.2047	.2731
UB	Cz	.0192	.07695	1.000	-.2421	.2805
	LS	.0891	.03941	.286	-.0323	.2104
	S	.0790	.05846	.870	-.0945	.2525
	G	-.0342	.07557	1.000	-.2731	.2047

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logSr

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.130(a)	4	.782	4.261	.004
Intercept	209.445	1	209.445	1140.590	.000
bedrock	3.130	4	.782	4.261	.004
Error	13.956	76	.184		
Total	247.678	81			
Corrected Total	17.085	80			

a R Squared = .183 (Adjusted R Squared = .140)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logSr
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.01382	.156644	1.000	-.47095	.49859
	S	.30060	.125668	.227	-.08868	.68988
	G	.36525	.170091	.354	-.16235	.89284
	UB	.58065(*)	.117939	.001	.20269	.95861
LS	Cz	-.01382	.156644	1.000	-.49859	.47095
	S	.28678	.148331	.484	-.16650	.74006
	G	.35143	.187458	.524	-.21876	.92162
	UB	.56683(*)	.141842	.006	.12490	1.00876
S	Cz	-.30060	.125668	.227	-.68988	.08868
	LS	-.28678	.148331	.484	-.74006	.16650
	G	.06465	.162467	1.000	-.43677	.56607
	UB	.28005	.106650	.118	-.03744	.59754
G	Cz	-.36525	.170091	.354	-.89284	.16235
	LS	-.35143	.187458	.524	-.92162	.21876
	S	-.06465	.162467	1.000	-.56607	.43677
	UB	.21540	.156566	.869	-.27622	.70703
UB	Cz	-.58065(*)	.117939	.001	-.95861	-.20269
	LS	-.56683(*)	.141842	.006	-1.00876	-.12490
	S	-.28005	.106650	.118	-.59754	.03744
	G	-.21540	.156566	.869	-.70703	.27622

Based on observed means.
* The mean difference is significant at the .05 level.

Tests of Between-Subjects Effects

Dependent Variable: logTh

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.609(a)	4	.152	3.147	.019
Intercept	37.530	1	37.530	776.060	.000
bedrock	.609	4	.152	3.147	.019
Error	3.675	76	.048		
Total	45.328	81			
Corrected Total	4.284	80			

a R Squared = .142 (Adjusted R Squared = .097)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logTh
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.0100	.06523	1.000	-.2268	.2068
	S	.0031	.07513	1.000	-.2305	.2367
	G	-.2159	.09397	.270	-.5067	.0748
	UB	-.1274	.07322	.647	-.3605	.1058
LS	Cz	.0100	.06523	1.000	-.2068	.2268
	S	.0132	.05634	1.000	-.1537	.1800
	G	-.2059	.07975	.171	-.4592	.0473
	UB	-.1174	.05377	.337	-.2850	.0503
S	Cz	-.0031	.07513	1.000	-.2367	.2305
	LS	-.0132	.05634	1.000	-.1800	.1537
	G	-.2191	.08803	.180	-.4884	.0503
	UB	-.1305	.06543	.425	-.3260	.0650
G	Cz	.2159	.09397	.270	-.0748	.5067
	LS	.2059	.07975	.171	-.0473	.4592
	S	.2191	.08803	.180	-.0503	.4884
	UB	.0886	.08640	.978	-.1793	.3564
UB	Cz	.1274	.07322	.647	-.1058	.3605
	LS	.1174	.05377	.337	-.0503	.2850
	S	.1305	.06543	.425	-.0650	.3260
	G	-.0886	.08640	.978	-.3564	.1793

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logTl

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.211(a)	4	.053	.850	.498
Intercept	71.717	1	71.717	1157.559	.000
bedrock	.211	4	.053	.850	.498
Error	4.709	76	.062		
Total	86.977	81			
Corrected Total	4.919	80			

a R Squared = .043 (Adjusted R Squared = -.008)

Post Hoc Tests

Bedrock

Multiple Comparisons

Dependent Variable: logTl
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	.05915	.059044	.981	-.12693	.24523
	S	.09314	.070985	.891	-.12044	.30673
	G	-.04074	.084363	1.000	-.30293	.22144
	UB	.07638	.089530	.994	-.20724	.36001
LS	Cz	-.05915	.059044	.981	-.24523	.12693
	S	.03399	.066135	1.000	-.16167	.22966
	G	-.09989	.080325	.924	-.35057	.15078
	UB	.01723	.085736	1.000	-.25693	.29140
S	Cz	-.09314	.070985	.891	-.30673	.12044
	LS	-.03399	.066135	1.000	-.22966	.16167
	G	-.13389	.089469	.791	-.40419	.13642
	UB	-.01676	.094357	1.000	-.30714	.27362
G	Cz	.04074	.084363	1.000	-.22144	.30293
	LS	.09989	.080325	.924	-.15078	.35057
	S	.13389	.089469	.791	-.13642	.40419
	UB	.11713	.104793	.959	-.20402	.43828
UB	Cz	-.07638	.089530	.994	-.36001	.20724
	LS	-.01723	.085736	1.000	-.29140	.25693
	S	.01676	.094357	1.000	-.27362	.30714
	G	-.11713	.104793	.959	-.43828	.20402

Based on observed means.

Tests of Between-Subjects Effects

Dependent Variable: logV

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	3.710(a)	4	.927	20.012	.000
Intercept	97.602	1	97.602	2106.103	.000
bedrock	3.710	4	.927	20.012	.000
Error	3.522	76	.046		
Total	112.528	81			
Corrected Total	7.232	80			

a R Squared = .513 (Adjusted R Squared = .487)

Post Hoc Tests

Bedrock

Multiple Comparisons

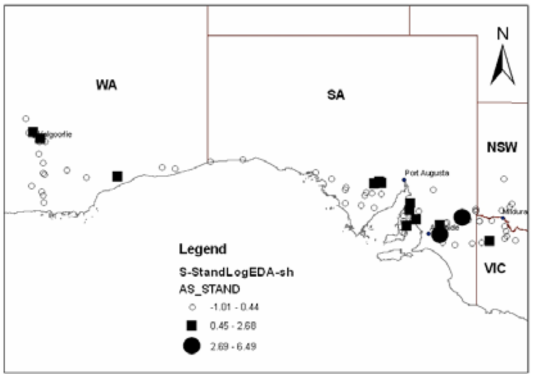
Dependent Variable: logV
Tamhane

(I) Bedrock	(J) Bedrock	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Cz	LS	-.02352	.069358	1.000	-.24117	.19413
	S	-.02158	.064975	1.000	-.22653	.18336
	G	-.05572	.096773	1.000	-.35644	.24500
	UB	-.60775(*)	.069781	.000	-.82771	-.38780
LS	Cz	.02352	.069358	1.000	-.19413	.24117
	S	.00193	.059560	1.000	-.17688	.18074
	G	-.03220	.093224	1.000	-.32208	.25768
	UB	-.58424(*)	.064769	.000	-.78242	-.38605
S	Cz	.02158	.064975	1.000	-.18336	.22653
	LS	-.00193	.059560	1.000	-.18074	.17688
	G	-.03414	.090010	1.000	-.31635	.24808
	UB	-.58617(*)	.060053	.000	-.76838	-.40396
G	Cz	.05572	.096773	1.000	-.24500	.35644
	LS	.03220	.093224	1.000	-.25768	.32208
	S	.03414	.090010	1.000	-.24808	.31635
	UB	-.55204(*)	.093539	.000	-.84312	-.26095
UB	Cz	.60775(*)	.069781	.000	.38780	.82771
	LS	.58424(*)	.064769	.000	.38605	.78242
	S	.58617(*)	.060053	.000	.40396	.76838
	G	.55204(*)	.093539	.000	.26095	.84312

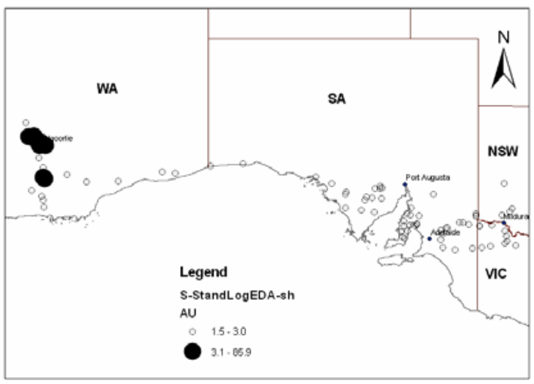
Based on observed means.
* The mean difference is significant at the .05 level.

APPENDIX L: PEDOGEOCHEMICAL RECONNASSIANCE MAPS Concentrations are in ppm (except for Au in ppb).

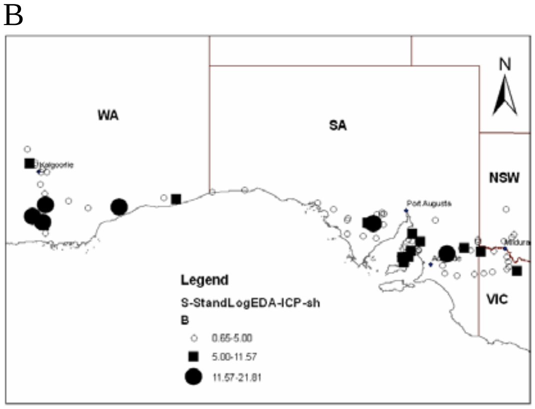
As



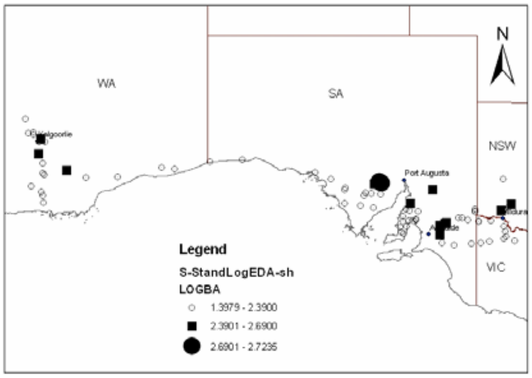
Au



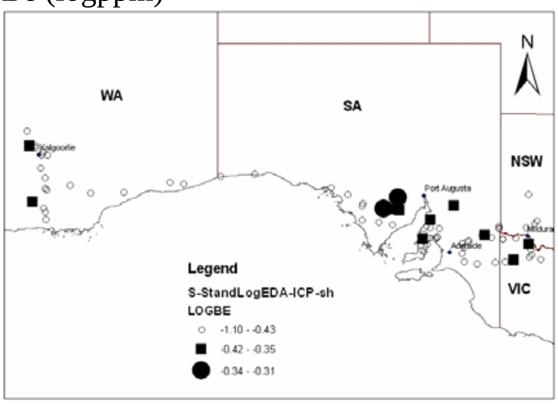
B



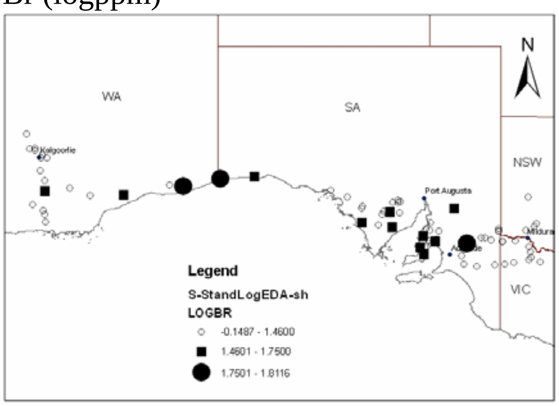
Ba (logppm)



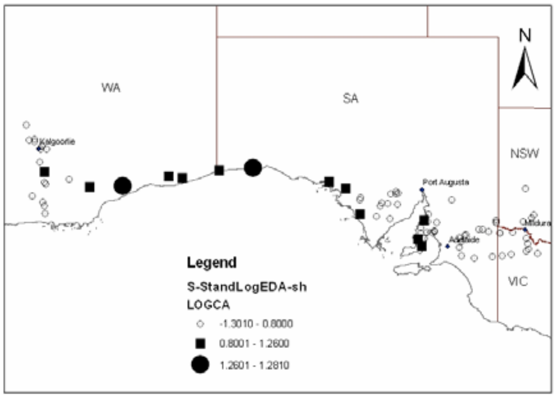
Be (logppm)



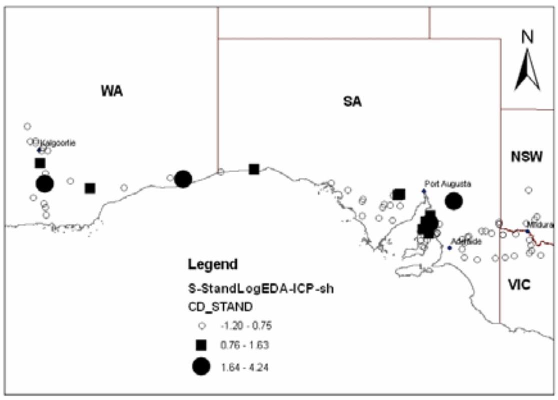
Br (logppm)



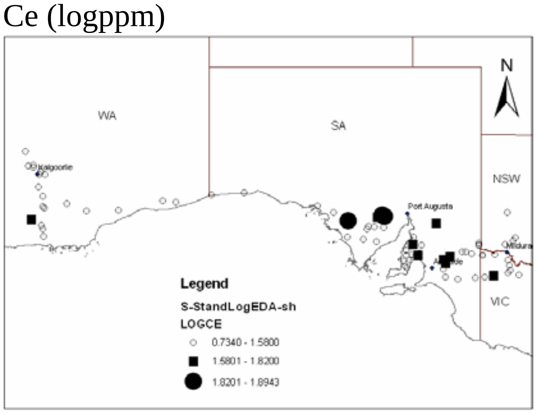
Ca (logppm)



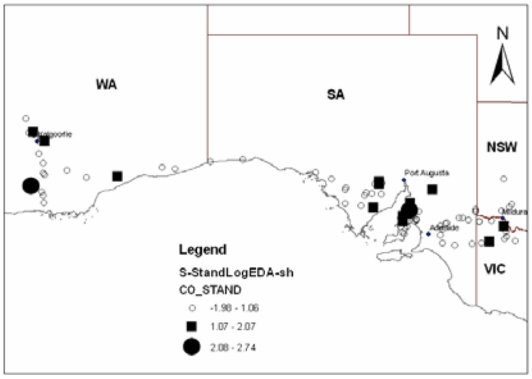
Cd



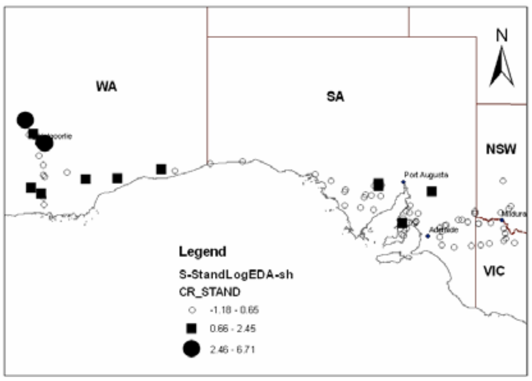
Ce (logppm)



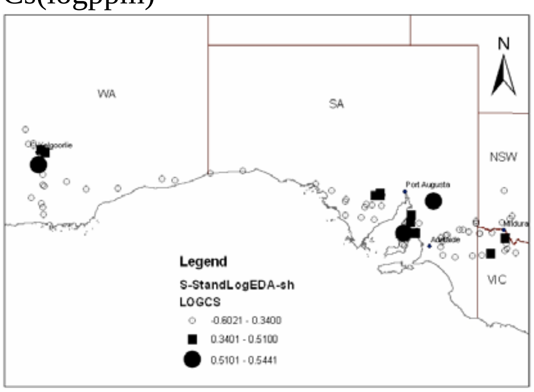
Co



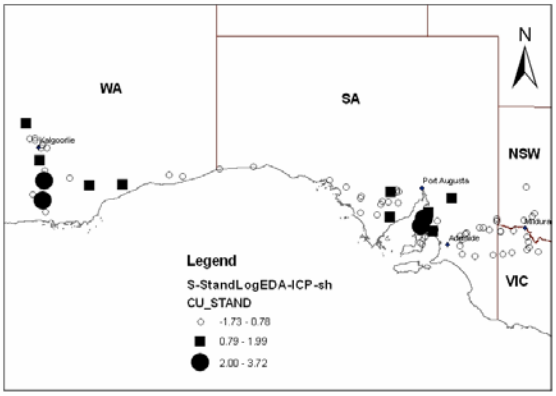
Cr



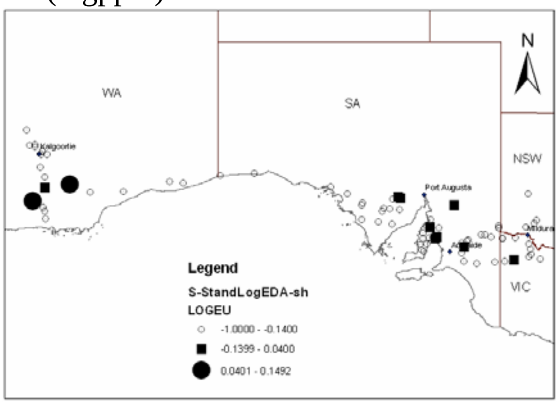
Cs(logppm)



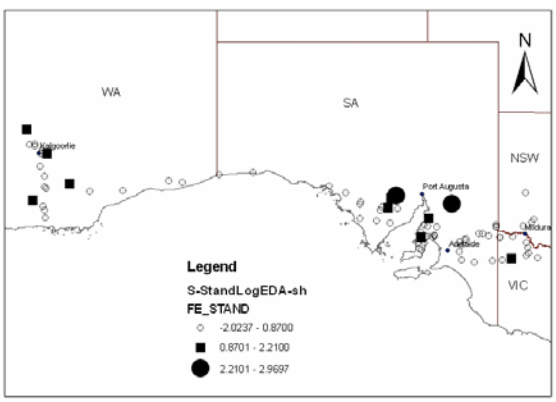
Cu



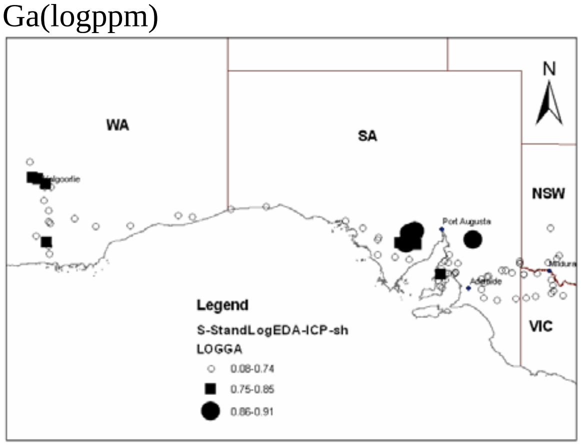
Eu (logppm)



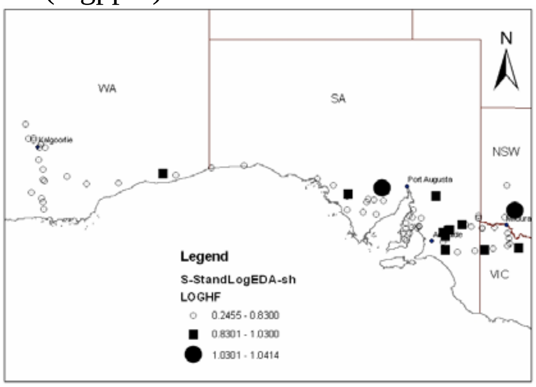
Fe



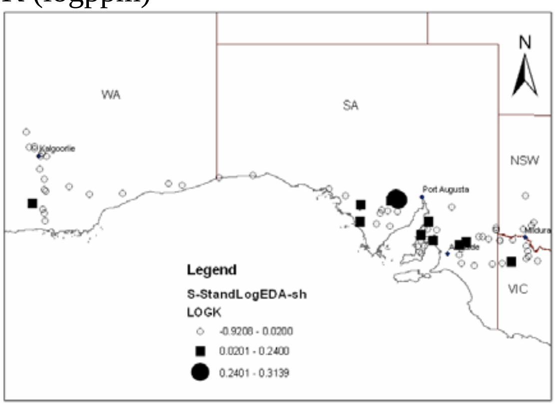
Ga(logppm)



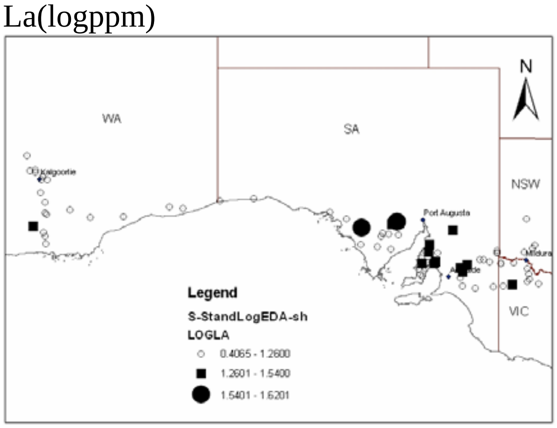
Hf (logppm)



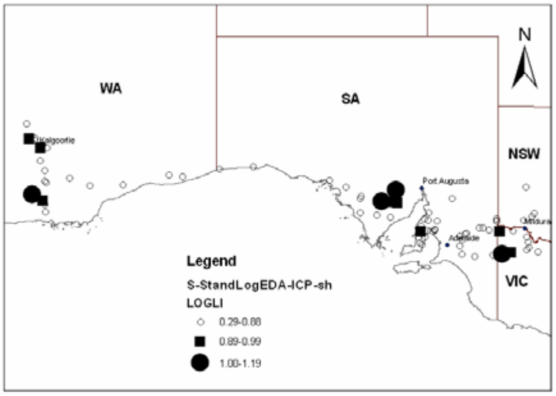
K (logppm)



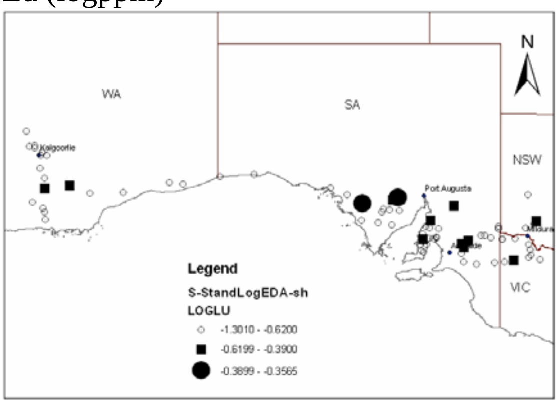
La(logppm)



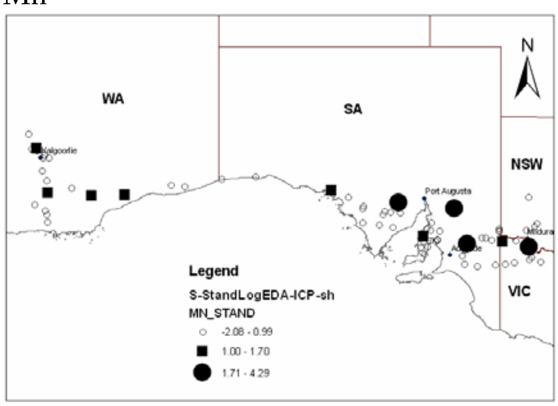
Li (logppm)



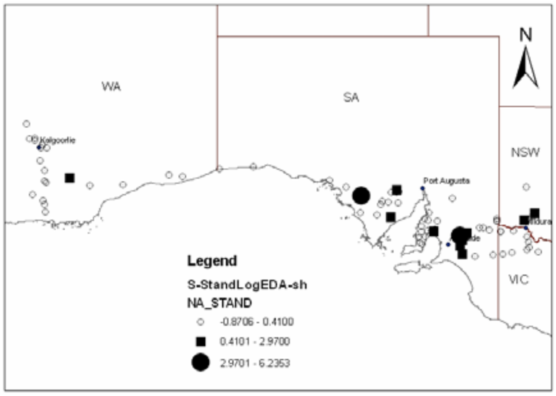
Lu (logppm)



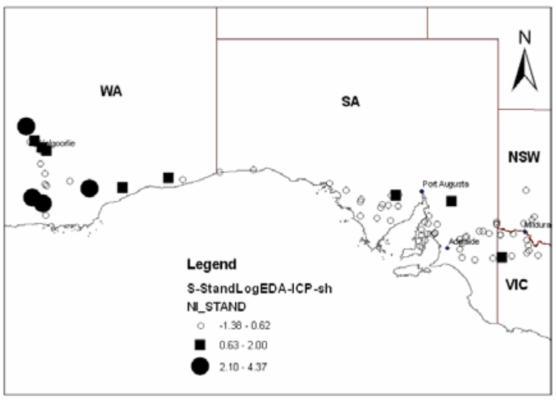
Mn



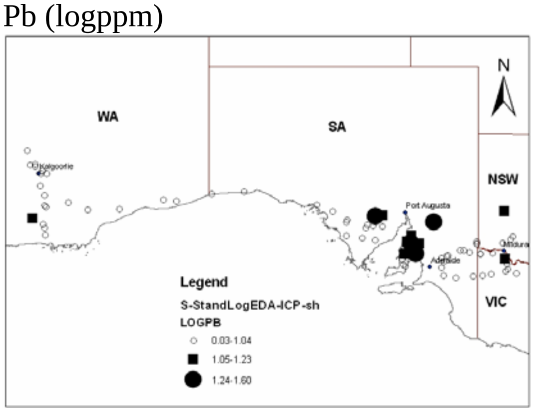
Na



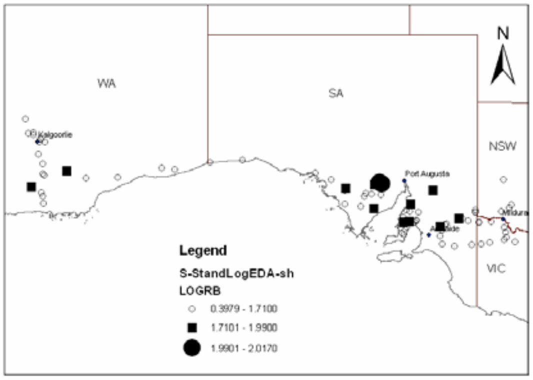
Ni



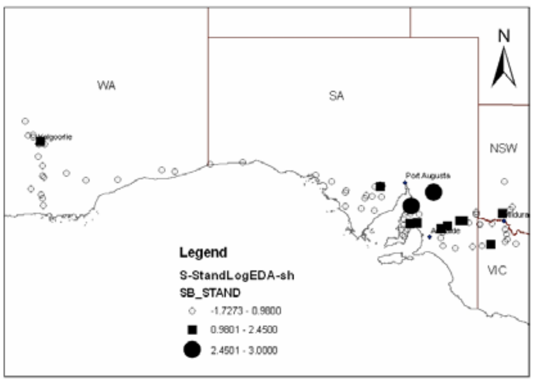
Pb (logppm)



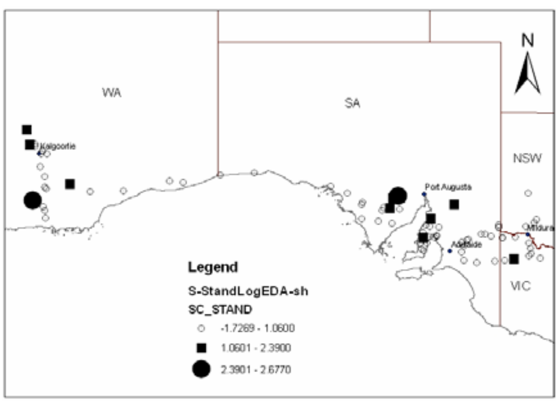
Rb (logppm)



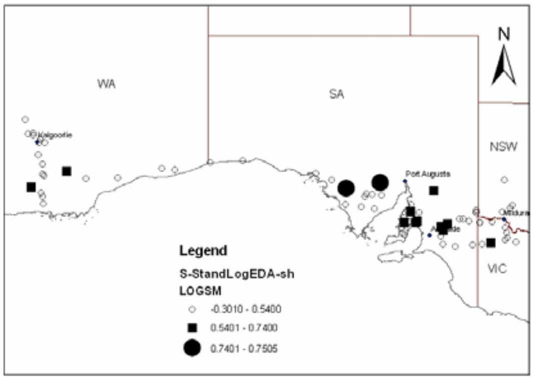
Sb



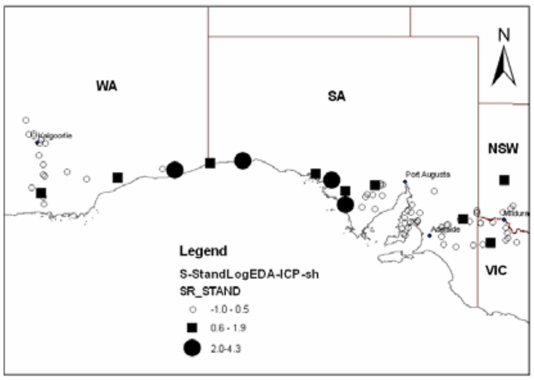
Sc



Sm (logppm)


N
WA
SA
NSW
VIC
Kalgoorlie
Port Augusta
Legend
S-StandLogEDA-sh
LOGSM
-0.3010 - 0.5400
0.5401 - 0.7400
0.7401 - 0.7505

Sr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NSW
VIC
Kalgoorlie
Port Augusta
Legend
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SR_STAND
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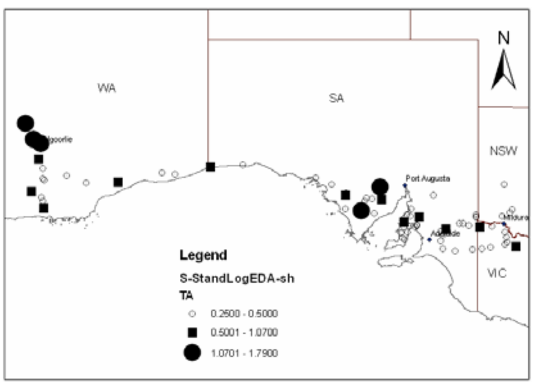
0.6 - 1.9
2.0-4.3

Ta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NSW
VIC
Kalgoorlie
Port Augusta
Legend
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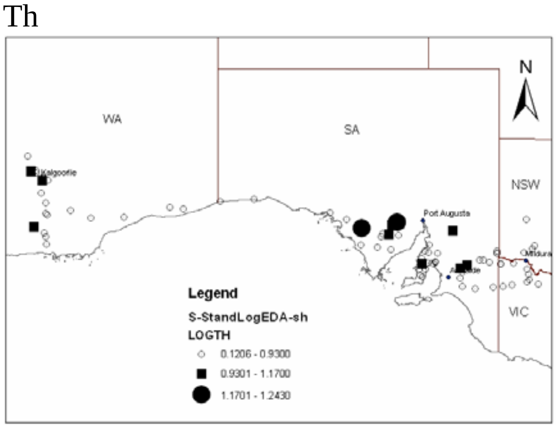
TA
0.2600 - 0.5000
0.5001 - 1.0700
1.0701 - 1.7900

Th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NSW
VIC
Kalgoorlie
Port Augusta
Legend
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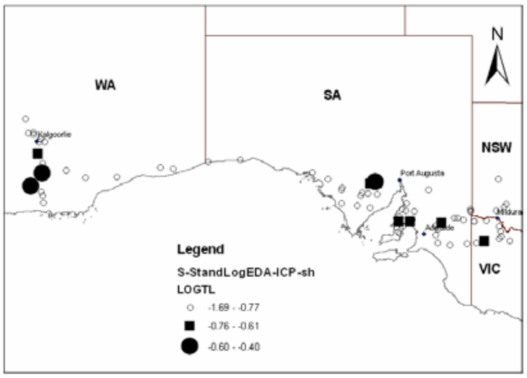
0.9301 - 1.1700
1.1701 - 1.2430

Tl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NSW
VIC
Kalgoorlie
Port Augusta
Mildura
Legend
S-StandLogEDA-ICP-sh
LOGTL
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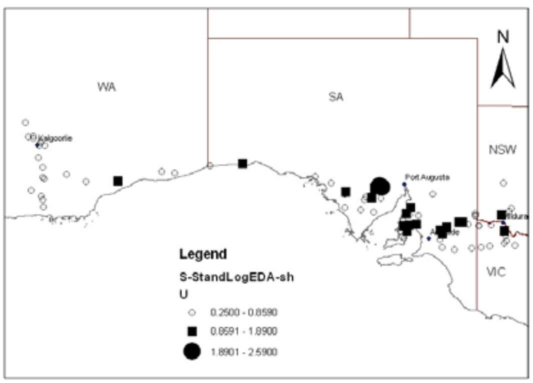
-0.76 - -0.61
-0.60 - -0.40

U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SA
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VIC
Kalgoorlie
Port Augusta
Mildura
Legend
S-StandLogEDA-sh
U
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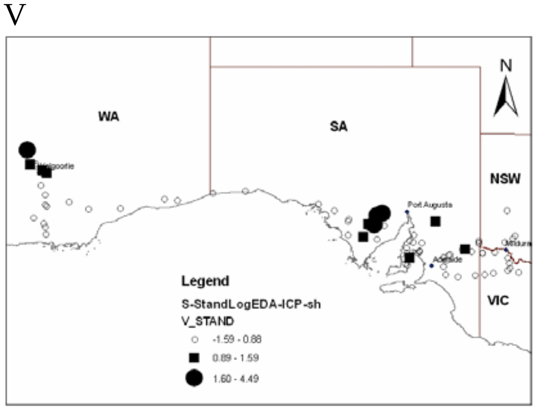
0.8591 - 1.8900
1.8901 - 2.5900

V


N
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SA
NSW
VIC
Port Augusta
Legend
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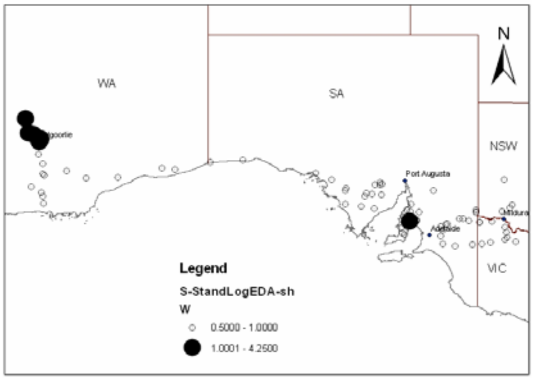
0.89 - 1.59
1.60 - 4.49

W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SA
NSW
VIC
N
Kalgoorlie
Port Augusta
Adelaide
Mildura
Legend
S-StandLogEDA-sh
W
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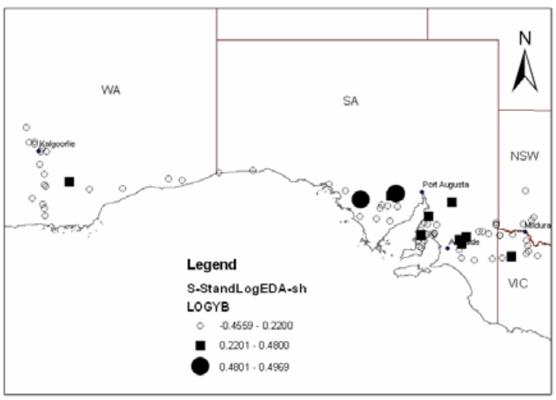
1.0001 - 4.2500

Yb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SA
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VIC
N
Kalgoorlie
Port Augusta
Adelaide
Mildura
Legend
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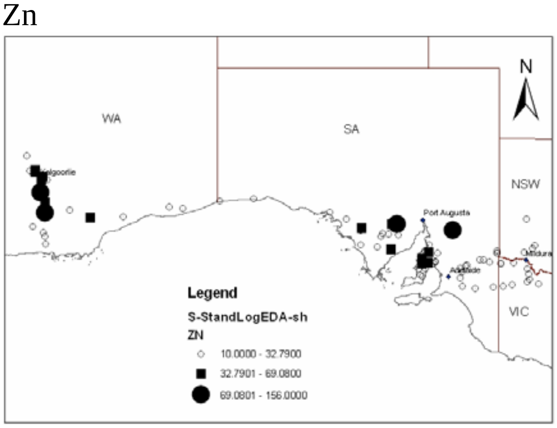
0.4801 - 0.4969

Zn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Kalgoorlie
Port Augusta
Adelaide
Mildura
Legend
S-StandLogEDA-sh
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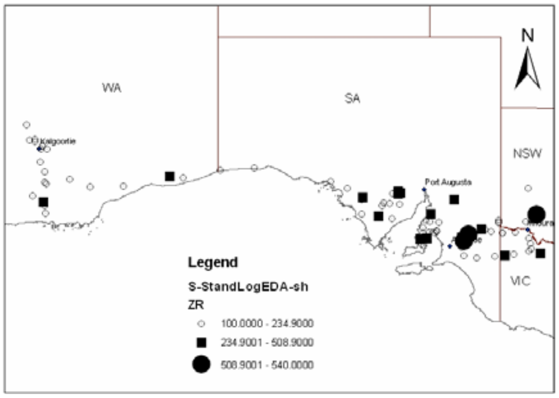
69.0801 - 156.0000

Zr


N
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Kalgoorlie
Port Augusta
Legend
S-StandLogEDA-sh
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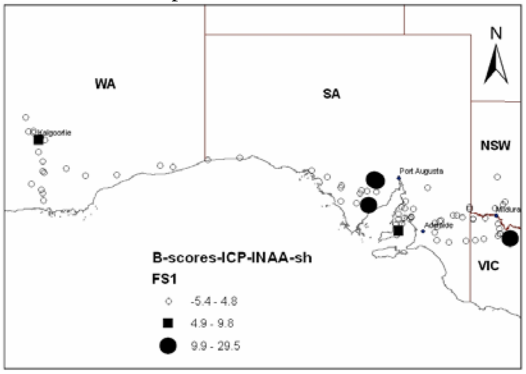
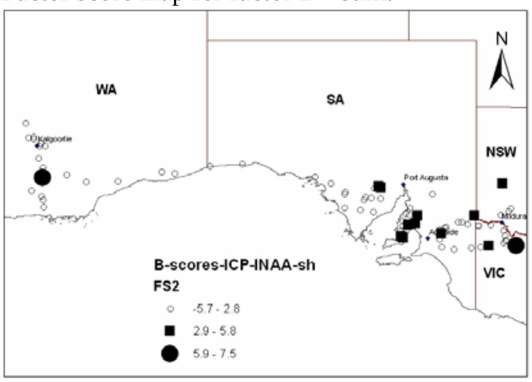
234.9001 - 508.9000
508.9001 - 540.0000

APPENDIX M: FACTOR SCORES MAPS - VEGETATION DATA

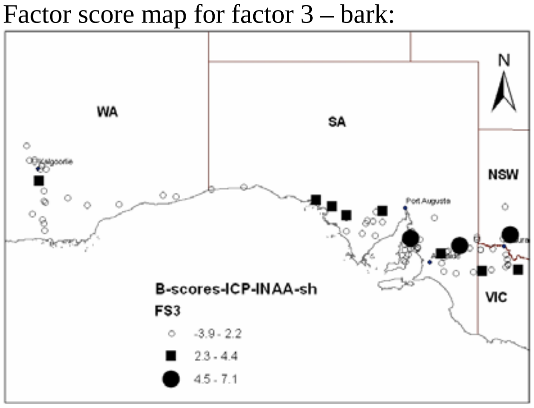
Factor score map for factor 1- bark:



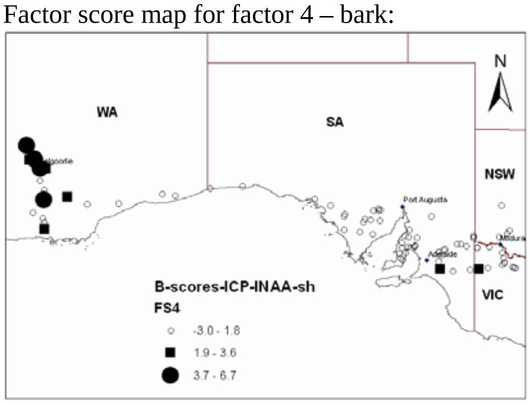
Factor score map for factor 2 – bark:



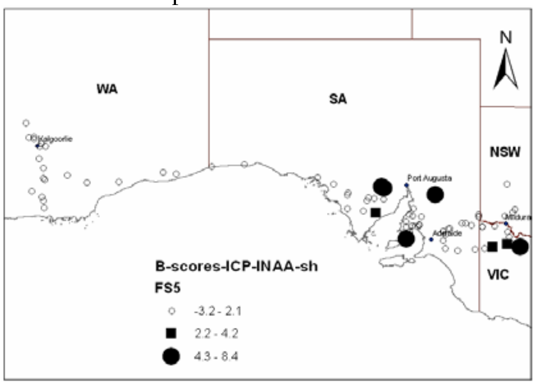
Factor score map for factor 3 – bark:



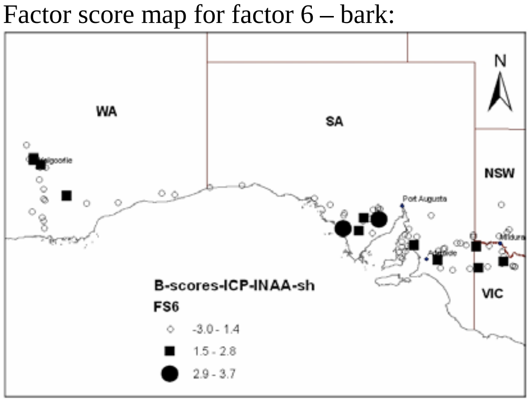
Factor score map for factor 4 – bark:



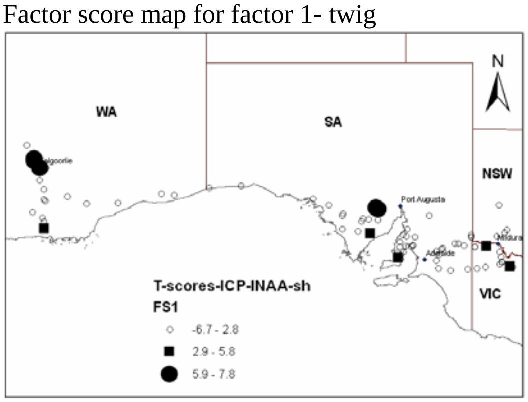
Factor score map for factor 5 – bark:



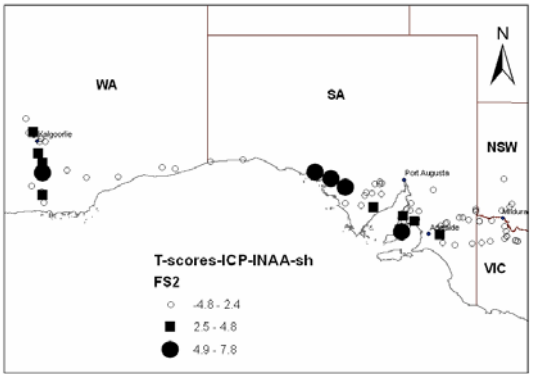
Factor score map for factor 6 – bark:



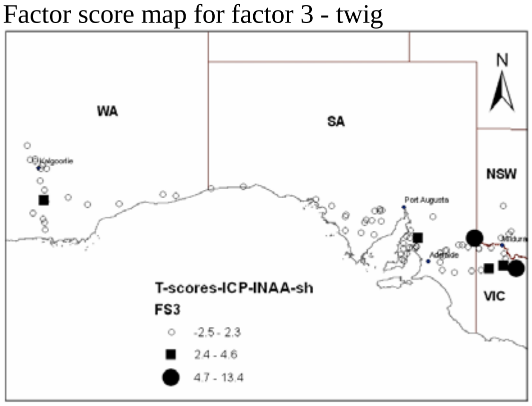
Factor score map for factor 1- twig



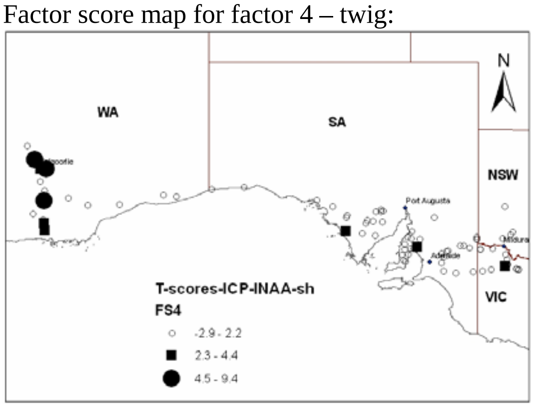
Factor score map for factor 2 – twig:



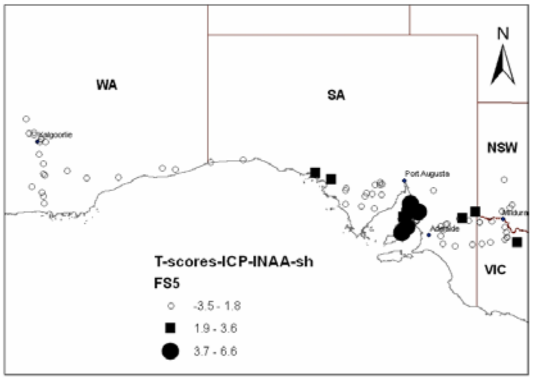
Factor score map for factor 3 - twig



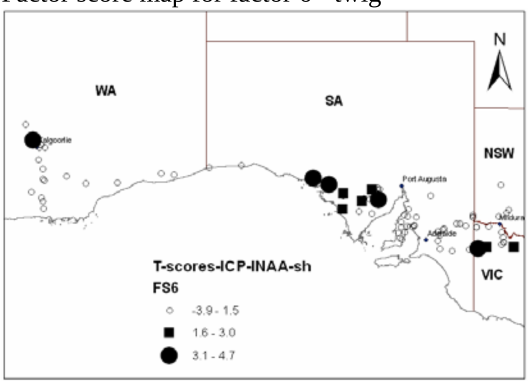
Factor score map for factor 4 – twig:



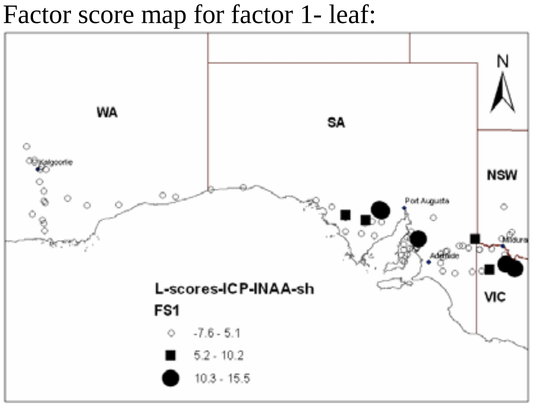
Factor score map for factor 5 – twig:



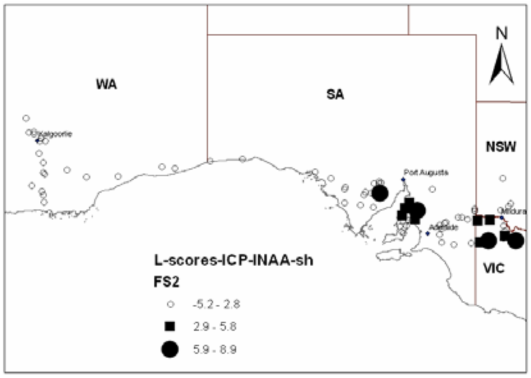
Factor score map for factor 6 - twig



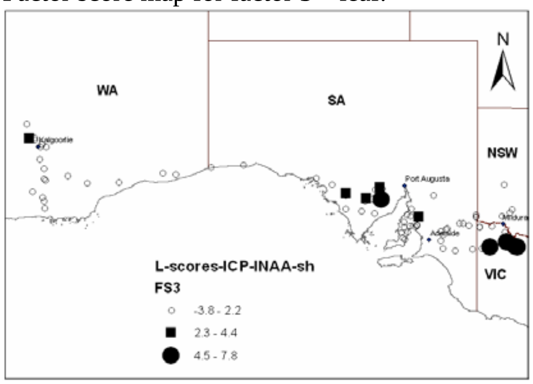
Factor score map for factor 1- leaf:



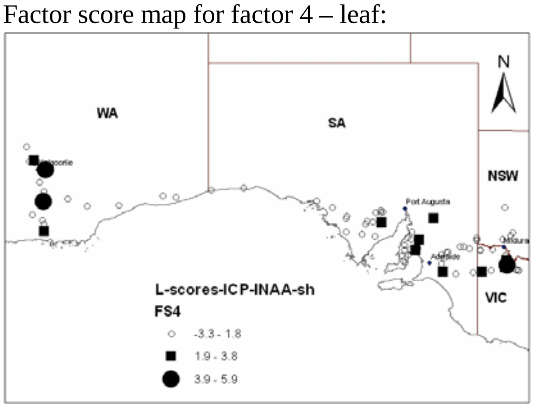
Factor score map for factor 2 – leaf:



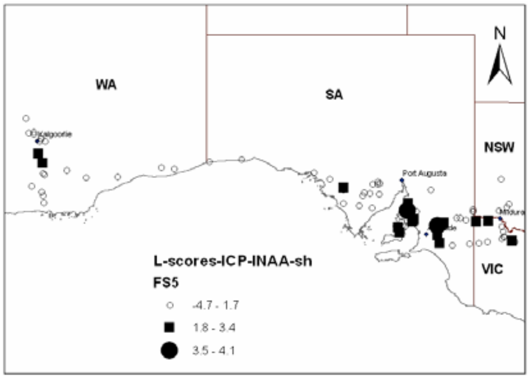
Factor score map for factor 3 – leaf:



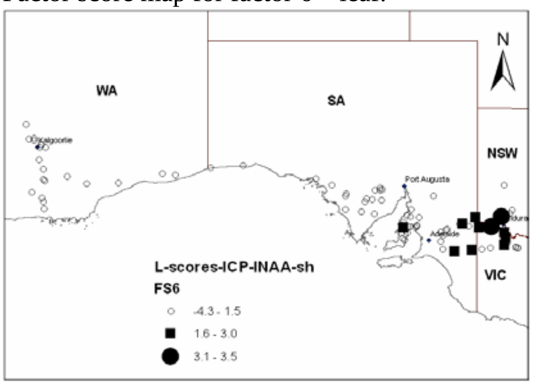
Factor score map for factor 4 – leaf:



Factor score map for factor 5 – leaf:

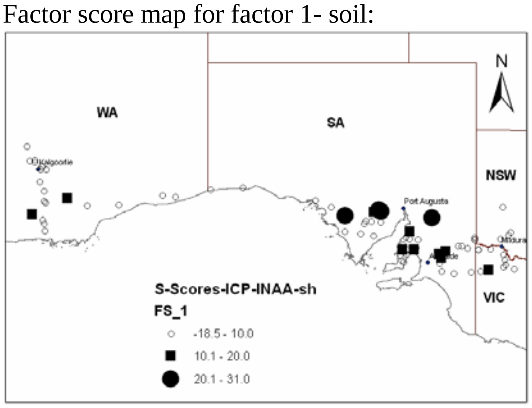


Factor score map for factor 6 – leaf:

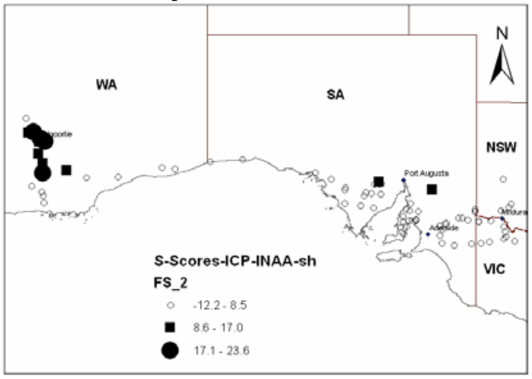


FACTOR SCORE MAPS FOR SOIL DATA

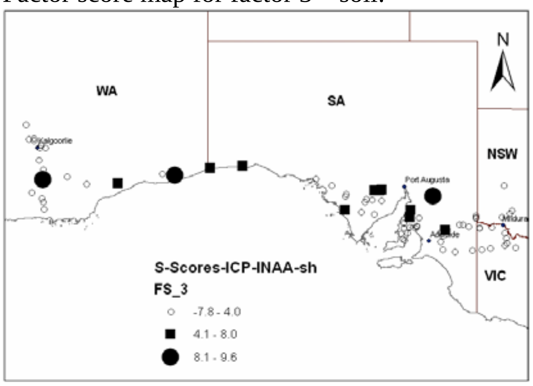
Factor score map for factor 1- soil:



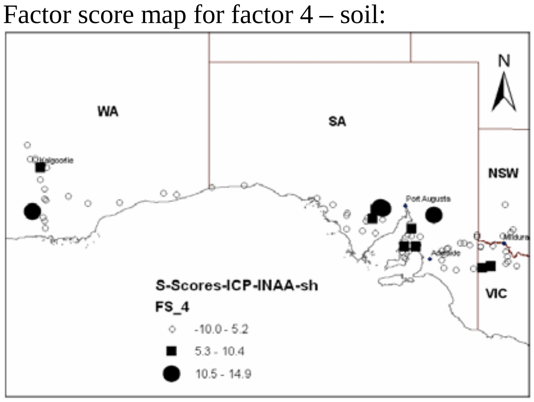
Factor score map for factor 2 – soil:



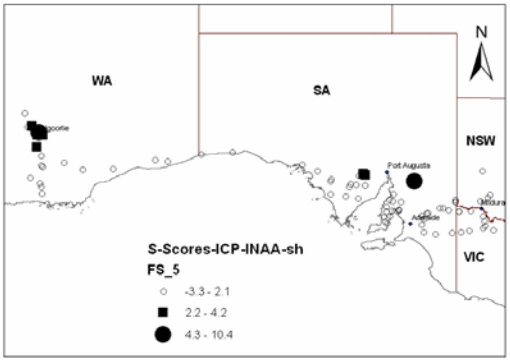
Factor score map for factor 3 – soil:



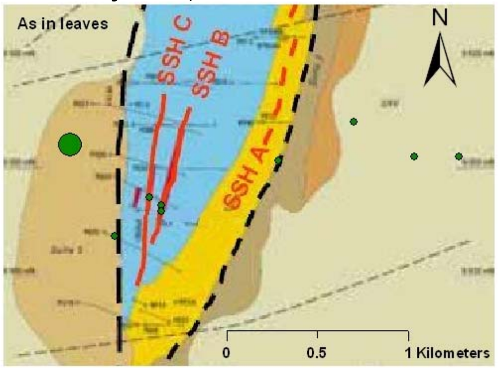
Factor score map for factor 4 – soil:

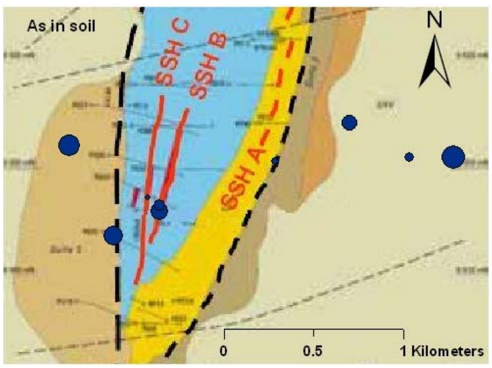


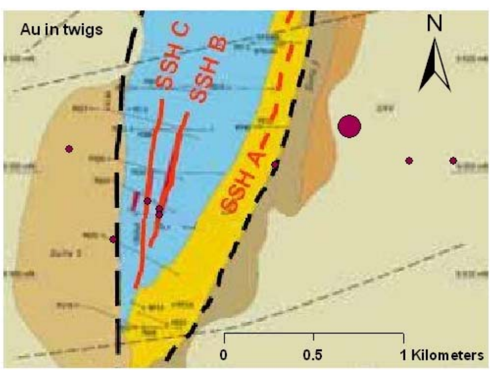
Factor score map for factor 5 – soil:

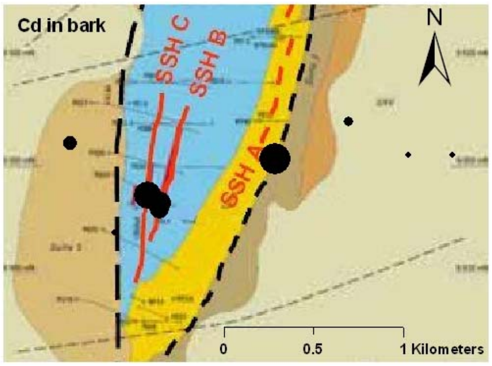

N
WA
SA
NSW
VIC
Port Augusta
S-Scores-ICP-INAA-sh
FS_5
-3.3 - 2.1
2.2 - 4.2
4.3 - 10.4

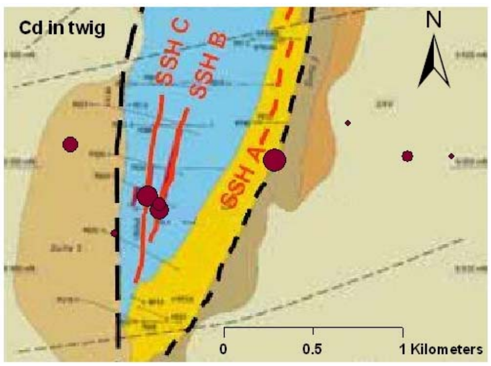
APPENDIX O: BIO- AND PEDOGEOCHEMICAL MAPS- MENNINNIE DAM
(Symbols are proportional to their concentrations, Refer to Appendix N, soil and plant chemistry data).

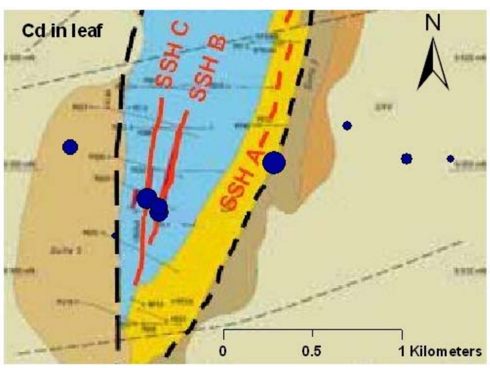


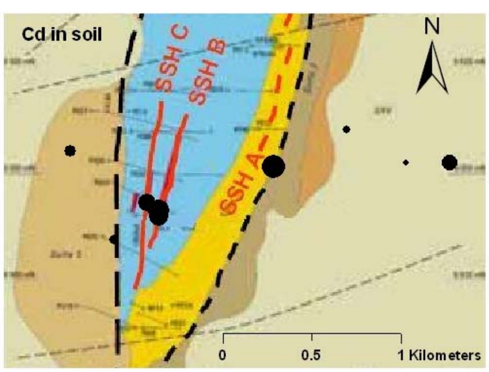


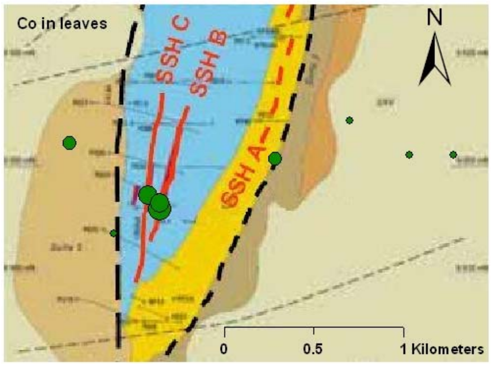


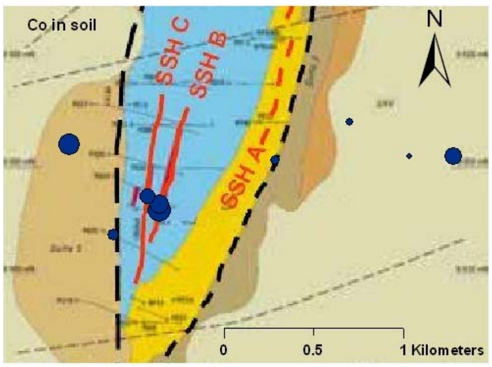

Cd in bark
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

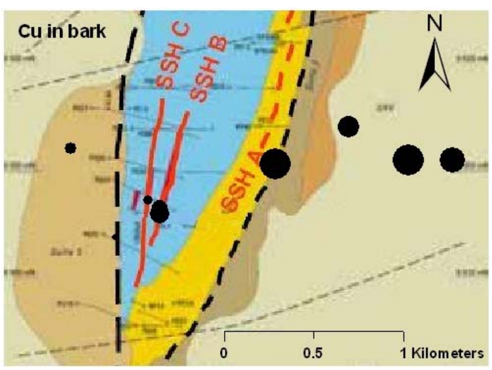

Cd in twig
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

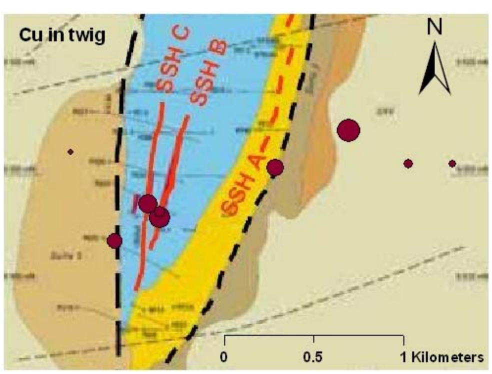

Cd in leaf
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

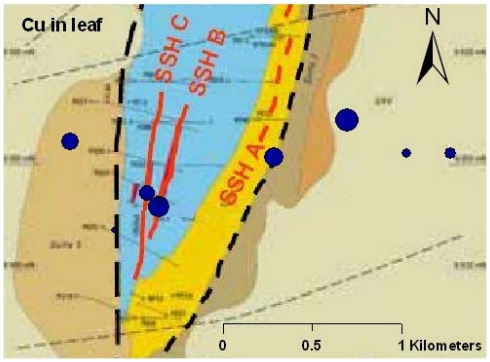

Cd in soil
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

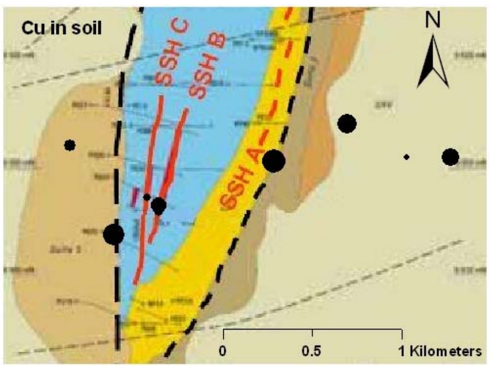

Co in leaves
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

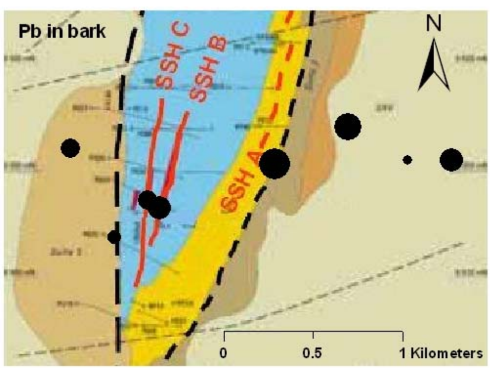

Co in soil
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

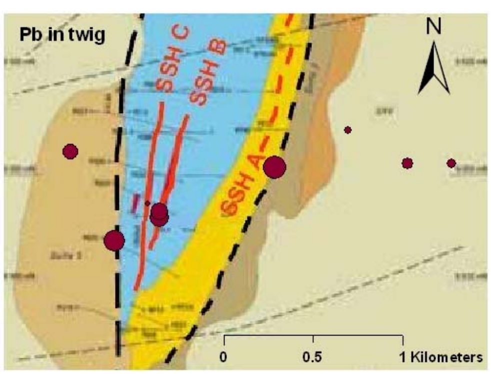

Cu in bark
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

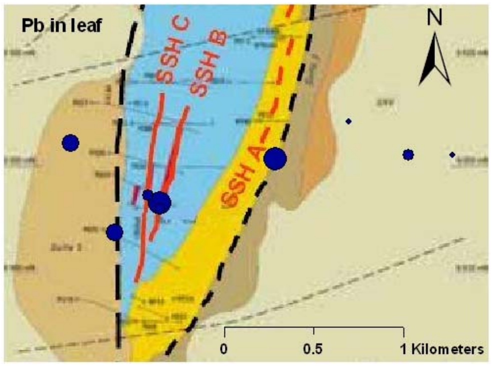

Cu in twig
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

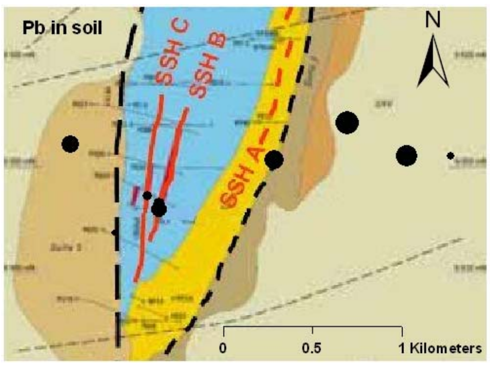

Cu in leaf
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

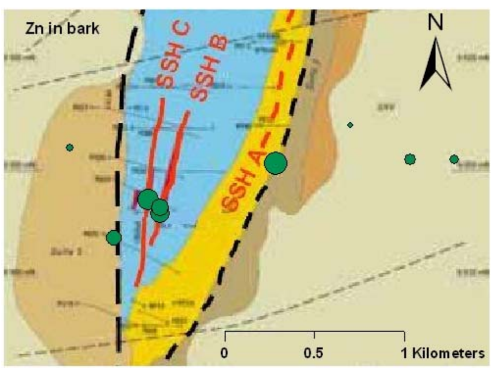

Cu in soil
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

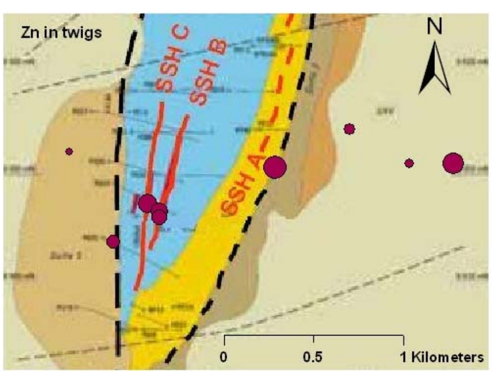

Pb in bark
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

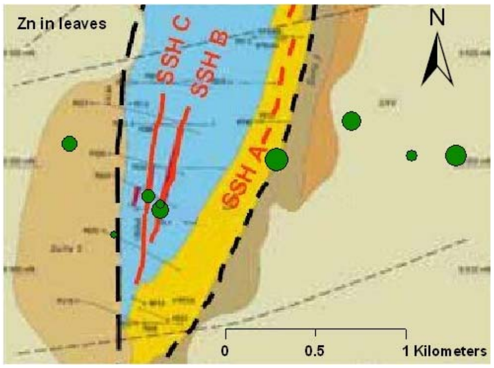

Pb in twig
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

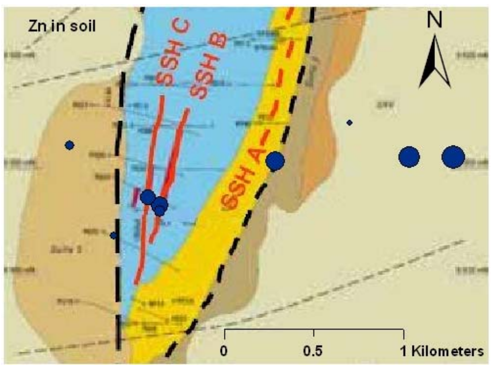

Pb in leaf
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers


Pb in soil
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers


Zn in bark
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

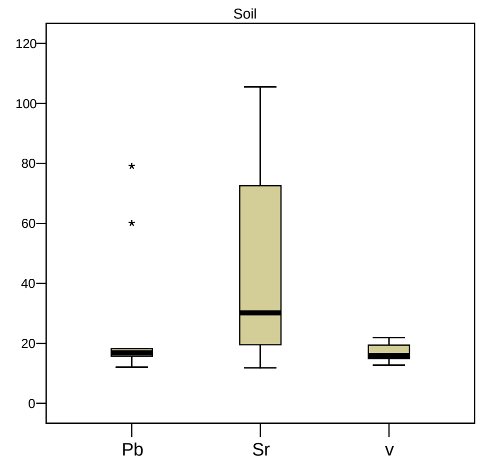

Zn in twigs
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

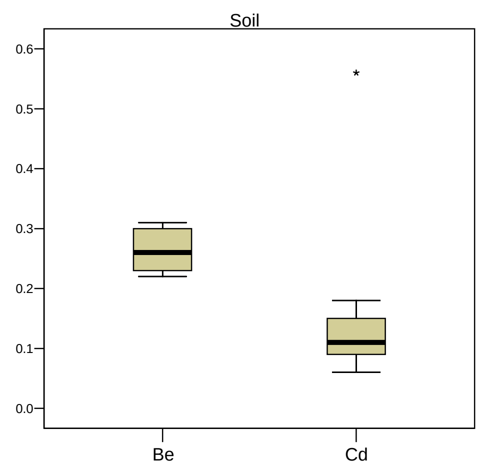

Zn in leaves
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

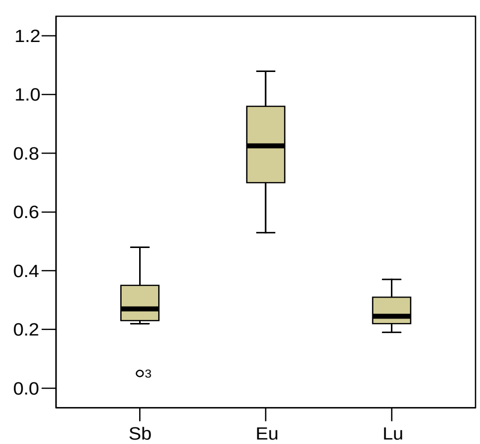

Zn in soil
SSH C
SSH B
SSH A
N
0
0.5
1 Kilometers

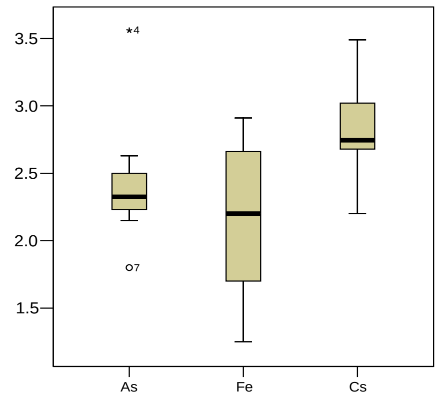
APPENDIX Q: EXPLORATORY DATA ANALYSIS- MENNINNIE DAM

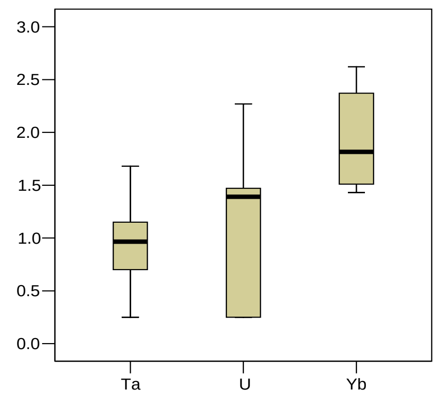
A. Soil (The Y axis is ppm.)

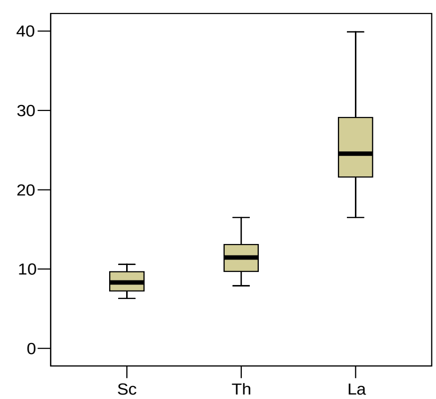


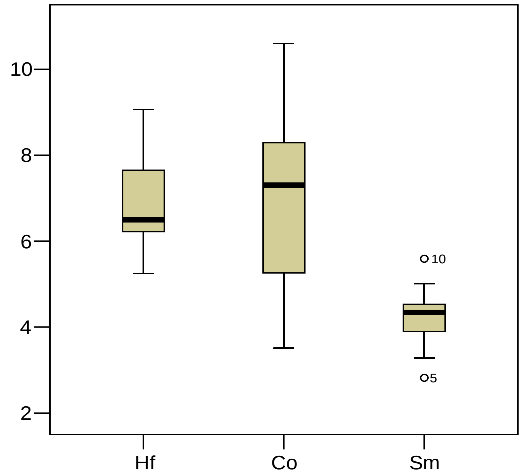


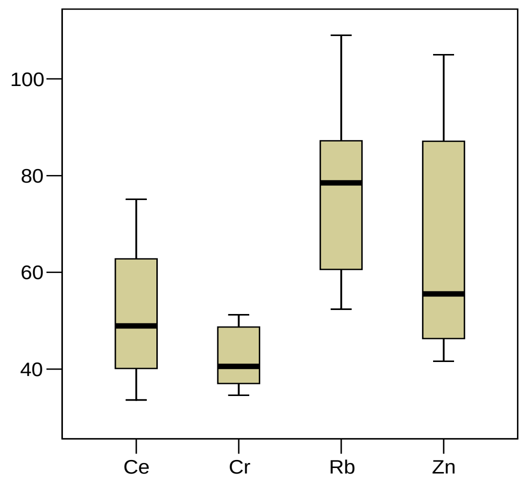



3.5
3.0
2.5
2.0
1.5
4
7
As
Fe
Cs

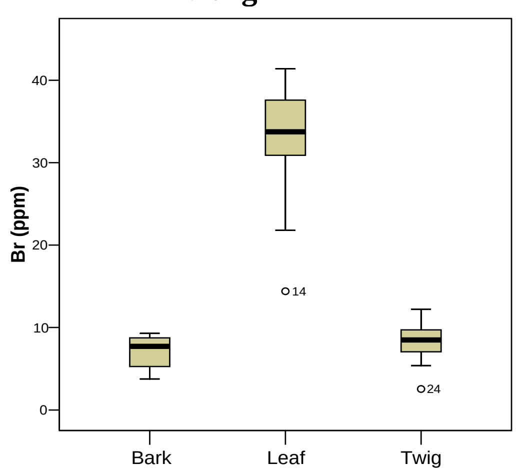

3.0
2.5
2.0
1.5
1.0
0.5
0.0
Ta
U
Yb

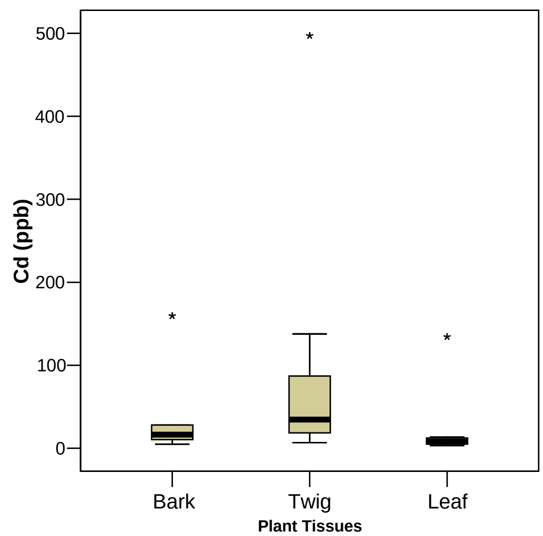

40
30
20
10
0
Sc
Th
La



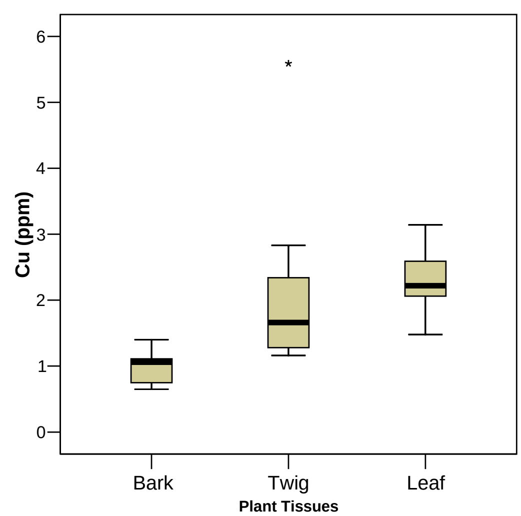


B. Vegetation

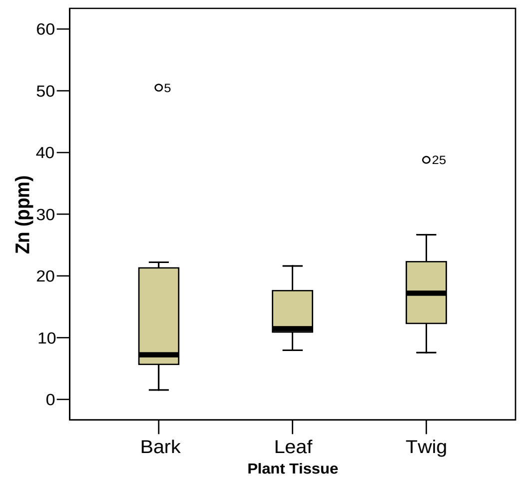




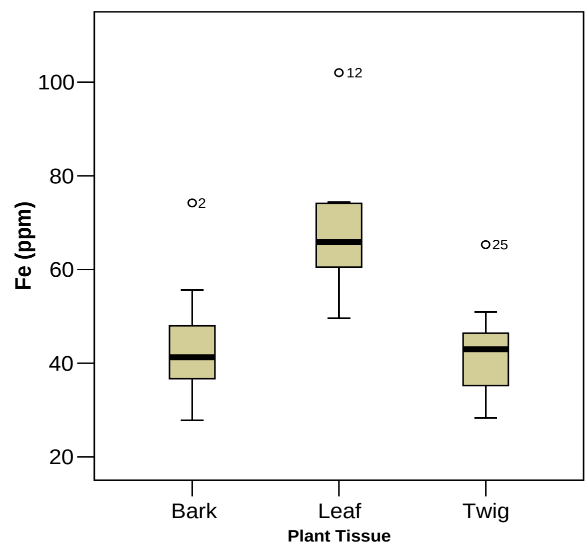
Cd (ppb)
500
400
300
200
100
0
Bark
Twig
Leaf
Plant Tissues



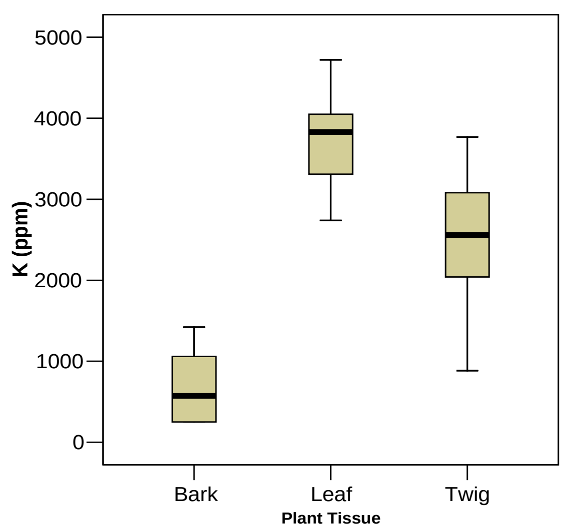
Cu (ppm)
6
5
4
3
2
1
0
Bark
Twig
Leaf
Plant Tissues



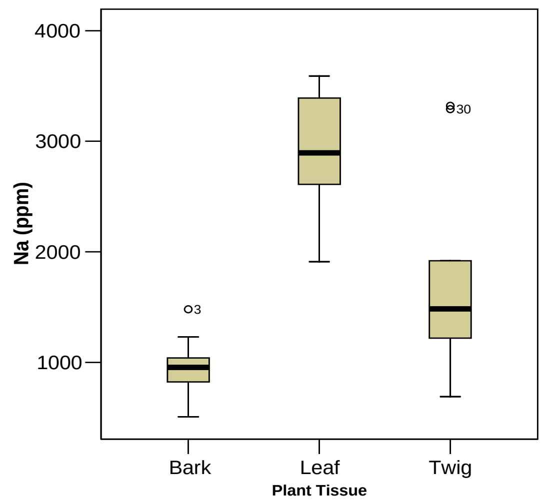
Zn (ppm)
0
10
20
30
40
50
60
5
25
Bark
Leaf
Twig
Plant Tissue



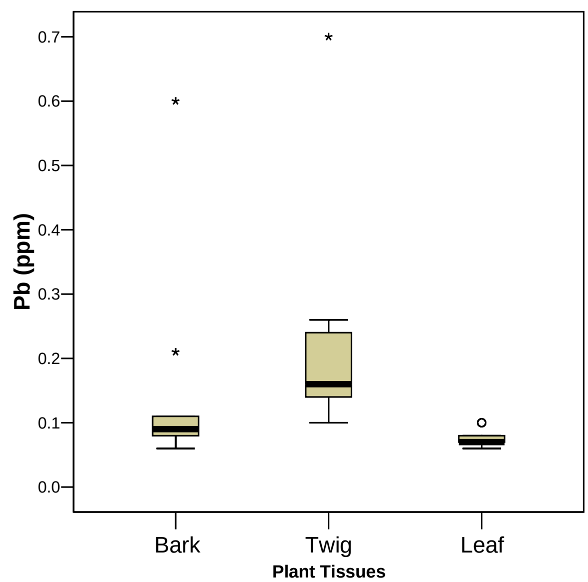
Fe (ppm)
20
40
60
80
100
12
2
25
Bark
Leaf
Twig
Plant Tissue



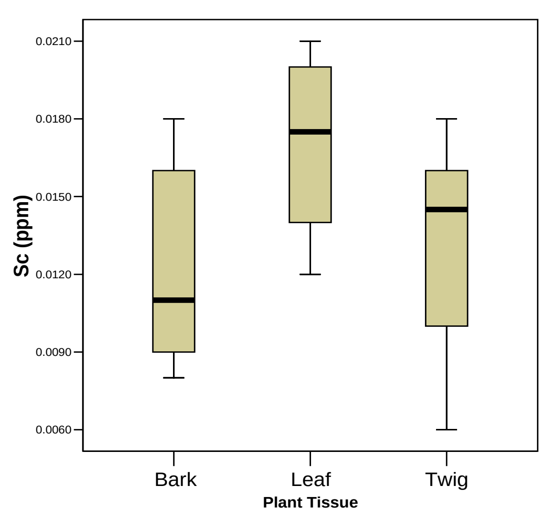
K (ppm)
0
1000
2000
3000
4000
5000
Bark
Leaf
Twig
Plant Tissue



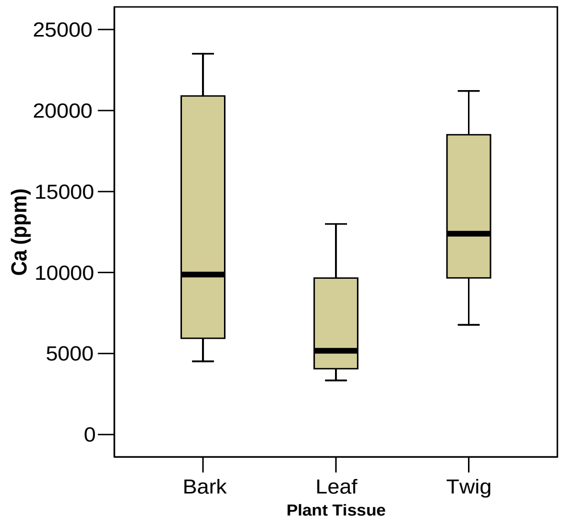
Na (ppm)
4000
3000
2000
1000
3
30
Bark
Leaf
Twig
Plant Tissue



Pb (ppm)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Bark
Twig
Leaf
Plant Tissues



Sc (ppm)
0.0210
0.0180
0.0150
0.0120
0.0090
0.0060
Bark
Leaf
Twig
Plant Tissue


25000
20000
15000
10000
5000
0
Ca (ppm)
Bark
Leaf
Twig
Plant Tissue

APPENDIX S: SOME PHOTOGRAPHS OF STUDY SITES

S.1 A photograph of study site 30, north of Waikerie, SA.

S.2 A photograph of study site 115, Pinkawillinie, SA.

S.3 A photograph of study site 114, Buckleboo-Kyancutta, SA.

S.4 A photograph of study site 59, SW. of Pinnaroo, SA.


S.5 A photograph of study site 208, Menninnie Dam, SA.


S.6 A photograph of study site 145, Bardoc, WA.

APPENDIX A: DISTRIBUTION OF MALLEE SPECIES AMONG SAMPLING SITES

Table A1: Distribution of sampling sites based on botanical regions

No.	Botanical Regions	Number of sample sites
1	NSW: South Far Western Plains	20-22-23
2	Vic.: Murray & Lowan Mallee	12-13-15-16-18-19-24-25-60-61-62
3	SA: Northern Lofty	94 to 97-99
4	SA: Murray	51 to 53,55 to 59, 27-29-30, 201-202,65
5	SA: Yorke Peninsula	98-100-102 to 106-108-109
6	SA: Eastern (southern section)	65
7	SA: Eyre Peninsula	92-113-114-115-203 to 215- 164-166-167-168-173-217-218
8	SA&WA: Nullarbor	156 to 158, 160 to 162
9	WA: Eastern gold fields	116-127-129-130-134-136 to 139-141-142-144-145-148-152-155

Table A2: Type of mallee species in the sampling sites

	LAT.	LONG.	E.oleosa	E.gracilis	E.socialis	E.eremophila	Botanical Regions (state)
B-12-1	-35.195	142.802		*			2 (VIC)
B-12-2	-35.195	142.802	*				2 (VIC)
B-13-1	-35.186	142.687	*				2 (VIC)
B-13-2	-35.186	142.687	*				2 (VIC)
B-15-1	-34.972	142.313			*		2 (VIC)
B-15-2	-34.972	142.313			*		2 (VIC)
B-16	-34.745	142.274			*		2 (VIC)
B-18	-34.543	142.211			*		2 (VIC)
B-19	-32.404	142.186		*			2 (VIC)
B-20	-33.828	142.078			*		1 (NSW)
B-22	-33.663	142.436	*				1 (NSW)
B-23	-33.531	142.553	*				1 (NSW)
B-24	-34.277	141.653	*				2 (VIC)
B-25-1	-34.307	141.097			*		2 (VIC)
B-25-2	-34.306	141.097			*		2 (VIC)
B-27	-34.247	140.622			*		4 (SA)
B-29	-34.154	140.357		*			4 (SA)
B-30	-34.154	140.189		*			4 (SA)
B-51	-34.403	139.599	*				4 (SA)
B-52	-34.358	139.661			*		4 (SA)
B-53	-34.484	139.360		*			4 (SA)
B-55	-34.672	139.455		*			4 (SA)
B-56	-34.905	139.364			*		4 (SA)
B-57	-35.271	139.459			*		4 (SA)
B-58	-35.379	140.019		*			4 (SA)
B-59	-35.306	140.786		*			4 (SA)
B-60	-35.264	141.196		*			2 (VIC)
B-61	-35.198	141.579	*				2 (VIC)
B-62	-35.080	142.229	*				2 (VIC)
B-65	-32.905	139.038			*		6 (SA)
B-92	-33.076	136.725		*			7 (SA)
B-94	-34.312	138.256			*		3 (SA)
B-95	-34.234	138.294		*			3 (SA)
B-96	-34.208	138.318	*				3 (SA)

B-97	-33.847	138.407		*			3 (SA)
B-98	-33.834	138.017	*				5 (SA)
B-99	-33.519	138.063	*				3 (SA)
B-100	-33.772	137.846	*				5 (SA)
B-102	-34.085	137.730			*		5 (SA)
B-103	-34.315	137.719	*				5 (SA)
B-104	-34.578	137.598		*			5 (SA)
B-105	-34.788	137.651			*		5 (SA)
B-106	-34.850	137.762		*			5 (SA)
B-108	-34.537	137.880		*			5 (SA)
B-109	-34.280	137.987		*			5 (SA)
B-113	-33.054	136.325			*		7 (SA)
B-114	-33.016	136.056	*				7 (SA)
B-115	-33.139	136.002	*				7 (SA)
B-116	-31.305	121.505				*	9 (WA)
B-127	-32.743	121.193		*			9 (WA)
B-129	-32.979	121.641	*				9 (WA)
B-130	-33.466	121.737	*(1)				9 (WA)
B-134	-33.147	121.706	*(1)				9 (WA)
B-136	-32.215	121.778				*	9 (WA)
B-137	-30.433	121.286				*	9 (WA)
B-138	-30.359	121.056				*	9 (WA)
B-139	-30.742	121.551				*	9 (WA)
B-141	-30.743	121.796				*	9 (WA)
B-142	-30.616	121.600				*	9 (WA)
B-144	-30.616	121.600				*	9 (WA)
B-145	-30.333	121.290	*				9 (WA)
B-148	-29.708	120.930	*				9 (WA)
B-152	-32.150	121.717	*(1)				9 (WA)
B-155	-32.036	122.759				*	9 (WA)
B-156	-32.354	123.616	*				8 (WA)
B-157	-32.323	125.048	*				8 (WA)
B-158	-31.899	127.005		*			8 (WA)
B-160	-31.959	127.579		*			8 (WA)
B-161	-31.658	129.128	*(2)				8 (SA)
B-162	-31.552	130.595		*			8 (SA)
B-164	-32.125	133.829	*				7 (SA)
B-166	-32.405	134.515			*		7 (SA)
B-167	-32.815	135.159			*		7 (SA)
B-168	-32.892	135.117	*				7 (SA)
B-173	-33.491	135.146	*				7 (SA)
B-201-1	-33.848	140.949		*			4 (SA)
B-201-2	-33.848	140.949		*			4 (SA)
B-202	-33.776	140.940		*			4 (SA)
B-203	-32.620	136.771	*				7 (SA)
B-204	-32.534	136.677			*		7 (SA)
B-205	-32.644	136.428	*				7 (SA)
B-206	-32.646	136.431	*				7 (SA)
B-207	-32.646	136.433	*				7 (SA)
B-208	-32.648	136.434	*				7 (SA)

B-209	-32.646	136.424	*				7 (SA)
B-210	-32.636	136.676	*				7 (SA)
B-211	-32.646	136.414	*				7 (SA)
B-212	-32.648	136.418		*			7 (SA)
B-213	-32.648	136.419	*				7 (SA)
B-214	-32.650	136.416	*				7 (SA)
B-215	-32.649	136.419	*				7 (SA)
B-216	-31.716	121.691		*			9 (WA)
B-217	-33.599	135.823			*		7 (SA)
B-218	-33.691	136.409			*		7 (SA)

*(1) E.transcontinentialis, *(2) E. diversifolia

APPENDIX E: BIOGEOCHEMICAL DATASET

	Ag	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs
DL	0.20	0.10	0.50	0.3	5.00	0.004	0.10	200.0	0.005	0.30	0.10	0.20	0.020
	ppm	ppm	ppb	ppm	ppm	ppb	ppm	ppm	ppb	ppm	ppm	ppm	ppm
B-12-1	-0.20	-0.10	-0.50	6.97	6.07	4.2	6.84	17700.0	<DL	-0.30	-0.10	-0.20	-0.020
B-12-2	-0.20	-0.10	-0.50	4.73	7.51	6.8	5.97	12800.0	<DL	0.44	-0.10	0.35	0.029
B-13-1	-0.20	-0.10	-0.50	4.09	5.45	<DL	10.50	2590.0	25.7	-0.30	-0.10	-0.20	-0.020
B-13-2	-0.20	-0.10	-0.50	13.05	6.74	3.4	6.09	6190.0	8.9	-0.30	-0.10	-0.20	-0.020
B-15-1	-0.20	-0.10	-0.50	19.13	9.52	6.9	5.69	3590.0	21.6	0.31	-0.10	-0.20	0.028
B-15-2	-0.20	-0.10	-0.50	10.05	-5.00	4.1	5.61	2310.0	11.3	-0.30	-0.10	-0.20	-0.020
B-16	-0.20	-0.10	-0.50	13.06	-5.00	4.9	8.00	12900.0	4.1	-0.30	-0.10	-0.20	-0.020
B-18	-0.20	-0.10	-0.50	10.14	-5.00	4.8	10.10	6870.0	3.2	-0.30	-0.10	-0.20	0.022
B-19	-0.20	-0.10	-0.50	9.34	-5.00	7.8	10.20	6080.0	7.3	-0.30	-0.10	-0.20	-0.020
B-20	-0.20	-0.10	-0.50	10.22	-5.00	<DL	10.60	3890.0	3.5	-0.30	-0.10	-0.20	-0.020
B-22	-0.20	-0.10	-0.50	5.77	5.22	2.9	7.16	31100.0	6.0	-0.30	-0.10	-0.20	0.021
B-23	-0.20	-0.10	-0.50	11.46	-5.00	<DL	3.79	7830.0	4.1	-0.30	-0.10	-0.20	-0.020
B-24	-0.20	-0.10	-0.50	6.89	-5.00	<DL	7.03	3980.0	4.8	-0.30	-0.10	0.21	-0.020
B-25-1	-0.20	-0.10	-0.50	13.38	-5.00	<DL	6.69	13000.0	7.2	-0.30	-0.10	-0.20	-0.020
B-25-2	-0.20	-0.10	-0.50	10.22	6.08	<DL	11.30	7630.0	7.0	-0.30	-0.10	-0.20	0.023
B-27	-0.20	-0.10	-0.50	6.84	-5.00	<DL	8.74	5140.0	3.4	-0.30	-0.10	-0.20	-0.020
B-29	-0.20	-0.10	-0.50	10.48	12.50	11.6	9.91	4460.0	5.7	-0.30	-0.10	-0.20	-0.020
B-30	-0.20	-0.10	-0.50	9.11	-5.00	<DL	7.57	31800.0	5.4	0.31	-0.10	0.27	-0.020
B-51	-0.20	-0.10	-0.50	9.11	-5.00	4.1	13.60	7110.0	5.1	-0.30	-0.10	-0.20	-0.020
B-52	-0.20	-0.10	-0.50	10.47	6.48	4.0	7.76	18800.0	3.5	-0.30	-0.10	-0.20	-0.020
B-53	-0.20	-0.10	-0.50	6.63	5.17	<DL	5.99	20700.0	3.4	-0.30	-0.10	-0.20	-0.020
B-55	-0.20	-0.10	-0.50	4.81	-5.00	3.3	7.33	3340.0	21.2	0.30	-0.10	-0.20	-0.020
B-56	-0.20	-0.10	-0.50	18.70	-5.00	<DL	9.32	3490.0	4.7	-0.30	-0.10	-0.20	0.021
B-57	-0.20	-0.10	-0.50	9.10	-5.00	<DL	7.52	4310.0	17.6	-0.30	-0.10	-0.20	-0.020
B-58	-0.20	-0.10	-0.50	12.33	8.29	<DL	5.57	3400.0	7.0	-0.30	-0.10	0.22	-0.020
B-59	-0.20	-0.10	-0.50	8.74	-5.00	<DL	6.56	6720.0	8.8	-0.30	-0.10	-0.20	-0.020
B-60	-0.20	-0.10	-0.50	7.94	-5.00	<DL	7.64	10500.0	2.7	-0.30	-0.10	-0.20	-0.020
B-61	-0.20	-0.10	-0.50	6.62	7.39	<DL	7.82	3620.0	3.0	-0.30	-0.10	-0.20	0.025
B-62	-0.20	-0.10	-0.50	5.12	-5.00	13.3	9.45	5410.0	9.5	0.48	-0.10	-0.20	0.066
B-65	-0.20	-0.10	-0.50	6.33	7.76	<DL	7.63	6560.0	5.8	-0.30	-0.10	-0.20	0.022
B-92	-0.20	-0.10	-0.50	21.50	-5.00	<DL	5.72	8250.0	<DL	-0.30	-0.10	-0.20	-0.020
B-94	-0.20	-0.10	-0.50	4.68	-5.00	<DL	12.70	4050.0	7.9	-0.30	-0.10	-0.20	-0.020
B-95	-0.20	-0.10	-0.50	15.42	-5.00	<DL	12.20	4250.0	6.1	-0.30	-0.10	-0.20	-0.020
B-96	-0.20	-0.10	-0.50	4.32	5.38	<DL	12.40	4590.0	22.0	-0.30	-0.10	-0.20	0.032
B-97	-0.20	-0.10	-0.50	5.64	-5.00	<DL	8.07	3890.0	8.4	-0.30	-0.10	-0.20	-0.020
B-98	-0.20	-0.10	0.73	1.67	7.11	<DL	5.39	26900.0	2.4	-0.30	-0.10	-0.20	-0.020
B-99	-0.20	-0.10	-0.50	9.44	6.44	<DL	9.07	4290.0	16.2	-0.30	-0.10	-0.20	-0.020
B-100	-0.20	-0.10	-0.50	3.38	9.33	<DL	10.20	3450.0	8.8	-0.30	-0.10	-0.20	0.044
B-102	-0.20	-0.10	-0.50	11.32	-5.00	<DL	10.00	6330.0	5.5	-0.30	-0.10	-0.20	-0.020
B-103	-0.20	-0.10	-0.50	9.36	-5.00	<DL	7.84	13700.0	12.0	-0.30	-0.10	-0.20	0.033
B-104	-0.20	-0.10	0.72	6.12	-5.00	<DL	5.78	12400.0	1.8	-0.30	-0.10	-0.20	-0.020
B-105	-0.20	-0.10	-0.50	14.99	-5.00	<DL	6.91	4530.0	10.1	0.34	-0.10	0.23	-0.020
B-106	-0.20	-0.10	-0.50	8.84	-5.00	<DL	11.50	5010.0	33.8	0.35	0.12	0.54	-0.020
B-108	-0.20	-0.10	-0.50	8.13	-5.00	<DL	7.96	3210.0	8.2	-0.30	-0.10	-0.20	-0.020
B-109	-0.20	-0.10	-0.50	7.86	-5.00	<DL	13.70	4540.0	9.2	-0.30	-0.10	-0.20	-0.020
B-113	-0.20	-0.10	-0.50	4.14	-5.00	<DL	4.43	3540.0	9.6	-0.30	-0.10	-0.20	-0.020
B-114	-0.20	-0.10	-0.50	16.98	-5.00	<DL	8.05	4140.0	8.6	-0.30	-0.10	-0.20	-0.020
B-115	-0.20	-0.10	-0.50	8.89	-5.00	<DL	5.98	9140.0	5.3	-0.30	-0.10	-0.20	-0.020
B-116	-0.20	-0.10	-0.50	9.42	-5.00	<DL	5.04	20000.0	4.3	-0.30	-0.10	-0.20	-0.020

B-127	-0.20	-0.10	-0.50	8.24	-5.00	<DL	4.09	5660.0	4.6	-0.30	-0.10	-0.20	-0.020
B-129	-0.20	-0.10	-0.50	2.39	-5.00	<DL	6.02	2320.0	2.1	-0.30	-0.10	-0.20	-0.020
B-130	-0.20	-0.10	-0.50	5.18	-5.00	<DL	6.67	7060.0	10.0	-0.30	-0.10	0.24	-0.020
B-134	-0.20	-0.10	-0.50	3.42	5.22	<DL	7.33	2350.0	28.1	-0.30	-0.10	-0.20	-0.020
B-136	-0.20	-0.10	-0.50	9.92	-5.00	<DL	3.50	5280.0	5.4	-0.30	-0.10	0.27	-0.020
B-137	-0.20	0.11	-0.50	12.46	6.67	<DL	4.67	10400.0	6.0	-0.30	-0.10	-0.20	-0.020
B-138	-0.20	-0.10	-0.50	8.22	-5.00	<DL	3.74	9460.0	2.5	-0.30	-0.10	0.49	-0.020
B-139	-0.20	0.18	4.20	4.49	-5.00	<DL	3.18	11400.0	16.1	-0.30	0.25	0.95	0.020
B-141	-0.20	-0.10	-0.50	3.37	-5.00	<DL	2.75	5430.0	9.1	-0.30	0.11	0.25	-0.020
B-142	-0.20	0.37	0.61	11.26	-5.00	<DL	3.73	13000.0	2.8	-0.30	-0.10	0.31	-0.020
B-144	-0.20	0.28	0.65	9.90	9.94	<DL	2.83	7980.0	<DL	-0.30	0.27	1.67	0.039
B-145	-0.20	0.44	1.66	11.09	-5.00	<DL	3.33	8880.0	7.5	-0.30	0.15	1.25	0.029
B-148	-0.20	-0.10	-0.50	6.46	7.12	<DL	2.71	13600.0	3.3	-0.30	-0.10	-0.20	-0.020
B-152	-0.20	-0.10	-0.50	8.47	-5.00	<DL	11.20	1840.0	61.0	-0.30	0.32	0.44	-0.020
B-155	-0.20	-0.10	-0.50	8.70	-5.00	<DL	2.74	3070.0	9.8	-0.30	-0.10	-0.20	-0.020
B-156	-0.20	-0.10	-0.50	12.20	-5.00	<DL	2.23	10600.0	<DL	-0.30	-0.10	-0.20	0.050
B-157	-0.20	-0.10	-0.50	11.53	-5.00	<DL	5.71	3870.0	<DL	-0.30	-0.10	-0.20	-0.020
B-158	-0.20	-0.10	-0.50	8.47	-5.00	<DL	5.58	13400.0	7.4	-0.30	-0.10	0.40	0.024
B-160	-0.20	-0.10	-0.50	10.50	-5.00	<DL	6.28	7800.0	2.6	-0.30	-0.10	-0.20	0.048
B-161	-0.20	-0.10	-0.50	9.60	-5.00	<DL	6.22	15800.0	10.8	-0.30	-0.10	-0.20	0.020
B-162	-0.20	-0.10	-0.50	11.00	-5.00	<DL	6.38	5980.0	2.6	-0.30	-0.10	-0.20	-0.020
B-164	-0.20	-0.10	-0.50	5.81	-5.00	<DL	9.99	17900.0	<DL	-0.30	-0.10	0.36	0.043
B-166	-0.20	-0.10	-0.50	7.47	-5.00	<DL	6.71	16200.0	<DL	-0.30	-0.10	-0.20	-0.020
B-167	-0.20	-0.10	-0.50	10.19	-5.00	<DL	8.20	26900.0	<DL	-0.30	-0.10	0.33	0.047
B-168	-0.20	-0.10	-0.50	9.44	7.09	<DL	14.00	7550.0	4.8	0.30	-0.10	0.28	-0.020
B-173	-0.20	-0.10	-0.50	18.79	6.40	13.4	9.33	6060.0	4.7	-0.30	-0.10	-0.20	-0.020
B-201-1	-0.20	-0.10	-0.50	6.11	5.63	20.3	8.03	4600.0	4.0	-0.30	-0.10	-0.20	0.021
B-201-2	-0.20	-0.10	-0.50	3.70	-5.00	13.4	10.60	2670.0	6.0	-0.30	-0.10	-0.20	-0.020
B-202	-0.20	-0.10	-0.50	5.62	6.15	5.7	10.10	6830.0	18.7	-0.30	-0.10	-0.20	0.030
B-203	-0.20	-0.10	-0.50	5.65	16.60	7.7	11.50	19100.0	5.3	1.06	0.14	0.78	-0.020
B-204	-0.20	-0.10	-0.50	8.30	9.64	10.9	8.19	3760.0	20.2	0.44	-0.10	0.40	-0.020
B-208	-0.20	-0.10	-0.50	10.52	-5.00	<DL	3.76	11000.0	<DL	-0.30	-0.10	-0.20	-0.020
B-210	-0.20	-0.10	-0.50	7.42	-5.00	<DL	5.37	13700.0	<DL	-0.30	-0.10	-0.20	-0.020
B-217	-0.20	-0.10	0.52	12.97	-5.00	<DL	8.40	3040.0	9.9	-0.30	-0.10	-0.20	0.040
B-218	-0.20	-0.10	-0.50	3.75	-5.00	<DL	11.20	6850.0	5.1	0.53	0.12	0.49	0.028
T-12-1	-0.20	-0.10	-0.50	7.9	-5.00	10.2	5.93	17000.0	6.3	0.51	-0.10	-0.20	-0.020
T-12-2	-0.20	-0.10	-0.50	7.4	8.98	7.7	4.84	20800.0	7.4	-0.30	-0.10	-0.20	-0.020
T-13-1	-0.20	-0.10	-0.50	8.5	-5.00	<DL	7.97	9230.0	18.5	0.52	-0.10	-0.20	-0.020
T-13-2	-0.20	-0.10	-0.50	11.7	6.35	5.5	8.75	10600.0	26.8	-0.30	-0.10	-0.20	0.022
T-15-1	-0.20	-0.10	-0.50	4.5	6.97	<DL	3.90	5880.0	19.6	-0.30	-0.10	-0.20	-0.020
T-15-2	-0.20	-0.10	-0.50	9.2	-5.00	3.7	8.40	8790.0	17.3	-0.30	-0.10	0.52	-0.020
T-16	-0.20	-0.10	-0.50	12.3	-5.00	<DL	6.50	9340.0	<DL	-0.30	-0.10	-0.20	-0.020
T-18	-0.20	-0.10	-0.50	9.7	5.42	7.0	2.84	13300.0	7.3	-0.30	-0.10	-0.20	-0.020
T-19	-0.20	-0.10	-0.50	8.1	7.07	7.8	4.05	9050.0	11.9	-0.30	-0.10	-0.20	0.029
T-20	-0.20	-0.10	-0.50	12.1	5.10	<DL	7.18	11700.0	3.9	-0.30	-0.10	-0.20	-0.020
T-22	-0.20	0.10	-0.50	8.6	-5.00	<DL	7.32	12000.0	3.4	-0.30	-0.10	-0.20	-0.020
T-23	-0.20	-0.10	-0.50	11.9	-5.00	<DL	4.47	11100.0	3.8	-0.30	-0.10	-0.20	0.030
T-24	-0.20	-0.10	-0.50	6.6	5.54	8.4	5.39	6210.0	18.5	-0.30	-0.10	-0.20	0.022
T-25-1	-0.20	-0.10	-0.50	12.5	-5.00	<DL	6.15	12200.0	4.5	-0.30	-0.10	-0.20	-0.020
T-25-2	-0.20	-0.10	-0.50	7.9	-5.00	<DL	9.46	10900.0	10.7	-0.30	-0.10	-0.20	-0.020
T-27	-0.20	-0.10	-0.50	5.0	-5.00	<DL	3.93	8390.0	5.5	-0.30	-0.10	-0.20	-0.020
T-29	-0.20	0.11	-0.50	12.1	14.20	24.2	6.94	8320.0	10.0	0.58	-0.10	-0.20	-0.020
T-30	-0.20	-0.10	-0.50	7.0	-5.00	<DL	5.73	10300.0	11.6	-0.30	-0.10	-0.20	-0.020
T-51	-0.20	-0.10	-0.50	9.2	-5.00	<DL	11.60	11000.0	5.8	-0.30	-0.10	-0.20	-0.020
T-52	-0.20	-0.10	-0.50	10.4	-5.00	<DL	6.56	14400.0	3.4	-0.30	-0.10	-0.20	-0.020

T-53	-0.20	-0.10	0.51	8.3	5.71	<DL	7.92	7220.0	<DL	-0.30	-0.10	-0.20	-0.020
T-55	-0.20	-0.10	-0.50	5.4	-5.00	7.6	5.60	6460.0	40.4	-0.30	-0.10	-0.20	-0.020
T-56	-0.20	-0.10	-0.50	12.1	-5.00	<DL	11.90	11900.0	17.1	-0.30	-0.10	-0.20	-0.020
T-57	-0.20	-0.10	-0.50	6.0	-5.00	<DL	9.01	4390.0	60.1	-0.30	-0.10	-0.20	-0.020
T-58	-0.20	-0.10	-0.50	14.1	-5.00	<DL	11.20	11000.0	48.9	0.53	-0.10	-0.20	-0.020
T-59	-0.20	-0.10	-0.50	6.2	-5.00	4.4	3.81	8360.0	37.9	-0.30	-0.10	-0.20	-0.020
T-60	-0.20	-0.10	-0.50	20.0	-5.00	<DL	4.90	14700.0	14.9	-0.30	-0.10	-0.20	-0.020
T-61	-0.20	-0.10	-0.50	6.7	5.15	11.5	5.23	6530.0	10.0	0.40	-0.10	-0.20	-0.020
T-62	-0.20	-0.10	-0.50	11.5	-5.00	20.9	4.77	9980.0	29.9	0.51	-0.10	-0.20	-0.020
T-65	-0.20	-0.10	-0.50	7.0	10.40	<DL	5.54	14700.0	34.2	-0.30	-0.10	0.21	-0.020
T-92	-0.20	-0.10	-0.50	8.9	-5.00	<DL	12.60	20600.0	8.7	-0.30	-0.10	-0.20	-0.020
T-94	-0.20	-0.10	-0.50	10.7	-5.00	<DL	16.00	10300.0	24.7	-0.30	-0.10	-0.20	0.020
T-95	-0.20	-0.10	-0.50	8.7	-5.00	<DL	15.70	11300.0	11.6	-0.30	-0.10	-0.20	-0.020
T-96	-0.20	-0.10	-0.50	12.5	-5.00	4.6	11.40	6840.0	44.0	-0.30	-0.10	-0.20	-0.020
T-97	-0.20	-0.10	-0.50	7.2	-5.00	9.7	10.40	9290.0	56.3	0.47	-0.10	-0.20	-0.020
T-98	-0.20	-0.10	-0.50	9.6	-5.00	4.5	7.22	10500.0	11.1	-0.30	-0.10	-0.20	-0.020
T-99	-0.20	-0.10	-0.50	11.9	-5.00	<DL	10.20	8830.0	55.5	-0.30	-0.10	-0.20	-0.020
T-100	-0.20	-0.10	-0.50	8.5	-5.00	<DL	7.76	7620.0	26.5	-0.30	-0.10	-0.20	-0.020
T-102	-0.20	-0.10	-0.50	11.9	5.30	<DL	13.40	14200.0	8.2	0.31	-0.10	-0.20	-0.020
T-103	-0.20	-0.10	-0.50	11.2	-5.00	<DL	10.60	10800.0	127.0	-0.30	-0.10	0.26	-0.020
T-104	-0.20	-0.10	-0.50	8.1	-5.00	<DL	9.75	11600.0	13.1	-0.30	-0.10	-0.20	-0.020
T-105	-0.20	-0.10	-0.50	18.1	-5.00	4.4	15.90	9480.0	6.0	-0.30	-0.10	0.61	-0.020
T-106	-0.20	-0.10	-0.50	12.3	-5.00	<DL	8.98	14300.0	21.0	-0.30	-0.10	-0.20	-0.020
T-108	-0.20	-0.10	-0.50	9.7	-5.00	19.3	13.50	6390.0	25.6	0.72	-0.10	0.24	-0.020
T-109	-0.20	-0.10	-0.50	16.7	-5.00	7.8	8.82	10100.0	19.5	-0.30	-0.10	-0.20	0.025
T-113	-0.20	0.12	-0.50	9.4	-5.00	<DL	6.96	7930.0	29.1	-0.30	-0.10	-0.20	0.020
T-114	-0.20	-0.10	-0.50	10.0	5.65	<DL	7.63	7130.0	13.9	-0.30	-0.10	-0.20	-0.020
T-115	-0.20	-0.10	-0.50	4.6	-5.00	<DL	8.81	21800.0	22.5	-0.30	-0.10	-0.20	0.024
T-116	-0.20	0.18	-0.50	21.6	-5.00	<DL	16.50	14100.0	19.4	-0.30	-0.10	-0.20	-0.020
T-127	-0.20	-0.10	-0.50	5.4	-5.00	<DL	6.87	12100.0	8.1	-0.30	-0.10	1.07	-0.020
T-129	-0.20	-0.10	-0.50	6.6	5.84	<DL	9.31	8270.0	<DL	-0.30	-0.10	0.28	-0.020
T-130	-0.20	0.11	-0.50	9.4	-5.00	<DL	9.55	11500.0	37.3	-0.30	-0.10	-0.20	-0.020
T-134	-0.20	-0.10	-0.50	13.1	-5.00	<DL	15.70	6690.0	26.3	0.34	-0.10	-0.20	0.026
T-136	-0.20	-0.10	-0.50	11.8	-5.00	<DL	6.11	8660.0	8.2	-0.30	-0.10	0.20	-0.020
T-137	-0.20	0.20	0.96	23.8	-5.00	<DL	8.69	17900.0	7.8	-0.30	-0.10	0.57	0.061
T-138	-0.20	-0.10	-0.50	7.8	-5.00	<DL	6.91	16900.0	7.1	-0.30	-0.10	0.67	-0.020
T-139	-0.20	-0.10	2.47	9.2	12.80	<DL	6.89	11700.0	54.4	-0.30	-0.10	0.52	-0.020
T-141	-0.20	-0.10	-0.50	17.4	9.86	<DL	3.87	13000.0	34.7	-0.30	-0.10	0.54	-0.020
T-142	-0.20	0.53	2.17	12.6	6.62	<DL	6.87	11700.0	5.3	-0.30	-0.10	0.36	0.026
T-144	-0.20	0.22	0.99	10.1	10.50	<DL	5.97	11800.0	10.4	-0.30	-0.10	0.24	-0.020
T-145	-0.20	0.32	0.92	17.2	-5.00	<DL	10.10	8430.0	6.5	-0.30	0.11	0.66	-0.020
T-148	-0.20	-0.10	-0.50	7.5	6.03	<DL	6.47	12300.0	18.5	0.44	-0.10	0.26	-0.020
T-152	-0.20	-0.10	-0.50	9.2	-5.00	<DL	14.60	5330.0	267.7	0.34	0.19	0.39	-0.020
T-155	-0.20	-0.10	-0.50	4.3	8.45	<DL	6.45	7560.0	8.0	-0.30	-0.10	-0.20	0.021
T-156	-0.20	-0.10	-0.50	8.7	-5.00	<DL	4.50	11400.0	6.3	-0.30	-0.10	5.21	-0.020
T-157	-0.20	-0.10	-0.50	6.3	-5.00	<DL	10.60	13300.0	8.1	-0.30	-0.10	-0.20	-0.020
T-158	-0.20	-0.10	-0.50	4.2	7.17	<DL	5.34	10700.0	9.2	-0.30	-0.10	-0.20	-0.020
T-160	-0.20	-0.10	-0.50	6.2	-5.00	<DL	6.99	9980.0	9.3	-0.30	-0.10	-0.20	-0.020
T-161	-0.20	-0.10	-0.50	9.9	-5.00	<DL	7.24	12100.0	27.7	-0.30	-0.10	-0.20	-0.020
T-162	-0.20	-0.10	-0.50	8.9	-5.00	<DL	9.90	15200.0	9.0	-0.30	-0.10	-0.20	0.032
T-164	-0.20	-0.10	-0.50	13.3	-5.00	<DL	23.60	25600.0	6.4	0.40	-0.10	0.76	-0.020
T-166	-0.20	-0.10	-0.50	11.3	-5.00	<DL	24.20	21200.0	14.9	-0.30	-0.10	1.20	0.039
T-167	-0.20	0.12	-0.50	10.3	-5.00	<DL	13.10	19700.0	<DL	-0.30	-0.10	-0.20	-0.020
T-168	-0.20	-0.10	-0.50	7.9	-5.00	<DL	17.70	11800.0	6.5	-0.30	-0.10	-0.20	0.032
T-173	-0.20	-0.10	-0.50	12.7	-5.00	<DL	13.50	19500.0	<DL	-0.30	-0.10	-0.20	-0.020

T-201-1	-0.20	-0.10	-0.50	4.1	6.17	71.2	8.86	8970.0	24.4	1.60	-0.10	-0.20	-0.020
T-201-2	-0.20	-0.10	-0.50	5.8	6.71	50.1	6.00	7010.0	18.1	1.14	-0.10	-0.20	-0.020
T-202	-0.20	-0.10	-0.50	6.7	5.41	7.1	4.48	8970.0	22.1	-0.30	-0.10	0.28	-0.020
T-203	-0.20	-0.10	-0.50	3.9	5.84	4.6	8.97	18400.0	11.3	0.32	-0.10	-0.20	0.034
T-204	-0.20	-0.10	-0.50	8.4	14.90	4.0	11.30	14300.0	31.1	-0.30	-0.10	-0.20	0.022
T-208	-0.20	-0.10	0.58	13.6	-5.00	<DL	2.54	21200.0	<DL	-0.30	-0.10	0.20	-0.020
T-210	-0.20	-0.10	-0.50	5.3	-5.00	4.0	8.72	12700.0	<DL	-0.30	-0.10	-0.20	0.040
T-216	-0.20	-0.10	0.55	8.1	-5.00	<DL	7.63	6170.0	<DL	-0.30	-0.10	0.32	-0.020
T-217	-0.20	-0.10	-0.50	4.3	-5.00	<DL	10.00	8380.0	8.5	-0.30	-0.10	-0.20	0.029
T-218	-0.20	-0.10	-0.50	6.1	-5.00	<DL	15.30	16900.0	7.1	-0.30	-0.10	-0.20	0.034
L-12-1	-0.20	-0.10	-0.50	29.14	-5.00	8.1	33.50	6820.0	1.4	0.34	-0.10	0.32	-0.020
L-12-2	-0.20	-0.10	-0.50	56.95	5.42	6.6	40.10	10400.0	6.1	0.42	-0.10	-0.20	0.022
L-13-1	-0.20	-0.10	-0.50	64.92	5.10	7.4	29.80	3790.0	2.0	0.32	-0.10	-0.20	0.026
L-13-2	-0.20	-0.10	-0.50	140.14	14.20	22.9	38.00	6130.0	13.6	0.51	0.14	0.35	0.020
L-15-1	-0.20	-0.10	-0.50	80.10	9.41	15.1	32.70	11700.0	12.7	0.75	0.12	0.29	-0.020
L-15-2	-0.20	-0.10	-0.50	87.43	-5.00	11.2	26.70	7460.0	12.4	-0.30	0.10	0.28	0.029
L-16	-0.20	-0.10	-0.50	27.78	5.98	3.7	36.20	6260.0	<DL	-0.30	-0.10	-0.20	0.024
L-18	-0.20	-0.10	-0.50	21.56	-5.00	7.0	24.50	5400.0	3.9	-0.30	0.18	-0.20	0.021
L-19	-0.20	-0.10	-0.50	56.86	6.85	23.3	27.10	4500.0	3.2	-0.30	0.18	-0.20	0.028
L-20	-0.20	0.20	-0.50	33.14	9.95	6.0	46.70	7370.0	1.3	-0.30	-0.10	-0.20	-0.020
L-22	-0.20	-0.10	-0.50	58.80	-5.00	1.7	30.70	4970.0	<DL	-0.30	-0.10	-0.20	0.030
L-23	-0.20	-0.10	-0.50	31.10	-5.00	2.1	25.00	6260.0	<DL	-0.30	-0.10	-0.20	0.043
L-24	-0.20	-0.10	-0.50	29.63	-5.00	9.8	60.00	3710.0	3.8	-0.30	0.21	-0.20	0.027
L-25-1	-0.20	-0.10	-0.50	21.35	-5.00	0.5	49.20	7190.0	4.7	-0.30	-0.10	-0.20	0.025
L-25-2	-0.20	-0.10	-0.50	59.02	-5.00	2.0	52.00	6020.0	<DL	-0.30	-0.10	-0.20	0.027
L-27	-0.20	-0.10	-0.50	76.43	-5.00	0.9	30.10	5240.0	<DL	-0.30	-0.10	0.20	-0.020
L-29	-0.20	-0.10	-0.50	40.97	-5.00	23.6	47.00	4280.0	<DL	0.53	0.13	-0.20	-0.020
L-30	-0.20	-0.10	-0.50	74.66	-5.00	2.3	43.40	4110.0	<DL	-0.30	-0.10	0.24	0.023
L-51	-0.20	-0.10	-0.50	28.74	-5.00	<DL	56.10	4490.0	4.8	-0.30	-0.10	0.23	0.037
L-52	-0.20	-0.10	-0.50	56.16	-5.00	1.8	64.70	6420.0	<DL	-0.30	-0.10	-0.20	-0.020
L-53	-0.20	-0.10	-0.50	55.52	7.31	5.3	57.60	5830.0	<DL	0.30	-0.10	-0.20	-0.020
L-55	-0.20	-0.10	-0.50	36.34	-5.00	17.5	34.40	4160.0	1.5	-0.30	0.19	-0.20	-0.020
L-56	-0.20	-0.10	-0.50	50.94	-5.00	<DL	45.50	5700.0	<DL	-0.30	-0.10	-0.20	0.020
L-57	-0.20	0.17	-0.50	47.50	-5.00	<DL	49.40	3790.0	13.1	-0.30	0.25	-0.20	-0.020
L-58	-0.20	-0.10	-0.50	39.80	-5.00	<DL	37.30	5730.0	19.2	-0.30	-0.10	-0.20	0.023
L-59	-0.20	-0.10	-0.50	36.63	5.09	<DL	29.50	7990.0	17.2	-0.30	0.11	-0.20	-0.020
L-60	-0.20	0.11	-0.50	45.77	-5.00	<DL	41.20	8450.0	<DL	-0.30	-0.10	0.38	-0.020
L-61	-0.20	-0.10	-0.50	65.56	-5.00	<DL	32.00	5510.0	<DL	0.34	0.16	-0.20	0.021
L-62	-0.20	-0.10	-0.50	32.57	-5.00	37.5	40.10	4660.0	<DL	-0.30	0.36	-0.20	-0.020
L-65	-0.20	-0.10	-0.50	38.82	5.69	<DL	32.00	7590.0	17.5	-0.30	-0.10	-0.20	-0.020
L-92	-0.20	-0.10	-0.50	166.77	8.19	8.2	28.70	18000.0	<DL	-0.30	-0.10	-0.20	-0.020
L-94	-0.20	-0.10	-0.50	48.08	-5.00	<DL	61.30	6160.0	<DL	-0.30	-0.10	-0.20	-0.020
L-95	-0.20	-0.10	-0.50	67.30	-5.00	7.9	78.00	5790.0	<DL	-0.30	-0.10	-0.20	0.023
L-96	-0.20	-0.10	-0.50	30.41	-5.00	13.3	49.50	4460.0	<DL	-0.30	0.17	-0.20	-0.020
L-97	-0.20	-0.10	-0.50	55.73	-5.00	30.4	50.60	7590.0	31.8	1.09	0.29	-0.20	-0.020
L-98	-0.20	0.14	-0.50	34.45	6.04	6.0	71.30	4120.0	<DL	0.31	-0.10	-0.20	-0.020
L-99	-0.20	-0.10	-0.50	91.22	-5.00	9.5	57.90	6250.0	21.2	-0.30	-0.10	-0.20	0.025
L-100	-0.20	-0.10	-0.50	48.39	-5.00	10.5	52.60	4980.0	<DL	-0.30	0.12	-0.20	-0.020
L-102	-0.20	-0.10	-0.50	79.55	-5.00	<DL	49.70	9630.0	<DL	0.33	-0.10	-0.20	-0.020
L-103	-0.20	-0.10	-0.50	19.63	6.63	<DL	45.40	4980.0	7.4	-0.30	-0.10	-0.20	-0.020
L-104	-0.20	-0.10	0.80	51.61	-5.00	5.7	55.00	8420.0	<DL	-0.30	-0.10	-0.20	-0.020
L-105	-0.20	-0.10	-0.50	45.36	-5.00	<DL	38.60	5820.0	<DL	-0.30	-0.10	-0.20	-0.020
L-106	-0.20	-0.10	-0.50	23.91	-5.00	<DL	26.40	7320.0	<DL	-0.30	-0.10	-0.20	0.027
L-108	-0.20	-0.10	-0.50	41.16	-5.00	18.1	56.00	4240.0	<DL	0.38	0.11	-0.20	-0.020
L-109	-0.20	-0.10	-0.50	51.40	-5.00	7.5	50.70	3890.0	<DL	-0.30	0.15	-0.20	-0.020

L-113	-0.20	-0.10	-0.50	22.82	9.41	<DL	32.70	4710.0	<DL	-0.30	-0.10	-0.20	-0.020
L-114	-0.20	-0.10	-0.50	37.41	6.26	10.5	34.20	6440.0	<DL	-0.30	0.14	0.21	-0.020
L-115	-0.20	-0.10	-0.50	46.57	7.55	<DL	27.60	11200.0	10.8	-0.30	-0.10	-0.20	-0.020
L-116	-0.20	0.18	-0.50	46.41	7.83	<DL	76.60	7070.0	3.9	-0.30	-0.10	-0.20	-0.020
L-127	-0.20	-0.10	-0.50	34.48	-5.00	12.1	36.30	5190.0	<DL	-0.30	0.10	-0.20	-0.020
L-129	-0.20	-0.10	-0.50	23.96	-5.00	<DL	32.20	3180.0	<DL	-0.30	-0.10	-0.20	-0.020
L-130	-0.20	-0.10	-0.50	40.47	-5.00	<DL	31.10	4520.0	14.6	-0.30	-0.10	-0.20	-0.020
L-134	-0.20	-0.10	-0.50	37.08	6.35	4.9	49.60	3210.0	2.0	-0.30	-0.10	-0.20	-0.020
L-136	-0.20	0.10	-0.50	14.71	-5.00	<DL	30.60	4180.0	<DL	-0.30	0.41	-0.20	-0.020
L-137	-0.20	0.21	1.20	35.47	-5.00	<DL	53.70	7320.0	<DL	-0.30	-0.10	0.55	-0.020
L-138	-0.20	-0.10	-0.50	99.03	11.40	<DL	38.00	12500.0	3.4	-0.30	-0.10	0.57	0.021
L-139	-0.20	-0.10	1.71	21.36	7.22	<DL	37.80	6900.0	7.9	-0.30	0.10	0.29	-0.020
L-141	-0.20	-0.10	-0.50	18.88	-5.00	<DL	35.60	5160.0	<DL	-0.30	0.13	0.25	-0.020
L-142	-0.20	0.95	1.58	16.51	7.78	<DL	33.20	6230.0	<DL	-0.30	-0.10	0.50	-0.020
L-144	-0.20	0.46	0.79	17.85	-5.00	<DL	40.10	7080.0	<DL	-0.30	-0.10	0.26	-0.020
L-145	-0.20	0.44	-0.50	26.11	-5.00	<DL	47.80	2700.0	<DL	-0.30	0.19	1.27	-0.020
L-148	-0.20	-0.10	-0.50	32.86	5.37	<DL	35.40	9120.0	<DL	-0.30	-0.10	-0.20	-0.020
L-152	-0.20	-0.10	-0.50	167.88	-5.00	20.1	39.80	7130.0	75.7	-0.30	0.49	0.76	-0.020
L-155	-0.20	-0.10	-0.50	11.24	-5.00	<DL	32.10	7460.0	4.1	-0.30	-0.10	-0.20	-0.020
L-156	-0.20	-0.10	-0.50	26.39	-5.00	<DL	28.90	7730.0	2.6	-0.30	-0.10	-0.20	-0.020
L-157	-0.20	-0.10	-0.50	159.86	-5.00	3.1	46.50	11100.0	4.8	-0.30	-0.10	-0.20	-0.020
L-158	-0.20	-0.10	-0.50	31.05	7.07	<DL	21.40	5820.0	2.3	-0.30	-0.10	-0.20	-0.020
L-160	-0.20	-0.10	-0.50	109.91	-5.00	3.4	39.70	5620.0	3.8	-0.30	-0.10	-0.20	-0.020
L-161	-0.20	0.11	-0.50	53.79	-5.00	<DL	33.60	6070.0	5.8	-0.30	-0.10	-0.20	-0.020
L-162	-0.20	-0.10	-0.50	124.48	-5.00	3.0	57.40	4930.0	2.7	-0.30	-0.10	-0.20	-0.020
L-164	-0.20	-0.10	-0.50	47.73	-5.00	3.5	51.40	8220.0	6.1	0.33	-0.10	-0.20	-0.020
L-166	-0.20	-0.10	-0.50	79.84	-5.00	3.5	40.10	7130.0	6.9	-0.30	-0.10	0.20	0.020
L-167	-0.20	0.23	-0.50	45.35	7.68	7.3	50.10	13500.0	6.2	-0.30	-0.10	-0.20	-0.020
L-168	-0.20	-0.10	-0.50	90.76	-5.00	3.2	60.00	6600.0	<DL	-0.30	-0.10	-0.20	-0.020
L-173	-0.20	-0.10	-0.50	106.49	-5.00	0.8	44.10	6170.0	0.3	-0.30	-0.10	0.22	-0.020
L-201-1	-0.20	-0.10	-0.50	25.98	-5.00	152.0	53.60	4540.0	8.0	0.34	0.28	-0.20	-0.020
L-201-2	-0.20	-0.10	-0.50	23.69	-5.00	72.5	48.20	5020.0	4.9	0.57	-0.10	-0.20	-0.020
L-202	-0.20	-0.10	-0.50	42.30	-5.00	7.7	52.00	5250.0	64.6	-0.30	0.30	-0.20	-0.020
L-203	-0.20	-0.10	0.94	60.08	8.52	11.5	53.30	5600.0	10.9	0.48	-0.10	-0.20	-0.020
L-204	-0.20	-0.10	-0.50	81.66	10.20	6.7	29.00	7930.0	8.6	0.31	-0.10	0.26	-0.020
L-205	-0.20	-0.10	-0.50	108.74	-5.00	4.4	30.90	13000.0	4.2	0.32	-0.10	0.23	0.035
L-206	-0.20	-0.10	-0.50	111.72	-5.00	5.5	21.80	10900.0	5.5	0.42	-0.10	-0.20	-0.020
L-207	-0.20	-0.10	-0.50	76.27	-5.00	4.5	32.20	9660.0	3.2	0.51	-0.10	-0.20	-0.020
L-209	-0.20	-0.10	-0.50	80.35	-5.00	6.2	35.60	4720.0	134.3	-0.30	0.10	-0.20	-0.020
L-211	-0.20	0.10	-0.50	41.08	-5.00	5.2	39.40	3340.0	7.8	-0.30	0.10	-0.20	-0.020
L-212	-0.20	-0.10	-0.50	35.68	-5.00	4.9	37.60	4040.0	13.4	-0.30	0.12	-0.20	-0.020
L-213	-0.20	-0.10	-0.50	98.28	-5.00	21.6	35.30	5260.0	7.9	-0.30	0.12	-0.20	-0.020
L-214	-0.20	-0.10	-0.50	62.80	-5.00	12.0	30.90	4060.0	<DL	-0.30	-0.10	-0.20	-0.020
L-215	-0.20	-0.10	-0.50	66.97	6.35	10.8	41.40	5080.0	11.3	-0.30	0.13	-0.20	-0.020
L-216	-0.20	-0.10	-0.50	51.47	-5.00	<DL	54.20	3680.0	<DL	-0.30	-0.10	0.44	0.020
L-217	-0.20	-0.10	-0.50	14.00	-5.00	<DL	29.20	2900.0	<DL	-0.30	-0.10	-0.20	-0.020
L-218	-0.20	-0.10	-0.50	50.61	-5.00	2.2	59.00	7180.0	<DL	-0.30	-0.10	-0.20	-0.020

Cu	Eu	Fe	Ga	Hf	Ir	K	La	Li	Lu	Mn	Mo	Na	Ni
0.03	0.020	20.0	0.01	0.010	1.0	500.0	0.020	0.01	0.005	0.01	1.00	10.0	0.01
ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
1.62	-0.020	48.4	0.17	-0.010	-1.0	-500.0	0.098	0.41	-0.005	4.42	-1.00	1520.0	0.41
1.67	-0.020	164.0	0.20	0.015	-1.0	588.0	0.232	0.72	-0.005	6.61	-1.00	2120.0	0.27
0.72	-0.020	50.0	0.16	-0.010	-1.0	680.0	0.076	0.18	-0.005	4.25	-1.00	1400.0	<DL
1.01	-0.020	60.0	0.14	0.012	-1.0	-500.0	0.066	0.07	-0.005	7.46	-1.00	1660.0	0.12
1.07	-0.020	65.5	0.30	-0.010	-1.0	2410.0	0.128	0.13	-0.005	6.08	-1.00	1080.0	0.29
0.98	-0.020	67.7	0.13	-0.010	-1.0	758.0	0.105	0.14	-0.005	4.22	-1.00	1350.0	0.23
1.12	-0.020	20.0	0.14	0.013	-1.0	840.0	0.039	0.08	-0.005	18.37	-1.00	1270.0	0.22
0.93	-0.020	50.0	0.11	0.015	-1.0	1360.0	0.057	0.16	-0.005	8.18	-1.00	1210.0	0.15
1.37	-0.020	46.8	0.23	-0.010	-1.0	2500.0	0.093	0.25	-0.005	9.19	-1.00	1100.0	0.13
0.32	-0.020	31.7	0.28	-0.010	-1.0	1100.0	-0.020	0.02	-0.005	3.10	-1.00	1770.0	0.03
1.20	-0.020	40.0	0.10	0.015	-1.0	730.0	0.035	<DL	-0.005	3.85	-1.00	1410.0	0.22
1.03	-0.020	-20.0	0.07	-0.010	-1.0	866.0	0.027	0.08	-0.005	4.41	-1.00	1610.0	0.36
1.07	-0.020	50.8	0.16	0.012	-1.0	995.0	0.062	0.17	-0.005	3.53	-1.00	1240.0	0.26
1.33	0.023	70.0	0.13	0.017	-1.0	840.0	0.045	0.06	-0.005	6.69	-1.00	1260.0	0.25
0.78	-0.020	50.0	0.15	0.013	-1.0	940.0	0.053	0.14	-0.005	3.36	-1.00	1190.0	0.12
1.13	-0.020	34.5	0.08	-0.010	-1.0	1630.0	0.028	0.09	-0.005	8.57	-1.00	1700.0	0.19
0.94	-0.020	35.7	0.34	-0.010	-1.0	781.0	0.083	0.32	-0.005	4.57	-1.00	1180.0	0.20
0.77	-0.020	116.0	0.07	0.021	-1.0	-500.0	0.143	0.08	-0.005	2.81	-1.00	1590.0	0.32
0.46	0.024	60.0	0.07	-0.010	-1.0	-500.0	0.057	0.11	-0.005	4.58	-1.00	1300.0	0.31
1.47	-0.020	41.1	0.14	-0.010	-1.0	1150.0	0.059	0.15	-0.005	2.82	-1.00	1380.0	0.21
1.59	0.020	39.3	0.12	-0.010	-1.0	-500.0	0.060	0.05	-0.005	1.62	-1.00	984.0	0.23
0.89	-0.020	40.0	0.15	-0.010	-1.0	1670.0	0.033	0.08	-0.005	13.31	-1.00	1700.0	0.27
0.63	-0.020	49.6	<DL	-0.010	-1.0	591.0	0.052	0.08	-0.005	2.84	-1.00	1280.0	0.65
1.02	-0.020	50.0	0.02	-0.010	-1.0	-500.0	0.033	0.08	-0.005	24.70	-1.00	1410.0	0.68
0.35	-0.020	40.0	<DL	-0.010	-1.0	-500.0	0.056	0.04	-0.005	2.60	-1.00	840.0	0.36
0.81	-0.020	38.7	0.08	-0.010	-1.0	1600.0	0.071	0.17	-0.005	2.55	-1.00	1180.0	0.13
3.96	0.022	60.0	<DL	-0.010	-1.0	-500.0	0.072	0.23	-0.005	4.80	-1.00	860.0	0.33
0.77	-0.020	40.0	0.09	-0.010	-1.0	1060.0	0.062	0.42	-0.005	3.07	-1.00	1470.0	0.31
0.99	0.029	100.0	0.18	-0.010	-1.0	-500.0	0.158	0.21	-0.005	8.80	-1.00	950.0	0.34
1.46	0.020	99.2	0.22	0.021	-1.0	610.0	0.090	0.13	-0.005	7.50	-1.00	1130.0	0.19
1.28	0.020	22.8	0.01	-0.010	-1.0	743.0	0.040	0.03	-0.005	3.85	-1.00	920.0	0.12
0.95	-0.020	28.4	<DL	-0.010	-1.0	-500.0	0.029	0.19	-0.005	6.50	-1.00	1730.0	0.51
1.26	-0.020	30.4	0.14	-0.010	-1.0	576.0	0.047	0.11	-0.005	3.07	-1.00	1510.0	0.12
0.75	-0.020	70.8	0.11	-0.010	-1.0	764.0	0.124	0.31	-0.005	2.34	-1.00	1850.0	0.22
0.30	-0.020	20.0	0.09	-0.010	-1.0	2280.0	0.096	0.24	-0.005	2.48	-1.00	1640.0	0.06
0.32	-0.020	70.0	0.13	-0.010	-1.0	-500.0	0.094	0.08	-0.005	3.77	-1.00	1120.0	0.27
0.83	-0.020	29.8	0.12	-0.010	-1.0	1320.0	0.026	0.09	-0.005	2.66	-1.00	1160.0	0.07
0.93	0.021	60.0	0.10	-0.010	-1.0	500.0	0.105	0.16	-0.005	3.38	-1.00	1120.0	0.09
1.52	-0.020	38.9	0.08	-0.010	-1.0	608.0	0.082	0.15	-0.005	3.32	-1.00	1180.0	0.14
0.59	-0.020	80.0	0.17	-0.010	-1.0	-500.0	0.086	0.02	-0.005	6.13	-1.00	1370.0	0.17
1.00	0.020	40.0	0.01	-0.010	-1.0	950.0	-0.020	0.08	-0.005	2.40	-1.00	900.0	0.17
0.57	0.028	70.0	0.11	-0.010	-1.0	1360.0	0.082	0.08	-0.005	2.08	-1.00	3180.0	0.26
1.38	0.029	140.0	0.25	0.020	-1.0	-500.0	0.134	0.21	-0.005	9.39	-1.00	1700.0	0.36
1.11	-0.020	29.0	0.10	-0.010	-1.0	833.0	0.051	0.19	-0.005	3.69	-1.00	1120.0	0.12
1.05	-0.020	70.0	0.05	-0.010	-1.0	1860.0	0.090	0.27	-0.005	2.33	-1.00	1400.0	0.20
0.75	-0.020	35.3	0.20	-0.010	-1.0	661.0	0.030	0.04	-0.005	5.05	-1.00	800.0	0.17
1.27	0.020	46.8	0.25	-0.010	-1.0	2140.0	0.060	0.21	-0.005	14.88	-1.00	1330.0	0.61
0.96	-0.020	48.6	0.07	-0.010	-1.0	-500.0	0.030	0.02	-0.005	3.75	-1.00	889.0	0.30
0.95	-0.020	32.1	0.06	-0.010	-1.0	686.0	0.030	0.08	-0.005	7.23	-1.00	1660.0	0.43

0.81	0.020	43.5	0.05	-0.010	-1.0	833.0	0.140	0.31	-0.005	11.34	-1.00	632.0	0.30
0.72	0.020	31.3	0.05	-0.010	-1.0	-500.0	0.050	0.13	-0.005	2.96	-1.00	1270.0	0.15
1.25	0.020	22.5	0.01	-0.010	-1.0	1130.0	-0.020	0.06	-0.005	7.22	-1.00	1390.0	1.22
0.97	-0.020	-20.0	0.13	-0.010	-1.0	1250.0	0.060	0.20	-0.005	30.19	-1.00	1410.0	0.16
1.18	0.020	46.3	<DL	-0.010	-1.0	620.0	0.040	0.07	-0.005	9.31	-1.00	763.0	0.47
1.97	0.020	30.9	0.11	-0.010	-1.0	-500.0	-0.020	<DL	-0.005	8.70	-1.00	547.0	0.49
2.02	-0.020	36.4	0.09	-0.010	-1.0	-500.0	0.020	<DL	-0.005	7.16	-1.00	466.0	0.51
1.61	-0.020	166.0	0.15	-0.010	-1.0	-500.0	0.090	0.05	-0.005	10.52	-1.00	641.0	0.89
1.13	-0.020	39.8	0.11	-0.010	-1.0	-500.0	0.030	0.03	-0.005	17.00	-1.00	736.0	0.94
1.29	-0.020	30.1	0.17	-0.010	-1.0	-500.0	0.020	0.01	-0.005	6.89	-1.00	422.0	0.46
2.24	-0.020	118.0	0.16	-0.010	-1.0	-500.0	0.070	0.01	-0.005	7.71	-1.00	318.0	0.38
1.69	-0.020	116.0	0.09	0.018	-1.0	-500.0	0.040	0.03	-0.005	17.02	-1.00	1010.0	1.69
1.82	0.020	-20.0	0.06	0.019	-1.0	-500.0	0.040	0.01	-0.005	50.34	-1.00	481.0	0.28
1.50	-0.020	79.9	<DL	-0.010	-1.0	2830.0	0.020	0.10	-0.005	57.35	-1.00	2180.0	0.62
2.49	-0.020	26.7	0.18	-0.010	-1.0	-500.0	0.020	<DL	-0.005	16.96	-1.00	792.0	0.18
1.20	-0.020	46.1	0.01	0.010	-1.0	861.0	0.040	0.20	-0.005	10.76	-1.00	587.0	0.23
1.17	-0.020	20.3	<DL	-0.010	-1.0	869.0	-0.020	0.04	-0.005	3.46	-1.00	978.0	0.10
1.76	-0.020	141.0	0.04	0.028	-1.0	1190.0	0.140	0.18	-0.005	7.06	-1.00	1640.0	0.28
0.44	-0.020	20.6	<DL	-0.010	-1.0	1560.0	-0.020	0.06	-0.005	5.12	-1.00	991.0	<DL
0.93	0.020	48.8	<DL	-0.010	-1.0	1050.0	0.050	0.07	-0.005	4.01	-1.00	1650.0	0.13
0.51	-0.020	-20.0	<DL	-0.010	-1.0	996.0	0.030	0.07	-0.005	4.20	-1.00	1420.0	0.06
0.74	-0.020	96.3	0.02	-0.010	-1.0	579.0	0.110	0.08	-0.005	7.81	-1.00	1470.0	0.19
0.81	-0.020	35.0	0.02	-0.010	-1.0	-500.0	0.040	0.04	-0.005	3.19	-1.00	786.0	0.12
1.76	-0.020	94.8	0.08	0.023	-1.0	-500.0	0.120	0.10	-0.005	3.15	-1.00	1050.0	0.17
0.83	0.020	105.0	0.08	0.022	-1.0	967.0	0.150	0.13	-0.005	2.67	-1.00	1620.0	0.08
1.31	-0.020	63.0	0.14	0.012	-1.0	-500.0	0.070	0.08	-0.005	6.98	-1.00	990.0	0.33
0.65	-0.020	30.0	0.09	0.019	-1.0	1500.0	0.083	0.45	-0.005	5.46	-1.00	1110.0	0.09
0.79	-0.020	32.6	0.14	-0.010	-1.0	1250.0	0.122	0.27	-0.005	3.81	-1.00	1870.0	0.09
0.85	0.026	50.0	0.32	-0.010	-1.0	1100.0	0.085	0.41	-0.005	34.82	-1.00	1370.0	0.30
0.94	0.030	403.0	0.38	0.087	-1.0	547.0	0.520	0.14	0.006	6.47	-1.00	968.0	0.29
1.35	-0.020	210.0	0.64	0.035	-1.0	1190.0	0.230	0.22	-0.005	8.33	-1.00	1900.0	0.27
0.99	-0.020	36.7	0.06	-0.010	-1.0	-500.0	0.030	0.03	-0.005	1.57	-1.00	508.0	0.17
0.75	-0.020	29.7	0.11	-0.010	-1.0	-500.0	0.020	0.03	-0.005	2.79	-1.00	706.0	0.33
2.76	-0.020	97.9	0.12	0.021	-1.0	-500.0	0.080	0.05	-0.005	1.79	-1.00	1660.0	0.23
0.68	0.020	196.0	0.11	0.018	-1.0	600.0	0.250	0.06	-0.005	11.71	-1.00	825.0	0.27
3.94	-0.020	34.3	0.21	-0.010	-1.0	1890.0	0.202	1.37	-0.005	22.1	-1.00	1850.0	0.95
3.82	-0.020	36.3	0.22	-0.010	-1.0	2370.0	0.110	0.83	-0.005	24.8	-1.00	1200.0	0.87
1.53	-0.020	39.8	0.20	-0.010	-1.0	1350.0	0.194	0.15	-0.005	18.1	-1.00	1840.0	0.32
1.07	-0.020	40.8	0.35	-0.010	-1.0	1450.0	0.097	0.21	-0.005	45.9	-1.00	1930.0	0.46
2.38	-0.020	32.8	0.39	-0.010	-1.0	2000.0	0.116	0.47	-0.005	17.9	-1.00	922.0	0.43
4.94	-0.020	56.2	0.16	-0.010	-1.0	2950.0	0.090	0.19	-0.005	16.3	-1.00	1580.0	0.59
3.22	-0.020	31.3	0.22	-0.010	-1.0	3510.0	0.054	0.15	-0.005	143.8	-1.00	1510.0	0.77
3.17	-0.020	31.0	0.35	-0.010	-1.0	3300.0	0.048	0.19	-0.005	42.2	-1.00	512.0	0.89
4.06	-0.020	60.0	0.42	-0.010	-1.0	2900.0	0.071	0.15	-0.005	35.8	-1.00	1010.0	0.53
1.93	-0.020	38.2	0.23	-0.010	-1.0	2080.0	0.055	0.10	-0.005	9.1	-1.00	1660.0	0.49
1.49	-0.020	27.0	0.09	-0.010	-1.0	2240.0	0.040	0.05	-0.005	17.5	-1.00	1590.0	0.62
1.55	-0.020	26.1	0.09	-0.010	-1.0	2080.0	0.057	0.08	-0.005	22.0	-1.00	1270.0	0.49
2.48	-0.020	57.0	0.47	-0.010	-1.0	3560.0	0.069	0.22	-0.005	14.7	-1.00	1280.0	0.55
1.38	-0.020	40.4	0.15	-0.010	-1.0	2390.0	0.038	0.24	-0.005	28.0	-1.00	1340.0	0.46
1.36	-0.020	42.0	0.19	-0.010	-1.0	3420.0	0.044	0.33	-0.005	23.5	-1.00	1410.0	0.29
4.74	-0.020	34.6	0.07	0.010	-1.0	1870.0	0.028	0.11	-0.005	18.6	-1.00	736.0	0.95
1.90	0.020	29.0	0.55	0.010	-1.0	2280.0	0.141	0.30	-0.005	9.5	-1.00	1080.0	0.40
1.26	-0.020	34.1	0.07	-0.010	-1.0	1880.0	-0.020	0.14	-0.005	11.0	-1.00	996.0	0.16
1.33	-0.020	28.3	0.02	-0.010	-1.0	1320.0	0.021	0.07	-0.005	28.8	-1.00	1070.0	0.86
1.78	-0.020	40.6	0.12	-0.010	-1.0	2540.0	0.039	0.21	-0.005	10.1	-1.00	1050.0	0.36

1.30	-0.020	40.1	0.15	-0.010	-1.0	1900.0	0.073	0.10	-0.005	5.5	-1.00	1460.0	0.50
1.16	-0.020	37.2	0.25	-0.010	-1.0	2580.0	0.041	0.12	-0.005	64.2	-1.00	1320.0	0.48
1.62	-0.020	44.3	0.07	-0.010	-1.0	3150.0	0.042	0.15	-0.005	9.7	-1.00	2440.0	1.05
1.83	-0.020	30.5	0.11	-0.010	-1.0	2300.0	-0.020	0.11	-0.005	91.2	-1.00	2180.0	1.29
3.09	-0.020	44.4	0.12	-0.010	-1.0	2460.0	0.232	0.12	-0.005	23.2	-1.00	1870.0	1.14
2.79	-0.020	26.6	0.23	-0.010	-1.0	1910.0	0.046	0.23	-0.005	10.7	-1.00	992.0	0.68
3.86	-0.020	23.4	0.12	-0.010	-1.0	2170.0	0.050	0.42	-0.005	15.5	-1.00	966.0	0.82
4.69	-0.020	30.0	0.13	-0.010	-1.0	3290.0	0.159	0.78	-0.005	7.9	-1.00	972.0	1.40
5.90	-0.020	45.1	0.36	-0.010	-1.0	2270.0	0.220	0.17	-0.005	81.1	-1.00	772.0	1.18
3.95	-0.020	37.9	0.41	-0.010	-1.0	3160.0	0.040	0.08	-0.005	66.0	-1.00	1420.0	1.03
6.02	-0.020	52.1	0.14	-0.010	-1.0	3380.0	0.060	0.08	-0.005	21.6	-1.00	1130.0	0.89
3.00	-0.020	40.0	0.13	-0.010	-1.0	3070.0	0.049	0.32	-0.005	35.6	-1.00	2830.0	2.22
1.96	-0.020	36.5	0.12	-0.010	-1.0	1580.0	0.058	0.23	-0.005	5.9	-1.00	1480.0	0.24
9.31	-0.020	39.3	0.21	-0.010	-1.0	1950.0	0.071	0.07	-0.005	7.8	-1.00	1670.0	0.36
1.77	-0.020	43.7	0.27	-0.010	-1.0	2460.0	0.471	0.08	-0.005	11.0	-1.00	1780.0	0.36
2.05	-0.020	29.9	0.20	-0.010	-1.0	1760.0	0.072	0.03	-0.005	15.6	-1.00	1190.0	0.33
2.45	-0.020	30.2	0.27	-0.010	-1.0	1940.0	0.031	<DL	-0.005	7.7	-1.00	1130.0	0.45
3.01	-0.020	39.6	0.23	-0.010	-1.0	1850.0	0.105	<DL	-0.005	9.2	-1.00	1480.0	0.27
2.63	-0.020	42.1	0.16	-0.010	-1.0	1730.0	0.168	0.02	-0.005	13.7	-1.00	2100.0	0.40
3.05	-0.020	56.3	0.27	-0.010	-1.0	2830.0	0.063	<DL	-0.005	69.4	-1.00	2320.0	0.94
1.81	-0.020	29.5	0.08	-0.010	-1.0	2340.0	-0.020	0.04	-0.005	11.5	-1.00	1720.0	0.58
2.65	-0.020	55.7	0.20	-0.010	-1.0	2040.0	0.073	<DL	-0.005	2.0	-1.00	2890.0	0.70
1.91	-0.020	37.5	0.16	-0.010	-1.0	4600.0	0.023	<DL	-0.005	11.7	-1.00	2370.0	0.70
2.74	-0.020	30.8	0.16	-0.010	-1.0	1970.0	0.270	<DL	-0.005	10.3	-1.00	1590.0	0.42
3.26	-0.020	28.0	0.10	-0.010	-1.0	2130.0	0.045	0.27	-0.005	17.2	-1.00	999.0	0.61
2.80	-0.020	34.4	0.42	-0.010	-1.0	1880.0	0.020	0.06	-0.005	40.9	-1.00	1710.0	0.20
3.45	-0.020	55.8	0.41	0.017	-1.0	2120.0	0.060	0.21	-0.005	60.5	-1.00	1390.0	0.31
1.84	-0.020	65.6	0.17	0.013	-1.0	1790.0	0.050	0.08	-0.005	18.5	-1.00	1490.0	0.47
3.07	-0.020	21.2	0.26	-0.010	-1.0	3670.0	0.050	0.16	-0.005	44.6	-1.00	2780.0	0.79
3.79	-0.020	25.6	0.05	0.014	-1.0	3620.0	0.070	0.47	-0.005	25.7	-1.00	798.0	0.64
1.79	-0.020	43.7	0.12	-0.010	-1.0	2400.0	0.170	0.32	-0.005	6.3	-1.00	1540.0	0.30
1.83	0.020	51.0	0.14	-0.010	-1.0	2730.0	0.120	0.22	-0.005	16.9	-1.00	1740.0	1.91
3.14	0.020	44.8	0.18	-0.010	-1.0	3120.0	0.160	0.26	-0.005	157.0	-1.00	2130.0	1.06
3.44	-0.020	40.0	0.05	-0.010	-1.0	2220.0	0.030	0.11	-0.005	44.8	-1.00	1060.0	0.91
2.23	-0.020	79.8	0.26	0.017	-1.0	2420.0	0.030	0.07	-0.005	34.8	-1.00	1650.0	0.91
2.76	-0.020	36.5	0.21	-0.010	-1.0	2010.0	0.020	<DL	-0.005	16.8	-1.00	1030.0	0.69
3.80	-0.020	71.6	0.64	-0.010	-1.0	1750.0	0.090	0.05	-0.005	106.6	-1.00	2280.0	1.53
3.38	-0.020	36.2	0.32	-0.010	-1.0	1870.0	0.070	0.03	-0.005	105.5	-1.00	1260.0	7.06
1.42	-0.020	57.8	0.43	-0.010	-1.0	1840.0	0.040	0.03	-0.005	7.6	-1.00	1290.0	1.05
2.64	-0.020	32.4	0.50	-0.010	-1.0	2390.0	0.020	0.03	-0.005	42.2	-1.00	1490.0	2.32
2.67	-0.020	88.5	0.07	-0.010	-1.0	2350.0	0.070	0.12	-0.005	33.3	-1.00	2550.0	3.83
4.64	-0.020	37.1	0.22	0.017	-1.0	2550.0	0.270	0.20	-0.005	72.9	-1.00	2480.0	0.78
10.15	0.020	58.3	0.02	-0.010	-1.0	2430.0	0.140	0.19	-0.005	124.9	-1.00	2560.0	1.21
4.11	-0.020	21.6	0.25	-0.010	-1.0	2050.0	0.020	0.01	-0.005	31.8	-1.00	1260.0	0.59
2.56	-0.020	51.0	<DL	-0.010	-1.0	2080.0	0.020	0.42	-0.005	12.8	-1.00	1020.0	0.43
6.16	-0.020	27.0	<DL	-0.010	-1.0	1860.0	0.030	0.08	-0.005	6.5	-1.00	1090.0	0.44
6.05	-0.020	-20.0	0.01	-0.010	-1.0	4150.0	-0.020	0.12	-0.005	13.2	-1.00	1390.0	0.53
2.94	-0.020	-20.0	0.04	0.012	-1.0	1880.0	0.020	0.08	-0.005	19.2	-1.00	934.0	0.18
2.94	-0.020	21.9	<DL	-0.010	-1.0	5550.0	-0.020	0.18	-0.005	10.2	-1.00	1890.0	0.56
2.61	-0.020	-20.0	<DL	-0.010	-1.0	3060.0	0.030	0.10	-0.005	28.7	-1.00	1300.0	0.42
3.76	-0.020	36.3	<DL	-0.010	-1.0	1030.0	0.180	0.35	-0.005	49.4	-1.00	3640.0	0.53
5.42	-0.020	71.1	0.06	-0.010	-1.0	2440.0	0.060	0.23	-0.005	11.1	-1.00	2790.0	0.49
1.40	-0.020	37.1	0.14	-0.010	-1.0	4160.0	0.020	0.33	-0.005	5.8	-1.00	3340.0	0.28
1.31	-0.020	37.6	0.05	-0.010	-1.0	3160.0	0.110	0.11	-0.005	6.1	-1.00	1340.0	0.35
5.44	-0.020	28.7	0.35	-0.010	-1.0	3060.0	0.050	0.10	-0.005	56.8	-1.00	2240.0	0.42

2.80	0.063	-20.0	0.19	-0.010	-1.0	3390.0	0.525	1.20	-0.005	29.6	-1.00	903.0	0.38
3.22	0.030	-20.0	0.47	-0.010	-1.0	2760.0	0.465	0.29	-0.005	19.7	-1.00	1700.0	0.56
1.93	-0.020	24.1	0.42	-0.010	-1.0	1810.0	0.084	0.41	-0.005	104.4	-1.00	778.0	0.93
1.39	-0.020	76.3	0.48	-0.010	-1.0	1860.0	0.140	0.14	-0.005	17.5	-1.00	1290.0	0.16
3.47	-0.020	67.8	0.93	-0.010	-1.0	2760.0	0.080	0.10	-0.005	13.4	-1.00	2010.0	0.54
1.97	-0.020	28.3	0.13	-0.010	-1.0	2670.0	0.090	0.05	-0.005	3.7	-1.00	691.0	0.46
1.85	-0.020	53.2	0.10	-0.010	-1.0	1740.0	0.090	0.08	-0.005	11.7	-1.00	1350.0	0.73
2.26	-0.020	34.4	0.02	-0.010	-1.0	1970.0	0.050	0.06	-0.005	18.7	-1.00	3770.0	1.51
4.76	-0.020	25.9	0.16	-0.010	-1.0	2590.0	0.030	0.06	-0.005	1.7	-1.00	2910.0	0.17
1.98	-0.020	81.3	0.10	-0.010	-1.0	1270.0	0.070	0.09	-0.005	67.2	-1.00	1270.0	0.44
4.66	-0.020	130.0	0.25	-0.010	-1.0	4160.0	0.110	2.95	-0.005	21.10	-1.00	3610.0	2.80
4.93	-0.020	130.0	0.55	0.016	-1.0	4030.0	0.129	4.42	-0.005	39.33	-1.00	3980.0	2.21
1.36	0.020	130.0	0.23	0.013	-1.0	4110.0	0.116	1.90	-0.005	38.46	-1.00	5640.0	1.59
1.38	-0.020	200.0	0.67	0.021	-1.0	3430.0	0.156	3.45	-0.005	95.79	-1.00	5450.0	0.47
3.13	-0.020	150.0	0.55	0.014	-1.0	5600.0	0.228	1.59	-0.005	79.01	-1.00	2480.0	1.39
3.20	-0.020	180.0	0.35	0.027	-1.0	5670.0	0.129	1.36	-0.005	23.70	-1.00	2240.0	2.11
4.13	-0.020	80.0	0.29	-0.010	-1.0	8020.0	0.054	0.44	-0.005	74.74	-1.00	2570.0	1.61
3.72	-0.020	60.0	0.17	-0.010	-1.0	6440.0	0.037	0.55	-0.005	31.30	-1.00	2780.0	1.73
3.52	-0.020	120.0	0.48	-0.010	-1.0	5350.0	0.042	0.97	-0.005	41.62	-1.00	2250.0	1.40
1.69	-0.020	90.0	0.45	-0.010	-1.0	8520.0	0.043	0.32	-0.005	16.60	-1.00	3200.0	0.83
3.18	-0.020	90.0	0.09	0.012	-1.0	4090.0	0.032	0.24	-0.005	22.68	-1.00	3480.0	1.34
2.03	-0.020	70.0	0.10	0.011	-1.0	6120.0	-0.020	0.29	-0.005	20.91	-1.00	3750.0	0.90
5.11	-0.020	140.0	0.30	-0.010	-1.0	7570.0	0.059	1.07	-0.005	19.07	-1.00	4030.0	1.18
3.43	-0.020	90.0	0.27	-0.010	-1.0	6970.0	0.028	0.70	-0.005	41.95	-1.00	4040.0	0.76
2.17	-0.020	70.0	0.20	-0.010	-1.0	6560.0	-0.020	1.19	-0.005	26.24	-1.00	3330.0	0.29
2.17	-0.020	90.0	0.20	-0.010	-1.0	4850.0	0.021	0.28	-0.005	32.01	-1.00	2880.0	1.65
0.73	-0.020	100.0	0.23	0.013	-1.0	7560.0	-0.020	0.74	-0.005	17.49	-1.00	3720.0	0.47
1.66	-0.020	100.0	0.09	-0.010	-1.0	3790.0	0.027	1.07	-0.005	15.21	-1.00	3810.0	0.21
4.53	-0.020	120.0	0.13	0.012	-1.0	4670.0	0.055	0.56	-0.005	13.84	-1.00	4430.0	0.81
2.05	-0.020	90.0	0.10	0.022	-1.0	5230.0	0.035	0.97	-0.005	25.17	-1.00	3680.0	0.36
0.97	-0.020	110.0	0.27	-0.010	-1.0	3990.0	0.091	0.70	-0.005	12.95	-1.00	5800.0	0.41
2.41	-0.020	100.0	0.15	-0.010	-1.0	4450.0	0.043	0.20	-0.005	48.92	-1.00	2730.0	0.71
2.37	-0.020	70.0	0.07	-0.010	-1.0	5140.0	-0.020	0.60	-0.005	15.82	-1.00	6220.0	1.51
4.05	-0.020	30.0	0.11	-0.010	-1.0	4090.0	-0.020	0.43	-0.005	50.11	-1.00	5720.0	2.35
3.47	-0.020	50.0	0.13	-0.010	-1.0	6670.0	0.033	0.49	-0.005	28.23	-1.00	5800.0	1.15
1.97	-0.020	80.0	0.22	-0.010	-1.0	5860.0	0.052	0.83	-0.005	34.91	-1.00	3640.0	1.07
5.43	-0.020	50.0	0.20	-0.010	-1.0	7160.0	0.084	2.34	-0.005	28.11	-1.00	4300.0	2.71
5.15	-0.020	80.0	0.21	-0.010	-1.0	6880.0	0.115	6.50	-0.005	16.36	-1.00	3020.0	1.28
5.28	-0.020	100.0	0.34	-0.010	-1.0	6980.0	0.111	0.74	-0.005	56.10	-1.00	3390.0	1.67
3.99	-0.020	99.8	0.41	0.015	-1.0	5010.0	0.080	0.41	-0.005	61.31	-1.00	3570.0	1.51
10.20	0.020	75.3	0.28	-0.010	-1.0	3190.0	0.120	1.14	-0.005	43.68	-1.00	1760.0	0.91
3.23	0.023	90.0	0.16	-0.010	-1.0	3540.0	0.058	1.32	-0.005	54.59	-1.00	5030.0	2.85
4.02	-0.020	110.0	0.23	0.016	-1.0	4960.0	-0.020	1.46	-0.005	13.51	-1.00	4060.0	0.76
5.95	-0.020	80.0	0.23	-0.010	-1.0	3250.0	-0.020	0.89	-0.005	10.20	-1.00	5410.0	0.48
6.33	0.028	100.0	0.36	0.015	-1.0	5630.0	0.474	0.86	-0.005	28.01	-1.00	3960.0	1.06
4.05	-0.020	70.0	0.19	0.015	-1.0	5210.0	0.057	2.09	-0.005	18.64	-1.00	6090.0	0.45
3.05	-0.020	80.0	0.27	-0.010	-1.0	4880.0	-0.020	1.23	-0.005	10.39	-1.00	5170.0	0.53
4.77	-0.020	100.0	0.17	-0.010	-1.0	4410.0	0.072	0.95	-0.005	12.73	-1.00	4210.0	0.49
5.77	0.020	80.0	0.19	-0.010	-1.0	5780.0	0.148	1.47	-0.005	17.38	-1.00	4300.0	0.88
4.73	-0.020	80.0	0.11	0.020	-1.0	8350.0	-0.020	0.19	-0.005	28.10	-1.00	4420.0	0.85
2.58	-0.020	90.0	0.12	-0.010	-1.0	5370.0	0.038	1.11	-0.005	18.55	-1.00	4870.0	0.86
3.20	-0.020	60.0	0.21	-0.010	-1.0	4370.0	-0.020	0.64	-0.005	5.47	-1.00	6490.0	0.83
2.47	-0.020	60.0	0.17	0.011	-1.0	6020.0	0.033	0.12	-0.005	24.96	-1.00	3720.0	0.94
3.84	-0.020	90.0	0.13	0.020	-1.0	6100.0	0.079	0.41	-0.005	14.96	-1.00	4080.0	0.66
5.28	-0.020	100.0	0.11	0.013	-1.0	5370.0	0.037	0.55	-0.005	7.70	-1.00	3260.0	0.52

3.65	-0.020	38.4	0.30	-0.010	-1.0	4840.0	0.020	0.14	-0.005	33.88	-1.00	3570.0	0.35
2.90	-0.020	122.0	0.31	-0.010	-1.0	5320.0	0.090	0.60	-0.005	74.50	-1.00	4030.0	0.75
2.55	-0.020	68.3	0.23	-0.010	-1.0	4730.0	0.060	0.56	-0.005	25.10	-1.00	4130.0	1.16
4.38	-0.020	40.6	0.11	0.012	-1.0	5760.0	-0.020	0.18	-0.005	84.70	-1.00	4400.0	0.64
4.93	-0.020	32.6	0.07	-0.010	-1.0	4320.0	-0.020	1.33	-0.005	31.57	-1.00	3570.0	1.67
3.60	-0.020	35.6	0.09	-0.010	-1.0	5160.0	0.030	0.45	-0.005	10.17	-1.00	3800.0	0.37
3.16	-0.020	57.9	0.10	-0.010	-1.0	3330.0	-0.020	1.04	-0.005	36.96	-1.00	3570.0	4.09
1.67	-0.020	34.9	<DL	-0.010	-1.0	5570.0	0.030	0.52	-0.005	47.01	-1.00	4460.0	1.19
1.52	-0.020	42.0	<DL	0.011	-1.0	4030.0	-0.020	0.06	-0.005	10.56	-1.00	4150.0	0.63
1.34	-0.020	82.2	0.06	-0.010	-1.0	4800.0	-0.020	<DL	-0.005	25.72	-1.00	4280.0	0.29
2.65	-0.020	52.9	0.18	-0.010	-1.0	3470.0	0.020	0.05	-0.005	54.88	-1.00	2230.0	0.94
2.95	-0.020	57.2	0.22	-0.010	-1.0	3800.0	-0.020	0.04	-0.005	75.66	-1.00	5020.0	1.29
2.31	-0.020	48.9	0.02	-0.010	-1.0	4570.0	-0.020	<DL	-0.005	63.47	-1.00	4650.0	5.39
1.41	-0.020	59.5	0.09	-0.010	-1.0	5690.0	0.030	0.03	-0.005	15.95	-1.00	3910.0	1.15
1.87	-0.020	47.6	0.12	-0.010	-1.0	5030.0	0.030	0.06	-0.005	33.33	-1.00	3780.0	1.54
3.49	-0.020	153.0	<DL	-0.010	-1.0	5900.0	0.050	0.19	-0.005	19.18	-1.00	5100.0	4.13
1.95	-0.020	48.4	0.04	-0.010	-1.0	4090.0	0.050	0.10	-0.005	69.86	-1.00	5910.0	0.51
2.52	0.020	125.0	0.05	-0.010	-1.0	4270.0	0.070	0.99	-0.005	70.63	-1.00	1880.0	3.51
3.32	-0.020	28.4	0.15	-0.010	-1.0	4790.0	-0.020	0.05	-0.005	55.53	-1.00	2700.0	0.34
2.50	-0.020	30.2	0.03	0.010	-1.0	5150.0	-0.020	2.20	-0.005	20.06	-1.00	3350.0	0.49
3.28	-0.020	52.8	0.08	-0.010	-1.0	3940.0	-0.020	1.14	-0.005	18.18	-1.00	2750.0	0.34
3.18	-0.020	40.2	0.04	-0.010	-1.0	4520.0	0.030	0.12	-0.005	12.95	-1.00	2720.0	0.32
2.80	-0.020	34.9	0.07	-0.010	-1.0	2960.0	-0.020	0.70	-0.005	13.73	-1.00	3850.0	0.09
2.31	-0.020	25.6	0.03	-0.010	-1.0	8060.0	-0.020	0.44	-0.005	12.81	-1.00	3180.0	0.83
2.35	-0.020	46.8	0.04	-0.010	-1.0	5690.0	-0.020	0.40	-0.005	13.76	-1.00	4660.0	0.35
2.93	-0.020	56.8	0.04	-0.010	-1.0	4920.0	0.110	0.82	-0.005	31.34	-1.00	3760.0	0.36
2.30	-0.020	48.0	0.09	-0.010	-1.0	4120.0	0.020	1.02	-0.005	12.20	-1.00	2910.0	0.27
2.15	0.020	142.0	0.41	0.015	-1.0	3980.0	0.120	1.00	-0.005	27.59	-1.00	7650.0	0.42
1.53	0.020	77.3	0.07	0.010	-1.0	3600.0	0.100	1.00	-0.005	9.76	-1.00	3140.0	0.27
4.90	-0.020	50.0	0.11	-0.010	-1.0	5730.0	0.030	0.73	-0.005	36.43	-1.00	5640.0	0.28
2.97	0.022	70.0	0.14	-0.010	-1.0	7960.0	0.060	1.29	-0.005	30.18	-1.00	2630.0	0.48
2.23	0.024	110.0	0.23	0.018	-1.0	5980.0	0.250	0.98	-0.005	11.70	-1.00	3450.0	0.50
3.69	-0.020	80.0	0.25	0.015	-1.0	5750.0	0.041	1.09	-0.005	63.41	-1.00	3420.0	1.59
1.70	0.020	200.0	0.24	0.017	-1.0	3130.0	0.200	0.94	-0.005	18.76	-1.00	4150.0	0.51
4.26	-0.020	193.0	0.45	0.012	-1.0	4170.0	0.140	0.45	-0.005	34.47	-1.00	2280.0	0.59
3.14	0.020	74.1	0.11	-0.010	-1.0	4050.0	0.120	1.18	-0.005	23.08	-1.00	2610.0	0.60
2.06	-0.020	102.0	0.17	-0.010	-1.0	3900.0	0.180	0.18	-0.005	7.85	-1.00	1910.0	0.18
2.08	-0.020	63.9	0.09	-0.010	-1.0	3630.0	0.210	0.43	-0.005	14.84	-1.00	1950.0	0.65
2.59	-0.020	52.0	0.13	-0.010	-1.0	4250.0	0.050	0.29	-0.005	10.61	-1.00	3350.0	0.52
2.23	-0.020	74.4	0.16	-0.010	-1.0	3760.0	0.030	0.14	-0.005	19.92	-1.00	3590.0	0.28
2.22	-0.020	67.9	0.13	-0.010	-1.0	3310.0	0.030	0.36	-0.005	57.31	-1.00	2700.0	0.37
1.70	-0.020	61.5	0.10	-0.010	-1.0	2740.0	0.040	0.81	-0.005	25.56	-1.00	3390.0	0.38
1.48	-0.020	69.1	0.14	0.016	-1.0	3110.0	0.050	0.58	-0.005	10.72	-1.00	2800.0	0.36
2.67	-0.020	60.5	0.13	-0.010	-1.0	4000.0	0.050	0.46	-0.005	22.39	-1.00	3460.0	0.44
4.00	-0.020	61.2	0.05	-0.010	-1.0	3150.0	0.030	0.29	-0.005	20.33	-1.00	5520.0	2.55
1.67	-0.020	49.2	0.07	-0.010	-1.0	3140.0	-0.020	0.13	-0.005	2.41	-1.00	4760.0	0.23
3.09	-0.020	94.1	0.09	0.010	-1.0	3440.0	0.020	0.67	-0.005	57.68	-1.00	4330.0	0.54

Pb	Rb	Sb	Sc	Se	Sm	Sr	Ta	Te	Th	Tl	U	V	W	Yb
0.009	0.50	0.020	0.005	0.20	0.010	0.009	0.050	0.20	0.010	0.0005	0.20	0.002	0.20	0.020
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm
0.14	-0.50	-0.020	0.017	-0.20	0.028	152.0	-0.050	-0.20	0.014	2.42	-0.20	0.11	-0.20	-0.020
0.27	0.62	-0.020	0.062	-0.20	0.051	125.0	-0.050	-0.20	0.051	4.95	-0.20	0.22	-0.20	0.023
0.16	-0.50	-0.020	0.015	-0.20	0.024	33.1	-0.050	-0.20	-0.010	1.84	-0.20	0.08	-0.20	-0.020
0.14	-0.50	-0.020	0.018	-0.20	0.025	59.0	-0.050	-0.20	0.023	2.14	-0.20	0.06	-0.20	-0.020
0.17	0.70	-0.020	0.020	-0.20	0.034	50.4	-0.050	-0.20	0.017	2.72	-0.20	0.20	-0.20	-0.020
0.10	-0.50	-0.020	0.024	-0.20	0.034	55.8	-0.050	-0.20	0.024	2.39	-0.20	0.10	-0.20	-0.020
0.07	-0.50	-0.020	0.010	-0.20	0.019	111.3	-0.050	-0.20	0.026	1.37	-0.20	0.07	-0.20	-0.020
0.08	0.53	-0.020	0.018	-0.20	0.025	52.8	-0.050	-0.20	0.033	2.86	-0.20	0.06	-0.20	-0.020
0.11	0.58	-0.020	0.016	-0.20	0.031	61.3	-0.050	-0.20	0.018	2.81	-0.20	0.14	-0.20	-0.020
0.05	-0.50	-0.020	0.009	-0.20	0.016	52.4	-0.050	-0.20	0.018	1.17	-0.20	0.06	-0.20	-0.020
0.05	-0.50	-0.020	0.011	-0.20	0.018	273.2	-0.050	-0.20	-0.010	2.98	-0.20	0.03	-0.20	-0.020
0.05	-0.50	-0.020	-0.005	-0.20	0.016	62.7	-0.050	-0.20	0.013	1.83	-0.20	0.10	-0.20	-0.020
0.06	-0.50	-0.020	0.019	-0.20	0.027	36.1	-0.050	-0.20	-0.010	2.46	-0.20	0.09	-0.20	-0.020
0.05	-0.50	-0.020	0.020	-0.20	0.021	73.5	-0.050	-0.20	0.023	1.44	-0.20	0.11	-0.20	-0.020
0.06	0.75	-0.020	0.015	-0.20	0.022	83.8	-0.050	-0.20	-0.010	2.37	-0.20	0.15	-0.20	-0.020
0.12	-0.50	-0.020	0.010	-0.20	0.017	45.0	-0.050	-0.20	-0.010	5.68	-0.20	0.07	-0.20	-0.020
0.07	-0.50	-0.020	0.012	-0.20	0.035	79.0	-0.050	-0.20	0.027	2.55	-0.20	0.09	-0.20	-0.020
0.05	-0.50	-0.020	0.041	-0.20	0.034	245.9	-0.050	-0.20	0.032	1.80	-0.20	0.07	-0.20	-0.020
0.13	-0.50	-0.020	0.019	-0.20	0.021	59.2	-0.050	-0.20	-0.010	3.11	-0.20	0.17	-0.20	-0.020
0.10	-0.50	-0.020	0.014	-0.20	0.021	73.5	-0.050	-0.20	0.019	2.18	-0.20	0.14	-0.20	-0.020
0.09	-0.50	-0.020	0.010	-0.20	0.020	145.0	-0.050	0.21	0.018	4.89	-0.20	0.08	-0.20	-0.020
0.15	-0.50	-0.020	0.017	-0.20	0.017	29.5	-0.050	-0.20	0.015	6.93	-0.20	0.16	-0.20	-0.020
0.10	-0.50	-0.020	0.013	-0.20	0.023	40.4	-0.050	-0.20	-0.010	3.78	-0.20	0.14	-0.20	-0.020
0.15	-0.50	-0.020	0.015	-0.20	0.016	45.0	-0.050	-0.20	-0.010	3.62	-0.20	0.07	-0.20	-0.020
0.05	-0.50	-0.020	0.014	-0.20	0.020	41.9	-0.050	-0.20	0.034	<DL	-0.20	0.08	-0.20	-0.020
0.11	-0.50	-0.020	0.014	-0.20	0.022	44.6	-0.050	-0.20	-0.010	5.91	-0.20	0.08	-0.20	-0.020
0.09	-0.50	-0.020	0.017	-0.20	0.026	218.5	-0.050	-0.20	0.031	3.25	-0.20	0.06	-0.20	-0.020
0.47	-0.50	-0.020	0.013	-0.20	0.022	109.8	-0.050	-0.20	-0.010	2.44	-0.20	0.12	-0.20	-0.020
0.12	-0.50	-0.020	0.035	-0.20	0.048	62.2	-0.050	-0.20	0.031	2.73	-0.20	0.17	-0.20	-0.020
0.56	-0.50	-0.020	0.032	-0.20	0.020	33.5	-0.050	-0.20	0.035	2.39	-0.20	0.21	-0.20	-0.020
0.11	-0.50	-0.020	0.008	-0.20	0.010	81.7	-0.050	-0.20	-0.010	2.70	-0.20	0.05	-0.20	-0.020
0.21	-0.50	-0.020	0.010	-0.20	0.018	27.8	-0.050	-0.20	0.012	0.77	-0.20	0.07	-0.20	-0.020
0.13	-0.50	-0.020	0.011	-0.20	0.019	43.4	-0.050	-0.20	-0.010	1.20	-0.20	0.09	-0.20	-0.020
0.21	-0.50	-0.020	0.029	-0.20	0.033	66.8	-0.050	-0.20	0.025	2.03	-0.20	0.11	-0.20	-0.020
0.28	-0.50	-0.020	0.009	-0.20	0.018	43.3	-0.050	-0.20	0.017	3.00	-0.20	0.06	-0.20	-0.020
0.22	-0.50	-0.020	0.026	-0.20	0.030	345.7	-0.050	0.28	0.017	2.46	-0.20	0.08	-0.20	-0.020
0.46	-0.50	-0.020	0.011	-0.20	0.016	57.8	-0.050	-0.20	0.010	1.24	-0.20	0.07	-0.20	-0.020
0.30	1.09	-0.020	0.026	-0.20	0.026	29.2	-0.050	-0.20	0.017	1.52	-0.20	0.18	-0.20	-0.020
0.21	-0.50	-0.020	0.014	-0.20	0.023	40.1	-0.050	-0.20	0.010	4.02	-0.20	0.14	-0.20	-0.020
0.08	-0.50	-0.020	0.027	-0.20	0.028	84.7	-0.050	-0.20	0.015	1.10	-0.20	0.04	-0.20	-0.020
0.08	-0.50	-0.020	0.013	-0.20	0.014	55.3	-0.050	-0.20	-0.010	1.89	-0.20	0.03	-0.20	-0.020
0.11	-0.50	-0.020	0.031	-0.20	0.031	34.9	-0.050	-0.20	0.017	5.46	-0.20	0.07	-0.20	-0.020
0.38	-0.50	-0.020	0.044	-0.20	0.040	22.1	-0.050	-0.20	0.039	6.00	-0.20	0.51	-0.20	-0.020
0.14	-0.50	-0.020	0.009	-0.20	0.016	30.2	-0.050	-0.20	-0.010	2.93	-0.20	0.07	-0.20	-0.020
0.17	-0.50	-0.020	0.024	-0.20	0.025	35.5	-0.050	-0.20	0.028	1.14	-0.20	0.12	-0.20	-0.020
0.08	-0.50	-0.020	0.010	-0.20	0.020	58.1	-0.050	-0.20	0.015	0.45	-0.20	0.14	-0.20	-0.020
0.17	-0.50	-0.020	0.022	-0.20	0.020	59.1	-0.050	-0.20	0.013	2.94	-0.20	0.33	-0.20	-0.020
0.05	-0.50	-0.020	0.015	-0.20	0.010	63.9	-0.050	-0.20	0.016	0.86	-0.20	0.06	-0.20	-0.020
0.03	-0.50	-0.020	0.012	-0.20	-0.010	142.9	-0.050	-0.20	-0.010	5.13	-0.20	0.03	-0.20	-0.020

0.07	-0.50	-0.020	0.016	-0.20	0.030	70.8	-0.050	-0.20	0.013	1.54	-0.20	0.09	-0.20	-0.020
0.06	-0.50	-0.020	0.013	-0.20	0.010	40.6	-0.050	-0.20	0.019	<DL	-0.20	0.06	-0.20	-0.020
0.07	-0.50	-0.020	-0.005	-0.20	0.020	50.4	-0.050	-0.20	-0.010	3.90	-0.20	0.06	-0.20	-0.020
0.04	-0.50	-0.020	0.006	-0.20	0.010	23.1	-0.050	0.39	-0.010	1.42	-0.20	0.03	-0.20	-0.020
0.08	-0.50	-0.020	0.025	-0.20	0.010	20.7	-0.050	-0.20	0.018	<DL	-0.20	0.13	-0.20	-0.020
0.07	-0.50	-0.020	0.013	-0.20	0.010	62.2	-0.050	-0.20	0.021	<DL	-0.20	0.05	-0.20	-0.020
0.01	-0.50	-0.020	0.018	-0.20	-0.010	94.5	-0.050	-0.20	0.014	1.84	-0.20	0.05	-0.20	-0.020
0.06	-0.50	-0.020	0.084	-0.20	0.030	103.4	-0.050	-0.20	0.027	4.07	-0.20	0.24	-0.20	-0.020
0.02	-0.50	-0.020	0.012	-0.20	0.010	46.3	-0.050	-0.20	0.011	2.77	-0.20	0.08	-0.20	-0.020
0.03	-0.50	-0.020	0.009	-0.20	0.010	99.0	-0.050	-0.20	0.016	0.52	-0.20	0.05	-0.20	-0.020
0.01	-0.50	-0.020	0.041	-0.20	0.030	57.3	-0.050	-0.20	0.027	<DL	-0.20	0.03	-0.20	-0.020
0.07	0.51	-0.020	0.057	-0.20	0.010	80.2	-0.050	-0.20	0.029	3.20	-0.20	0.15	-0.20	-0.020
0.05	-0.50	-0.020	0.009	-0.20	0.010	70.9	-0.050	-0.20	0.024	3.40	-0.20	0.06	-0.20	-0.020
0.06	-0.50	-0.020	0.028	-0.20	0.020	15.3	-0.050	-0.20	0.021	12.26	-0.20	0.18	-0.20	-0.020
0.04	-0.50	-0.020	0.006	-0.20	-0.010	39.6	-0.050	-0.20	-0.010	0.87	-0.20	0.03	-0.20	-0.020
<DL	-0.50	-0.020	0.016	-0.20	0.010	41.4	-0.050	-0.20	0.021	<DL	-0.20	0.05	-0.20	-0.020
<DL	-0.50	-0.020	0.008	-0.20	-0.010	25.2	-0.050	-0.20	-0.010	<DL	-0.20	0.05	-0.20	-0.020
<DL	-0.50	-0.020	0.050	-0.20	0.030	54.6	-0.050	-0.20	0.047	1.83	-0.20	0.15	-0.20	-0.020
<DL	-0.50	-0.020	-0.005	-0.20	0.010	60.0	-0.050	-0.20	-0.010	0.82	-0.20	0.22	-0.20	-0.020
<DL	0.81	-0.020	0.014	-0.20	0.010	53.5	-0.050	-0.20	-0.010	1.42	-0.20	0.02	-0.20	-0.020
<DL	-0.50	-0.020	0.005	-0.20	-0.010	48.9	-0.050	0.26	-0.010	0.57	-0.20	0.03	-0.20	-0.020
<DL	-0.50	-0.020	0.037	-0.20	0.020	110.2	-0.050	-0.20	0.047	5.74	-0.20	0.10	-0.20	0.020
<DL	1.00	-0.020	0.011	-0.20	0.010	167.3	-0.050	-0.20	0.023	4.79	-0.20	0.05	-0.20	-0.020
<DL	-0.50	-0.020	0.036	-0.20	0.030	87.3	-0.050	-0.20	0.036	4.23	-0.20	0.18	-0.20	-0.020
<DL	-0.50	-0.020	0.045	-0.20	0.030	27.4	0.054	-0.20	0.049	1.56	-0.20	0.13	-0.20	-0.020
0.15	-0.50	-0.020	0.021	-0.20	0.020	78.3	-0.050	-0.20	0.019	7.02	-0.20	0.20	-0.20	0.020
0.03	-0.50	-0.020	0.010	-0.20	0.022	34.6	-0.050	-0.20	0.014	2.55	-0.20	0.02	-0.20	-0.020
0.03	-0.50	-0.020	0.010	-0.20	0.032	39.3	-0.050	-0.20	-0.010	2.66	-0.20	0.02	-0.20	-0.020
0.07	-0.50	-0.020	0.019	-0.20	0.026	48.2	-0.050	-0.20	0.016	2.00	-0.20	0.08	-0.20	-0.020
0.26	1.46	-0.020	0.146	-0.20	0.100	97.8	-0.050	-0.20	0.194	4.64	-0.20	0.37	-0.20	0.050
0.24	1.02	-0.020	0.072	-0.20	0.040	26.3	-0.050	-0.20	0.109	4.15	-0.20	0.49	-0.20	0.020
0.08	-0.50	-0.020	0.009	-0.20	0.010	77.8	-0.050	-0.20	-0.010	6.88	-0.20	0.03	-0.20	-0.020
0.01	-0.50	-0.020	0.010	-0.20	0.010	55.2	-0.050	-0.20	-0.010	3.30	-0.20	0.03	-0.20	-0.020
0.08	0.91	-0.020	0.031	-0.20	0.020	40.6	-0.050	-0.20	0.043	1.18	-0.20	0.08	-0.20	-0.020
0.14	-0.50	-0.020	0.078	-0.20	0.060	218.4	-0.050	-0.20	0.073	1.15	-0.20	0.17	-0.20	0.020
0.34	0.56	-0.020	0.011	-0.20	0.036	137.9	-0.050	-0.20	0.014	12.9	-0.20	0.21	-0.20	-0.020
0.29	0.58	-0.020	0.015	-0.20	0.025	159.2	-0.050	-0.20	-0.010	6.4	-0.20	0.18	-0.20	-0.020
0.12	-0.50	-0.020	0.015	-0.20	0.043	121.6	-0.050	-0.20	0.014	8.2	-0.20	0.08	-0.20	-0.020
0.16	-0.50	-0.020	0.014	-0.20	0.022	115.9	-0.050	-0.20	0.017	8.9	-0.20	0.18	-0.20	-0.020
0.17	0.67	-0.020	0.011	-0.20	0.025	169.4	-0.050	0.36	-0.010	8.4	-0.20	0.11	-0.20	-0.020
0.10	0.58	-0.020	0.017	-0.20	0.027	185.1	-0.050	-0.20	0.018	8.9	-0.20	0.09	-0.20	-0.020
0.08	1.23	-0.020	0.009	-0.20	0.019	114.6	-0.050	-0.20	0.014	6.2	-0.20	0.08	-0.20	-0.020
0.08	1.29	-0.020	0.009	-0.20	0.014	223.0	-0.050	-0.20	-0.010	1.8	-0.20	0.12	-0.20	-0.020
0.05	0.60	-0.020	0.021	-0.20	0.026	145.0	-0.050	-0.20	-0.010	1.7	-0.20	0.11	-0.20	-0.020
0.08	0.50	-0.020	0.012	-0.20	0.016	201.3	-0.050	-0.20	-0.010	7.2	-0.20	0.08	-0.20	-0.020
0.09	-0.50	-0.020	0.008	-0.20	0.016	139.8	-0.050	-0.20	-0.010	5.5	-0.20	0.08	-0.20	-0.020
0.10	-0.50	-0.020	0.010	-0.20	0.015	153.2	-0.050	-0.20	-0.010	6.1	-0.20	0.08	-0.20	-0.020
0.08	0.84	-0.020	0.022	-0.20	0.026	67.8	-0.050	-0.20	0.014	4.7	-0.20	0.19	-0.20	-0.020
0.09	0.80	-0.020	0.012	-0.20	0.012	118.5	-0.050	-0.20	0.017	5.7	-0.20	0.13	-0.20	-0.020
0.07	0.75	-0.020	0.013	-0.20	0.020	170.4	-0.050	-0.20	-0.010	4.5	-0.20	0.10	-0.20	-0.020
0.06	-0.50	-0.020	0.009	-0.20	0.013	51.3	-0.050	-0.20	0.010	1.9	-0.20	0.10	-0.20	-0.020
0.16	0.51	-0.020	0.010	-0.20	0.067	179.8	-0.050	-0.20	-0.010	4.0	-0.20	0.16	-0.20	-0.020
0.06	-0.50	-0.020	0.010	-0.20	0.010	94.9	-0.050	-0.20	-0.010	3.7	-0.20	0.10	-0.20	-0.020
0.06	-0.50	-0.020	0.009	-0.20	0.010	205.7	-0.050	-0.20	-0.010	3.9	-0.20	0.06	-0.20	-0.020
0.15	-0.50	-0.020	0.010	-0.20	0.014	66.6	-0.050	0.24	0.019	9.0	-0.20	0.13	-0.20	-0.020

0.14	-0.50	-0.020	0.012	-0.20	0.016	161.0	-0.050	-0.20	0.014	4.5	-0.20	0.14	-0.20	-0.020
0.08	-0.50	-0.020	0.013	-0.20	0.016	56.0	-0.050	-0.20	0.018	5.2	-0.20	0.12	-0.20	-0.020
0.13	0.54	-0.020	0.014	-0.20	0.017	82.5	-0.050	-0.20	0.018	7.3	-0.20	0.12	-0.20	-0.020
0.10	-0.50	-0.020	0.005	-0.20	-0.010	49.3	-0.050	-0.20	-0.010	5.2	-0.20	0.05	-0.20	-0.020
0.12	0.78	-0.020	0.014	-0.20	0.032	118.4	-0.050	-0.20	0.015	6.1	-0.20	0.09	-0.20	-0.020
0.07	1.03	-0.020	0.006	-0.20	0.021	48.6	-0.050	-0.20	-0.010	3.7	-0.20	0.07	-0.20	-0.020
0.07	0.64	-0.020	0.007	-0.20	0.012	278.0	-0.050	-0.20	-0.010	4.0	-0.20	0.04	-0.20	-0.020
0.09	0.78	-0.020	0.008	-0.20	0.055	428.9	-0.050	-0.20	-0.010	4.7	-0.20	0.07	-0.20	-0.020
0.09	0.63	-0.020	0.014	-0.20	0.052	191.7	-0.050	-0.20	0.011	2.5	-0.20	0.13	-0.20	-0.020
0.20	-0.50	-0.020	0.012	-0.20	0.010	65.3	-0.050	-0.20	0.013	2.2	-0.20	0.06	-0.20	-0.020
0.23	0.75	-0.020	0.011	-0.20	0.020	246.9	-0.050	-0.20	0.021	6.8	-0.20	0.08	-0.20	-0.020
0.18	0.63	-0.020	0.012	-0.20	0.018	78.1	-0.050	-0.20	-0.010	6.6	-0.20	0.05	-0.20	-0.020
0.15	-0.50	-0.020	0.011	-0.20	0.013	106.1	-0.050	-0.20	0.014	5.8	-0.20	0.08	-0.20	-0.020
0.18	0.52	-0.020	0.012	-0.20	0.020	159.4	-0.050	-0.20	0.024	4.7	-0.20	0.10	-0.20	-0.020
0.56	0.66	-0.020	0.011	-0.20	0.043	119.2	-0.050	-0.20	-0.010	6.5	-0.20	0.11	-0.20	-0.020
0.42	0.80	-0.020	0.008	-0.20	0.015	189.1	-0.050	-0.20	0.014	11.4	-0.20	0.13	-0.20	-0.020
0.85	0.89	-0.020	0.011	-0.20	0.013	147.5	-0.050	-0.20	-0.010	6.9	-0.20	0.18	-0.20	-0.020
0.15	0.98	-0.020	0.012	-0.20	0.018	95.2	-0.050	0.31	-0.010	3.2	-0.20	0.06	-0.20	-0.020
0.27	0.57	-0.020	0.014	-0.20	0.029	96.6	-0.050	-0.20	0.013	7.4	-0.20	0.12	-0.20	-0.020
0.17	1.10	-0.020	0.017	-0.20	0.018	133.1	-0.050	-0.20	0.017	7.2	-0.20	0.10	-0.20	-0.020
0.20	0.64	-0.020	0.009	-0.20	0.012	82.6	-0.050	-0.20	-0.010	7.5	-0.20	0.07	-0.20	-0.020
0.32	0.50	-0.020	0.018	-0.20	0.014	72.9	-0.050	-0.20	0.020	11.1	-0.20	0.18	-0.20	-0.020
0.12	0.70	-0.020	0.009	-0.20	0.014	42.0	-0.050	-0.20	-0.010	7.7	-0.20	0.06	-0.20	-0.020
0.34	-0.50	-0.020	0.010	-0.20	0.045	71.2	-0.050	-0.20	-0.010	8.3	-0.20	0.16	-0.20	-0.020
0.16	-0.50	-0.020	0.008	-0.20	0.017	117.5	-0.050	-0.20	-0.010	8.1	-0.20	0.06	-0.20	-0.020
0.11	-0.50	-0.020	0.013	-0.20	0.010	73.6	-0.050	-0.20	0.015	1.9	-0.20	0.11	-0.20	-0.020
0.14	-0.50	-0.020	0.018	-0.20	0.020	219.3	-0.050	-0.20	-0.010	3.6	-0.20	0.13	-0.20	-0.020
0.09	0.88	-0.020	0.023	-0.20	0.020	151.3	-0.050	-0.20	-0.010	2.1	-0.20	0.11	-0.20	-0.020
0.06	-0.50	-0.020	0.005	-0.20	0.010	84.2	-0.050	-0.20	0.019	4.4	-0.20	0.03	-0.20	-0.020
0.03	1.60	-0.020	0.006	-0.20	0.020	149.2	-0.050	-0.20	-0.010	1.0	-0.20	0.02	-0.20	-0.020
0.09	-0.50	-0.020	0.013	-0.20	0.020	68.0	-0.050	-0.20	0.016	1.8	-0.20	0.08	-0.20	-0.020
0.17	0.80	-0.020	0.019	-0.20	0.030	48.5	-0.050	-0.20	0.026	4.2	-0.20	0.18	-0.20	-0.020
0.09	0.65	-0.020	0.020	-0.20	0.040	69.6	-0.050	-0.20	0.013	3.6	-0.20	0.10	-0.20	-0.020
0.09	-0.50	-0.020	0.021	-0.20	0.010	44.3	-0.050	-0.20	0.024	2.6	-0.20	0.09	-0.20	-0.020
0.03	1.01	-0.020	0.027	-0.20	0.020	165.7	-0.050	-0.20	0.019	1.4	-0.20	0.19	-0.20	-0.020
0.02	1.21	-0.020	0.016	-0.20	0.010	133.2	-0.050	-0.20	-0.010	2.8	-0.20	0.08	-0.20	-0.020
0.04	0.66	-0.020	0.025	-0.20	0.020	133.4	-0.050	-0.20	-0.010	3.9	-0.20	0.13	-0.20	-0.020
0.03	1.19	-0.020	0.011	-0.20	0.020	79.8	-0.050	-0.20	0.015	3.8	-0.20	0.09	-0.20	-0.020
0.04	-0.50	-0.020	0.017	-0.20	0.010	95.0	-0.050	0.21	0.013	1.3	-0.20	0.11	-0.20	-0.020
0.03	0.82	-0.020	0.009	-0.20	0.010	98.0	-0.050	-0.20	0.018	2.2	-0.20	0.07	-0.20	-0.020
0.07	1.10	-0.020	0.033	-0.20	0.020	50.5	-0.050	-0.20	-0.010	5.2	-0.20	0.24	-0.20	-0.020
0.09	1.29	-0.020	0.009	-0.20	0.030	91.0	-0.050	-0.20	0.014	7.1	-0.20	0.14	-0.20	-0.020
0.03	-0.50	-0.020	0.019	-0.20	0.050	37.1	-0.050	-0.20	0.036	3.5	-0.20	0.09	-0.20	0.030
0.07	1.39	-0.020	0.006	-0.20	0.010	62.8	-0.050	-0.20	-0.010	5.5	-0.20	0.03	-0.20	-0.020
0.05	-0.50	-0.020	0.007	-0.20	0.010	44.2	-0.050	-0.20	0.016	1.9	-0.20	0.02	-0.20	-0.020
0.06	0.53	-0.020	0.008	-0.20	0.010	76.4	-0.050	-0.20	0.012	3.7	-0.20	0.03	-0.20	-0.020
0.05	0.69	-0.020	0.006	-0.20	0.010	51.2	-0.050	-0.20	-0.010	3.3	-0.20	0.04	-0.20	-0.020
0.05	-0.50	-0.020	-0.005	-0.20	0.020	92.6	-0.050	0.37	0.024	2.9	-0.20	0.03	-0.20	-0.020
0.06	1.35	-0.020	0.005	-0.20	0.010	80.7	-0.050	-0.20	-0.010	4.6	-0.20	0.02	-0.20	-0.020
0.05	-0.50	-0.020	0.005	-0.20	0.020	104.9	-0.050	-0.20	0.012	2.8	-0.20	0.05	-0.20	-0.020
0.15	0.61	-0.020	0.014	-0.20	0.040	131.7	-0.050	-0.20	0.014	12.0	-0.20	0.07	-0.20	-0.020
0.15	-0.50	-0.020	0.021	-0.20	0.020	263.1	-0.050	-0.20	0.018	14.0	-0.20	0.07	-0.20	-0.020
0.12	-0.50	-0.020	0.018	-0.20	0.020	86.6	-0.050	-0.20	0.020	9.1	-0.20	0.12	-0.20	-0.020
0.11	1.01	-0.020	0.012	-0.20	0.020	82.8	-0.050	0.29	0.020	10.2	-0.20	0.06	-0.20	-0.020
0.08	0.90	-0.020	0.012	-0.20	0.020	226.8	-0.050	0.29	0.018	4.8	-0.20	0.07	-0.20	-0.020

0.09	0.63	-0.020	0.007	-0.20	0.242	116.5	-0.050	-0.20	-0.010	5.8	-0.20	0.06	-0.20	0.029
0.14	0.87	-0.020	0.007	-0.20	0.139	100.7	-0.050	-0.20	0.015	4.7	-0.20	0.05	-0.20	-0.020
0.07	-0.50	-0.020	0.007	-0.20	0.026	85.2	-0.050	-0.20	0.014	1.8	-0.20	0.10	-0.20	-0.020
0.14	0.72	-0.020	0.021	-0.20	0.030	78.1	-0.050	-0.20	0.025	9.2	-0.20	0.18	-0.20	-0.020
0.12	-0.50	-0.020	0.026	-0.20	0.020	92.1	-0.050	-0.20	0.033	4.2	-0.20	0.12	-0.20	-0.020
0.25	-0.50	-0.020	0.006	-0.20	0.020	100.8	-0.050	-0.20	-0.010	4.0	-0.20	0.06	-0.20	-0.020
0.13	0.50	-0.020	0.015	-0.20	0.030	44.6	-0.050	-0.20	-0.010	9.9	-0.20	0.08	-0.20	-0.020
0.06	-0.50	-0.020	0.012	-0.20	0.020	43.1	-0.050	-0.20	0.013	5.1	-0.20	0.03	-0.20	-0.020
0.06	0.77	-0.020	0.009	-0.20	0.010	105.2	-0.050	0.23	-0.010	4.3	-0.20	0.03	-0.20	-0.020
0.16	0.51	-0.020	0.026	-0.20	0.020	124.1	-0.050	-0.20	0.026	7.2	-0.20	0.14	-0.20	-0.020
0.13	0.83	-0.020	0.043	-0.20	0.030	93.7	-0.050	-0.20	0.038	42.2	-0.20	0.18	-0.20	-0.020
0.13	0.84	-0.020	0.037	-0.20	0.034	132.4	-0.050	-0.20	0.027	50.3	-0.20	0.16	-0.20	-0.020
0.11	0.61	-0.020	0.043	-0.20	0.037	36.8	-0.050	-0.20	0.040	23.0	-0.20	0.19	-0.20	0.022
0.18	-0.50	-0.020	0.065	-0.20	0.041	59.0	-0.050	-0.20	0.051	21.7	-0.20	0.31	-0.20	-0.020
0.09	0.92	-0.020	0.053	0.20	0.067	139.2	-0.050	-0.20	0.040	26.7	-0.20	0.20	-0.20	-0.020
0.14	1.11	-0.020	0.055	-0.20	0.038	121.8	-0.050	-0.20	0.028	17.4	-0.20	0.28	-0.20	-0.020
0.07	1.87	-0.020	0.028	-0.20	0.025	57.9	-0.050	-0.20	0.028	31.5	-0.20	0.09	-0.20	-0.020
0.08	1.39	-0.020	0.017	-0.20	0.021	42.6	-0.050	-0.20	0.020	23.1	-0.20	0.09	-0.20	-0.020
0.08	1.40	-0.020	0.040	-0.20	0.026	60.3	-0.050	-0.20	0.025	27.4	-0.20	0.15	-0.20	-0.020
0.12	1.12	-0.020	0.032	-0.20	0.023	95.8	-0.050	-0.20	0.026	48.3	-0.20	0.13	-0.20	-0.020
0.05	0.86	-0.020	0.028	-0.20	0.020	52.2	-0.050	-0.20	0.031	20.8	-0.20	0.12	-0.20	-0.020
0.01	1.27	-0.020	0.019	-0.20	0.019	55.1	-0.050	-0.20	0.015	26.6	-0.20	0.10	-0.20	-0.020
0.16	1.65	-0.020	0.042	-0.20	0.030	26.7	-0.050	-0.20	0.024	43.9	-0.20	0.17	-0.20	-0.020
0.25	1.07	-0.020	0.024	-0.20	0.018	64.9	-0.050	-0.20	0.020	60.4	-0.20	0.15	-0.20	-0.020
0.02	1.35	-0.020	0.023	-0.20	0.017	64.8	-0.050	-0.20	0.014	30.4	-0.20	0.08	-0.20	-0.020
0.01	0.68	-0.020	0.029	-0.20	0.018	77.6	-0.050	-0.20	0.034	16.4	-0.20	0.10	-0.20	-0.020
0.03	1.26	-0.020	0.025	-0.20	0.045	40.5	-0.050	-0.20	0.013	41.5	-0.20	0.09	-0.20	-0.020
<DL	0.91	-0.020	0.035	-0.20	0.019	63.1	-0.050	-0.20	0.028	20.9	-0.20	0.16	-0.20	-0.020
0.10	-0.50	-0.020	0.035	-0.20	0.021	53.1	-0.050	-0.20	0.031	38.4	-0.20	0.19	-0.20	-0.020
0.03	-0.50	-0.020	0.031	-0.20	0.020	28.7	-0.050	-0.20	0.038	34.7	-0.20	0.14	-0.20	-0.020
0.08	-0.50	-0.020	0.036	-0.20	0.028	78.6	-0.050	-0.20	0.018	39.3	-0.20	0.21	-0.20	-0.020
0.03	0.58	-0.020	0.035	-0.20	0.022	18.2	-0.050	-0.20	0.029	21.0	-0.20	0.21	-0.20	-0.020
0.13	0.70	-0.020	0.018	-0.20	0.018	29.1	-0.050	-0.20	0.020	25.0	-0.20	0.11	-0.20	-0.020
0.14	-0.50	-0.020	0.009	-0.20	0.015	24.1	-0.050	-0.20	-0.010	25.6	-0.20	0.06	-0.20	0.026
0.12	1.44	-0.020	0.012	-0.20	0.019	47.8	-0.050	-0.20	-0.010	33.5	-0.20	0.06	-0.20	-0.020
0.10	1.69	-0.020	0.027	-0.20	0.025	46.2	-0.050	-0.20	0.024	31.0	-0.20	0.05	-0.20	-0.020
0.11	1.02	-0.020	0.016	-0.20	0.021	165.2	-0.050	-0.20	0.022	14.2	-0.20	0.11	-0.20	-0.020
0.09	1.58	-0.020	0.027	-0.20	0.030	506.2	-0.050	-0.20	0.014	15.8	-0.20	0.11	-0.20	-0.020
0.12	1.22	-0.020	0.038	-0.20	0.034	62.6	-0.050	-0.20	0.039	22.4	-0.20	0.14	-0.20	-0.020
0.24	0.80	-0.020	0.031	-0.20	0.030	30.0	-0.050	-0.20	0.028	6.7	-0.20	0.14	-0.20	-0.020
0.17	-0.50	-0.020	0.018	0.20	0.040	184.2	-0.050	0.29	0.017	2.6	-0.20	0.11	-0.20	-0.020
0.25	-0.50	-0.020	0.028	0.20	0.026	36.9	-0.050	-0.20	0.029	28.3	-0.20	0.16	-0.20	-0.020
0.15	1.08	-0.020	0.037	-0.20	0.024	66.6	-0.050	-0.20	0.034	35.3	-0.20	0.14	-0.20	-0.020
0.15	0.74	-0.020	0.025	-0.20	0.024	50.6	-0.050	-0.20	0.023	35.9	-0.20	0.14	-0.20	-0.020
0.34	1.28	-0.020	0.028	-0.20	0.074	65.3	-0.050	-0.20	0.026	29.8	-0.20	0.16	-0.20	-0.020
0.16	1.08	-0.020	0.025	-0.20	0.023	55.6	-0.050	-0.20	-0.010	36.6	-0.20	0.12	-0.20	-0.020
0.25	1.28	-0.020	0.025	-0.20	0.023	72.2	-0.050	-0.20	0.023	49.5	-0.20	0.12	-0.20	-0.020
0.25	0.99	-0.020	0.034	-0.20	0.027	44.0	-0.050	-0.20	0.026	39.5	-0.20	0.11	-0.20	-0.020
0.19	1.58	-0.020	0.022	-0.20	0.034	55.1	-0.050	-0.20	-0.010	29.6	-0.20	0.11	-0.20	-0.020
0.12	2.98	-0.020	0.025	-0.20	0.018	27.9	-0.050	-0.20	0.017	28.9	-0.20	0.06	-0.20	0.021
0.18	0.62	-0.020	0.027	-0.20	0.019	51.4	-0.050	-0.20	-0.010	41.9	-0.20	0.10	-0.20	-0.020
0.13	1.06	-0.020	0.017	-0.20	0.013	41.2	-0.050	-0.20	-0.010	49.0	-0.20	0.07	-0.20	-0.020
0.10	0.76	-0.020	0.020	-0.20	0.015	16.1	-0.050	-0.20	-0.010	32.9	-0.20	0.05	-0.20	-0.020
0.15	-0.50	-0.020	0.025	-0.20	0.025	35.8	-0.050	-0.20	0.023	35.8	-0.20	0.12	-0.20	-0.020
0.21	1.32	-0.020	0.031	-0.20	0.020	32.1	-0.050	-0.20	0.027	30.7	-0.20	0.10	-0.20	-0.020

0.09	-0.50	0.034	0.012	-0.20	0.020	43.2	-0.050	-0.20	0.020	12.9	-0.20	0.07	-0.20	-0.020
0.18	0.60	0.026	0.040	-0.20	0.030	85.5	-0.050	-0.20	0.041	29.4	-0.20	0.20	-0.20	-0.020
0.09	0.63	-0.020	0.017	-0.20	0.020	53.9	-0.050	-0.20	0.023	12.2	-0.20	0.13	-0.20	-0.020
0.10	1.29	-0.020	0.008	-0.20	0.010	33.3	-0.050	-0.20	-0.010	37.5	-0.20	0.02	-0.20	-0.020
0.08	1.53	-0.020	0.006	-0.20	0.010	56.9	-0.050	-0.20	-0.010	21.9	-0.20	0.02	-0.20	-0.020
0.07	-0.50	-0.020	0.008	-0.20	0.020	45.8	-0.050	-0.20	0.019	16.6	-0.20	0.03	-0.20	-0.020
0.13	0.70	-0.020	0.013	-0.20	0.020	18.7	-0.050	-0.20	0.023	22.6	-0.20	0.17	-0.20	-0.020
0.01	0.85	-0.020	0.009	-0.20	0.020	11.3	-0.050	-0.20	0.020	2.6	-0.20	0.02	-0.20	-0.020
<DL	-0.50	-0.020	0.012	-0.20	0.020	9.1	-0.050	-0.20	-0.010	1.4	-0.20	0.02	-0.20	-0.020
<DL	1.50	-0.020	0.026	-0.20	0.020	27.3	-0.050	-0.20	-0.010	1.4	-0.20	0.06	-0.20	-0.020
0.07	1.35	-0.020	0.018	-0.20	0.020	73.3	-0.050	-0.20	0.015	10.4	-0.20	0.04	-0.20	-0.020
<DL	1.38	-0.020	0.016	-0.20	0.020	30.1	-0.050	-0.20	0.016	1.9	-0.20	0.08	-0.20	-0.020
<DL	1.38	-0.020	0.012	-0.20	0.020	13.6	-0.050	-0.20	-0.010	1.7	-0.20	0.03	-0.20	-0.020
<DL	0.53	-0.020	0.014	-0.20	0.020	22.6	-0.050	-0.20	0.012	1.6	-0.20	0.04	-0.20	-0.020
<DL	0.91	-0.020	0.012	-0.20	0.010	24.3	-0.050	-0.20	0.017	1.3	-0.20	0.03	-0.20	-0.020
0.03	1.35	-0.020	0.052	-0.20	0.020	6.8	-0.050	-0.20	0.025	2.0	-0.20	0.16	-0.20	-0.020
<DL	1.03	-0.020	0.008	-0.20	0.020	26.0	-0.050	-0.20	-0.010	1.6	-0.20	0.02	-0.20	-0.020
0.06	-0.50	-0.020	0.036	-0.20	0.040	28.4	-0.050	-0.20	0.022	2.0	-0.20	0.12	-0.20	0.020
0.03	1.88	-0.020	-0.005	-0.20	0.010	30.1	-0.050	-0.20	-0.010	3.0	-0.20	0.02	-0.20	-0.020
0.06	0.56	-0.020	0.008	-0.20	0.020	15.7	-0.050	-0.20	0.014	3.2	-0.20	0.03	-0.20	-0.020
0.06	-0.50	-0.020	0.011	0.34	0.020	51.2	-0.050	-0.20	0.025	3.5	-0.20	0.05	-0.20	-0.020
0.07	-0.50	-0.020	0.010	-0.20	0.010	16.5	-0.050	-0.20	-0.010	4.5	-0.20	0.03	-0.20	-0.020
0.04	-0.50	-0.020	0.006	-0.20	0.010	44.0	-0.050	-0.20	0.014	2.8	-0.20	0.04	-0.20	-0.020
0.04	1.02	-0.020	0.005	-0.20	0.010	24.6	-0.050	-0.20	-0.010	1.8	-0.20	0.02	-0.20	-0.020
0.09	-0.50	-0.020	0.009	-0.20	0.010	19.9	-0.050	0.21	-0.010	4.6	-0.20	0.05	-0.20	-0.020
0.07	0.99	-0.020	0.015	-0.20	0.030	33.5	-0.050	-0.20	0.024	5.9	-0.20	0.10	-0.20	-0.020
0.09	1.13	-0.020	0.017	-0.20	0.020	91.3	-0.050	-0.20	0.010	6.5	-0.20	0.13	-0.20	-0.020
0.14	1.24	-0.020	0.049	0.29	0.030	62.0	-0.050	-0.20	0.038	6.2	-0.20	0.22	0.40	0.030
0.07	0.50	-0.020	0.021	-0.20	0.030	30.3	-0.050	-0.20	0.015	4.1	-0.20	0.07	-0.20	-0.020
0.07	-0.50	-0.020	0.011	-0.20	0.030	51.7	-0.050	0.26	0.011	9.8	-0.20	0.04	-0.20	-0.020
0.10	1.79	-0.020	0.017	-0.20	0.066	32.5	-0.050	-0.20	0.016	7.1	-0.20	0.07	-0.20	-0.020
0.09	1.23	-0.020	0.036	-0.20	0.090	37.9	-0.050	-0.20	0.029	4.7	-0.20	0.12	-0.20	-0.020
0.12	0.78	-0.020	0.022	-0.20	0.033	23.3	-0.050	-0.20	-0.010	5.6	-0.20	0.13	-0.20	-0.020
0.15	1.09	-0.020	0.055	-0.20	0.050	40.5	-0.050	-0.20	0.063	15.2	-0.20	0.17	-0.20	-0.020
0.17	0.67	-0.020	0.052	-0.20	0.040	51.1	-0.050	-0.20	0.080	8.3	-0.20	0.19	-0.20	-0.020
0.06	0.69	-0.020	0.021	-0.20	0.050	48.7	-0.050	-0.20	0.015	2.4	-0.20	0.05	-0.20	-0.020
0.07	0.60	-0.020	0.020	-0.20	0.050	39.9	-0.050	0.27	0.022	1.6	-0.20	0.08	-0.20	-0.020
0.06	0.67	-0.020	0.017	-0.20	0.070	26.3	-0.050	-0.20	-0.010	2.2	-0.20	0.05	-0.20	-0.020
0.10	0.58	-0.020	0.014	-0.20	0.020	21.1	-0.050	-0.20	0.019	7.2	-0.20	0.05	-0.20	-0.020
0.08	1.11	-0.020	0.019	-0.20	0.030	11.5	-0.050	-0.20	0.014	4.6	-0.20	0.07	-0.20	-0.020
0.07	-0.50	-0.020	0.015	-0.20	0.030	20.4	-0.050	-0.20	-0.010	5.7	-0.20	0.04	-0.20	0.020
0.10	-0.50	-0.020	0.020	-0.20	0.020	42.7	-0.050	-0.20	0.018	3.8	-0.20	0.07	-0.20	-0.020
0.08	0.64	-0.020	0.018	-0.20	0.030	24.6	-0.050	-0.20	0.024	3.5	-0.20	0.07	-0.20	-0.020
0.07	0.67	-0.020	0.014	-0.20	0.020	23.2	-0.050	-0.20	-0.010	3.6	-0.20	0.04	-0.20	-0.020
0.08	0.57	-0.020	0.020	-0.20	0.010	26.2	-0.050	-0.20	0.016	5.7	-0.20	0.05	0.22	-0.020
0.05	-0.50	-0.020	0.013	-0.20	0.010	22.7	-0.050	-0.20	0.014	3.8	-0.20	0.03	-0.20	-0.020
0.11	0.66	-0.020	0.022	-0.20	0.010	25.7	-0.050	-0.20	-0.010	10.1	-0.20	0.08	-0.20	-0.020

Zn	Zr
1.00	10.00
ppm	ppm
-1.00	-10.00
1.19	-10.00
-1.00	-10.00
2.36	-10.00
2.34	-10.00
5.12	-10.00
1.62	-10.00
2.90	-10.00
14.40	-10.00
-1.00	-10.00
-1.00	-10.00
1.27	-10.00
1.89	-10.00
2.23	-10.00
1.14	-10.00
1.30	-10.00
3.57	-10.00
1.38	-10.00
1.32	-10.00
-1.00	-10.00
-1.00	-10.00
1.02	-10.00
1.40	-10.00
4.02	-10.00
1.12	-10.00
10.20	-10.00
-1.00	-10.00
2.02	-10.00
1.34	-10.00
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-1.00	-10.00
12.20	-10.00
1.04	-10.00
7.87	-10.00
2.63	-10.00
1.82	-10.00
6.43	-10.00
11.80	-10.00
1.53	-10.00
5.13	-10.00
1.25	-10.00
2.17	-10.00
3.07	-10.00
9.04	-10.00
5.40	-10.00
2.65	-10.00
1.73	-10.00
-1.00	-10.00
1.03	-10.00

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3.23	-10.00
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1.50	-10.00
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5.89	-10.00
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9.65	-10.00
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16.20	-10.00
2.24	-10.00
5.25	-10.00
8.33	-10.00
4.71	-10.00
3.53	-10.00
2.38	-10.00
3.97	-10.00

2.63	-10.00
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6.62	-10.00
11.90	-10.00
6.31	-10.00
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11.00	-10.00
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11.90	-10.00
9.88	-10.00
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6.95	-10.00
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10.40	-10.00
5.90	-10.00
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4.45	-10.00
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10.30	-10.00
6.64	-10.00
3.14	-10.00
8.08	-10.00
5.76	-10.00
3.92	-10.00
23.20	-10.00
7.11	-10.00
11.70	-10.00
12.20	-10.00
6.21	-10.00
17.40	-10.00
23.10	-10.00
9.69	-10.00
7.72	-10.00
17.30	-10.00
6.28	-10.00
43.00	-10.00
9.61	-10.00
3.41	-10.00
3.99	-10.00
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3.17	-10.00
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2.43	-10.00
8.06	-10.00
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8.21	-10.00
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7.96	-10.00
10.20	-10.00
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6.01	-10.00
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9.00	-10.00
8.38	-10.00
7.70	-10.00
9.17	-10.00
21.90	-10.00
11.70	-10.00
6.29	-10.00
8.31	-10.00
6.79	-10.00
6.03	-10.00
7.52	-10.00
5.75	-10.00
6.06	-10.00
6.57	-10.00
12.80	-10.00
5.17	-10.00
10.60	-10.00
11.80	-10.00
12.40	-10.00
9.15	-10.00
6.31	-10.00
11.00	-10.00
17.60	-10.00
11.20	-10.00
17.80	-10.00
21.60	-10.00
11.60	-10.00
11.30	-10.00
10.90	-10.00
9.25	-10.00
11.70	-10.00
6.76	-10.00
5.66	-10.00
6.38	-10.00

APPENDIX G: PEARSON CORRELATION TABLES-VEGETATION-BARK

	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu	Eu	Fe	Ga	Hf	K	La	Li	Mn	Na
As	1.00																					
Au	**-0.64**	1.00																				
B	0.25	-0.35	1.00																			
Ba	1.00	-1.00	0.11	1.00																		
Be	.(a)	.(a)	-0.07	0.09	1.00																	
Br	-0.45	-0.43	-0.07	0.09	0.22	1.00																
Ca	-0.10	-0.05	-0.10	-0.04	-0.40	-0.19	1.00															
Cd	-0.38	**0.82**	-0.09	-0.16	-0.17	0.22	-0.30	1.00														
Ce	.(a)	.(a)	-0.39	**0.94**	0.16	0.32	0.28	-0.35	1.00													
Co	**-0.85**	0.09	0.33	-1.00	.(a)	-0.14	-0.23	**0.72**	**0.97**	1.00												
Cr	-0.12	-0.03	0.01	0.35	-0.21	-0.28	-0.01	0.09	**0.87**	0.36	1.00											
Cs	0.35	**-0.97**	-0.06	**0.63**	0.26	0.00	-0.01	0.06	0.29	0.19	-0.09	1.00										
Cu	-0.38	0.00	0.12	0.02	-0.21	-0.26	0.09	0.03	0.00	**0.64**	**0.56**	0.08	1.00									
Eu	.(a)	.(a)	-0.05	**0.76**	**0.72**	0.47	0.00	**0.54**	0.37	**0.58**	**0.59**	**0.76**	-0.16	1.00								
Fe	0.04	**0.75**	-0.16	**0.74**	0.05	0.18	0.20	0.15	**0.93**	-0.24	0.34	-0.01	0.12	**0.56**	1.00							
Ga	-0.07	0.17	0.04	**0.58**	0.16	0.20	-0.17	0.34	0.36	-0.11	0.10	-0.16	0.05	**0.64**	0.44	1.00						
Hf	.(a)	-1.00	-0.31	**0.97**	0.05	0.30	0.20	0.06	**0.92**	0.32	0.29	-0.09	-0.04	**0.67**	**0.88**	**0.53**	1.00					
K	.(a)	.(a)	0.11	-0.14	0.12	0.11	-0.30	0.44	**-0.57**	0.99	-0.10	-0.08	0.00	-0.01	-0.18	0.11	-0.23	1.00				
La	**-0.86**	0.30	-0.19	**0.73**	0.17	0.32	0.15	0.00	**0.94**	-0.39	0.06	0.21	-0.05	0.50	**0.88**	0.48	**0.87**	-0.17	1.00			
Li	-0.47	0.05	-0.25	-0.10	0.28	0.27	-0.15	0.10	0.03	-0.25	-0.19	-0.13	0.05	0.35	0.09	0.25	-0.02	0.06	0.32	1.00		
Mn	0.46	**0.51**	-0.11	-0.10	-0.15	-0.09	-0.13	**0.55**	0.10	**0.58**	0.12	0.00	0.17	0.01	0.07	0.08	-0.07	0.38	-0.11	-0.01	1.00	
Na	0.38	-0.20	-0.03	-0.22	-0.23	0.46	-0.11	0.36	-0.40	0.19	-0.39	-0.27	-0.22	0.41	0.09	0.13	-0.02	0.24	0.10	0.27	-0.01	1.00
Ni	**0.53**	**0.51**	0.00	0.15	-0.24	-0.29	0.00	0.15	0.16	-0.04	0.35	-0.12	0.22	-0.03	0.12	-0.07	0.01	0.10	-0.11	-0.16	0.29	-0.12
Pb	-0.21	-0.11	-0.10	0.16	-0.15	0.35	-0.15	0.14	0.27	-0.49	-0.07	-0.05	-0.11	0.21	0.26	0.23	0.28	-0.05	0.31	0.32	-0.16	0.21
Rb	.(a)	-1.00	-0.41	**0.87**	0.48	0.43	0.34	0.05	**0.90**	-1.00	-0.20	**0.68**	-0.18	**0.94**	**0.64**	0.35	**0.91**	**-0.54**	**0.67**	-0.21	-0.45	-0.14
Sc	0.01	**0.88**	-0.16	**0.74**	0.05	0.15	0.19	0.11	**0.93**	-0.19	0.38	0.03	0.10	**0.52**	**0.98**	0.39	**0.84**	-0.17	**0.85**	0.08	0.02	0.05
Sm	-0.31	0.31	-0.16	**0.78**	0.14	0.37	0.11	0.06	**0.96**	-0.28	0.14	0.11	0.00	**0.65**	**0.83**	0.50	**0.80**	-0.16	**0.93**	0.34	-0.10	0.14
Sr	0.22	-0.04	-0.18	-0.11	-0.35	-0.11	**0.74**	-0.29	0.17	-0.34	0.04	-0.20	0.08	-0.11	0.15	-0.11	-0.02	-0.29	0.15	0.00	-0.14	-0.13
Te	.(a)	.(a)	-0.37	-0.10	.(a)	0.34	-0.44	**0.91**	.(a)	.(a)	.(a)	.(a)	-0.33	.(a)	1.00	**0.56**	.(a)	1.00	0.35	0.98	**0.89**	-0.16
Th	0.10	0.03	-0.14	**0.75**	0.06	0.27	0.18	0.01	**0.91**	-0.32	0.10	-0.05	0.04	0.44	**0.91**	0.47	**0.93**	-0.26	**0.88**	0.06	-0.04	0.06
Tl	-0.48	**0.83**	0.03	0.22	0.11	0.05	0.05	**0.51**	0.04	**0.77**	0.07	-0.01	0.09	**0.54**	0.16	-0.01	0.21	0.37	0.05	-0.01	0.33	0.23
V	-0.04	**0.93**	0.06	**0.56**	0.06	0.29	-0.09	0.33	0.35	-0.33	0.08	0.12	0.05	**0.53**	**0.63**	**0.63**	**0.51**	0.10	**0.57**	0.19	0.06	0.13
Zn	-0.12	**0.63**	-0.25	0.04	-0.06	0.28	-0.23	0.20	0.19	**0.57**	0.22	-0.04	0.00	-0.22	0.04	0.08	0.21	0.21	0.06	0.09	0.01	0.01

a.Cannot be computed because at least one of the variables is constant.

APPENDIX G: PEARSON CORRELATION TABLES-VEGETATION-TWIG

	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu	Eu	Fe	Ga	Hf	K	La	Li	Mn	Na
As	1.00																					
Au	**0.92**	1.00																				
B	0.22	-0.08	1.00																			
Ba	**-0.97**	0.49	0.22	1.00																		
Be	.(a)	.(a)	-0.26	-0.06	1.00																	
Br	-0.16	0.04	0.23	0.06	-0.02	1.00																
Ca	-0.10	0.01	0.20	0.24	-0.24	0.29	1.00															
Cd	-0.45	**0.67**	0.00	0.47	-0.01	0.14	-0.28	1.00														
Ce	.(a)	.(a)	-0.45	0.02	**0.98**	-0.25	-0.27	-0.15	1.00													
Co	.(a)	.(a)	-1.00	.(a)	.(a)	1.00	-1.00	1.00	.(a)	1.00												
Cr	-0.14	0.26	-0.07	0.45	**-0.76**	-0.03	0.08	-0.16	-0.49	-1.00	1.00											
Cs	-0.20	-1.00	0.45	-0.36	-0.43	0.17	**0.52**	**-0.51**	-1.00	.(a)	0.10	1.00										
Cu	-0.08	0.43	0.00	0.17	-0.02	0.12	-0.03	0.43	-0.18	1.00	-0.04	-0.07	1.00									
Eu	.(a)	.(a)	**-0.80**	**-0.72**	**0.94**	-0.30	0.18	-0.25	**0.92**	.(a)	.(a)	.(a)	-0.19	1.00								
Fe	0.50	0.43	0.08	0.15	-0.33	0.24	0.18	0.14	**-0.56**	-1.00	0.13	**0.52**	0.04	**-0.90**	1.00							
Ga	0.17	**0.82**	-0.02	**0.66**	0.01	-0.24	-0.01	-0.01	0.15	-1.00	-0.27	-0.27	-0.02	-0.05	0.20	1.00						
Hf	1.00	.(a)	0.42	-1.00	.(a)	**0.50**	0.26	0.33	-1.00	.(a)	**-0.93**	1.00	0.13	.(a)	**0.51**	0.10	1.00					
K	-0.35	**-0.57**	0.02	-0.05	0.37	-0.02	0.04	0.03	0.43	1.00	-0.07	-0.08	0.11	**0.72**	-0.12	-0.03	0.30	1.00				
La	-0.20	0.07	-0.19	-0.19	**0.80**	0.06	-0.15	0.14	**0.79**	1.00	-0.24	0.00	0.05	**0.85**	0.05	0.10	0.27	0.02	1.00			

Li	-0.46	-0.44	-0.15	-0.20	0.46	-0.09	0.06	-0.06	0.49	1.00	0.48	-0.21	0.06	**0.98**	-0.15	-0.03	-0.02	0.14	0.42	1.00		
Mn	-0.09	**0.63**	0.12	0.19	0.04	0.01	-0.13	0.47	-0.25	1.00	-0.22	-0.08	0.23	-0.31	0.10	0.18	**0.84**	0.01	0.03	-0.05	1.00	
Na	-0.15	-0.06	0.25	0.22	-0.17	**0.62**	0.12	0.26	-0.38	1.00	-0.14	-0.05	0.08	**-0.62**	0.18	-0.09	**0.71**	0.11	0.04	-0.10	0.11	1.00
Ni	0.37	0.04	0.32	0.25	-0.11	-0.11	-0.04	0.12	-0.27	-1.00	-0.11	-0.07	0.08	**-0.52**	0.12	0.03	0.16	-0.02	-0.06	-0.06	0.36	0.11
Pb	**-0.60**	-0.49	0.05	0.00	-0.12	0.17	0.04	0.07	-0.08	-1.00	-0.17	-0.25	-0.10	-0.16	-0.07	0.01	-0.12	-0.16	0.26	0.17	-0.23	0.01
Rb	**0.81**	**-0.83**	-0.02	-0.12	-0.01	-0.29	-0.05	0.10	0.00	.(a)	0.23	-0.03	-0.04	-0.08	-0.21	-0.03	**0.60**	0.31	-0.16	-0.14	0.21	-0.16
Sc	0.34	0.37	0.18	0.30	-0.39	0.27	0.16	0.13	**-0.62**	-1.00	-0.17	0.35	0.00	**-0.65**	**0.90**	0.23	0.41	-0.18	-0.10	-0.15	0.15	0.26
Sm	-0.34	-0.26	-0.19	-0.09	**0.98**	0.01	-0.15	0.11	**0.95**	1.00	-0.21	0.19	0.06	**0.96**	0.12	0.10	-0.33	0.09	**0.80**	**0.53**	0.06	-0.06
Sr	-0.19	0.14	0.14	-0.18	0.01	0.00	0.20	-0.18	-0.07	-1.00	-0.05	0.42	0.18	0.25	-0.04	0.06	0.38	-0.01	0.02	0.24	-0.10	-0.22
Te	.(a)	.(a)	-0.47	1.00	.(a)	-0.17	-0.32	**0.55**	.(a)	.(a)	.(a)	**0.96**	0.05	.(a)	-0.41	-0.17	.(a)	-0.24	0.38	**0.51**	0.29	-0.45
Th	**-0.65**	-0.16	0.00	**0.62**	-0.35	0.26	0.06	0.47	-0.24	.(a)	-0.06	0.08	0.26	-0.47	0.50	0.05	0.17	0.10	-0.11	-0.11	0.00	0.11
Tl	-0.41	-0.40	0.07	-0.20	-0.17	0.49	0.25	-0.07	-0.13	-1.00	-0.07	0.11	-0.11	**0.93**	0.06	-0.21	0.26	-0.10	0.18	0.21	-0.20	0.39
V	0.10	0.12	0.19	0.02	-0.34	-0.03	0.04	0.01	-0.36	-1.00	-0.31	0.25	-0.18	**-0.57**	**0.50**	0.28	0.31	-0.24	0.09	0.15	0.04	0.01
Zn	0.15	**0.54**	0.14	0.20	-0.03	0.00	-0.26	**0.69**	-0.07	1.00	-0.22	-0.18	0.43	-0.31	0.20	0.10	0.40	0.00	0.07	-0.06	0.35	0.08

a.Cannot be computed because at least one of the variables is constant.

APPENDIX G: PEARSON CORRELATION TABLES-VEGETATION-LEAF

	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu	Eu	Fe	Ga	Hf	K	La	Li	Mn	Na
As	1.00																					
Au	**0.63**	1.00																				
B	**-0.59**	**-0.55**	1.00																			
Ba	0.02	**-0.96**	**0.56**	1.00																		
Be	**0.76**	1.00	-0.18	**0.51**	1.00																	
Br	-0.30	**-0.64**	0.06	-0.01	0.07	1.00																
Ca	-0.06	-0.31	0.43	0.20	-0.15	-0.16	1.00															
Cd	-0.18	-1.00	0.30	0.05	0.04	0.09	0.00	1.00														
Ce	.(a)	.(a)	0.11	0.42	0.06	-0.03	0.28	**0.88**	1.00													
Co	**-0.83**	.(a)	0.23	0.11	0.29	0.13	-0.13	**0.76**	0.36	1.00												
Cr	0.05	0.22	0.03	0.32	**0.67**	0.31	-0.17	**0.78**	0.12	0.49	1.00											
Cs	.(a)	.(a)	-0.38	**-0.69**	-0.21	-0.13	-0.20	-0.15	**-0.70**	-0.07	-0.42	1.00										
Cu	-0.37	0.12	0.15	-0.08	0.02	0.06	0.25	0.08	0.19	0.02	-0.05	-0.07	1.00									
Eu	.(a)	.(a)	-0.42	0.35	0.32	0.28	-0.24	0.02	**0.92**	**-0.66**	.(a)	.(a)	0.19	1.00								
Fe	0.18	-0.35	0.22	0.35	0.06	0.10	0.06	0.15	0.14	-0.12	0.15	0.09	0.02	-0.20	1.00							
Ga	-0.18	0.09	0.12	0.42	0.08	-0.10	0.27	0.02	0.38	-0.14	-0.24	-0.16	0.17	0.32	**0.68**	1.00						
Hf	**0.57**	.(a)	0.32	0.35	0.26	0.07	-0.01	0.07	0.00	**-0.54**	**0.51**	-0.42	0.06	0.33	0.46	0.33	1.00					
K	-0.07	-0.05	-0.29	-0.21	0.34	0.04	-0.14	-0.05	0.12	0.02	0.13	0.14	0.08	0.42	-0.05	0.10	0.22	1.00				
La	**-0.56**	-0.18	0.19	0.26	0.23	0.04	0.24	0.14	**0.94**	0.08	-0.13	-0.04	0.24	**0.78**	0.44	0.44	0.17	-0.04	1.00			
Li	-0.41	**-0.63**	0.24	0.08	0.08	0.03	0.13	0.04	-0.16	-0.14	-0.17	-0.31	0.23	-0.33	0.29	0.35	0.25	0.02	0.28	1.00		
Mn	-0.15	**0.54**	0.10	0.19	0.05	-0.08	0.24	0.33	0.27	0.07	-0.07	-0.23	0.05	-0.10	0.14	0.33	0.06	-0.04	0.05	0.01	1.00	
Na	-0.14	0.25	-0.20	-0.20	-0.17	0.37	-0.19	-0.13	-0.19	-0.21	0.07	-0.14	-0.14	-0.03	-0.03	-0.06	-0.01	-0.17	-0.02	-0.01	-0.09	1.00
Ni	0.19	0.16	-0.07	-0.39	-0.01	-0.15	-0.09	0.44	0.03	0.15	0.44	-0.12	0.14	0.00	0.11	0.01	0.24	-0.01	-0.01	0.16	0.29	0.00
Pb	-0.45	-1.00	0.04	0.10	0.06	0.27	0.15	0.23	**0.53**	-0.04	-0.44	-0.32	0.43	**0.67**	0.33	0.38	0.20	-0.05	0.46	0.16	0.07	0.24
Rb	**-0.64**	0.23	-0.23	-0.08	0.40	0.12	-0.07	-0.05	0.08	0.00	0.36	0.10	0.27	0.27	-0.08	0.01	0.46	0.49	0.10	0.00	0.07	-0.07
Sc	0.08	-0.38	0.16	0.35	0.05	0.09	0.04	0.11	0.15	-0.13	0.18	0.03	0.00	-0.18	**0.97**	**0.71**	**0.52**	-0.02	0.40	0.30	0.16	-0.03
Sm	0.00	-0.10	0.17	0.28	**0.63**	0.03	0.17	0.24	**0.69**	0.21	-0.08	-0.07	0.12	**0.68**	**0.53**	0.48	0.26	0.14	**0.81**	0.28	0.12	-0.20
Sr	-0.31	**-0.51**	0.24	0.20	-0.10	-0.13	0.28	-0.07	-0.06	-0.18	-0.38	-0.19	0.35	-0.08	0.15	0.30	0.36	0.14	0.19	**0.74**	-0.02	-0.19
Te	.(a)	.(a)	**0.57**	.(a)	**0.57**	-0.98	**0.84**	-1.00	.(a)	.(a)	.(a)	.(a)	**0.94**	.(a)	**0.84**	**0.93**	.(a)	**-0.78**	1.00	**0.98**	0.99	**-0.61**
Th	**-0.68**	**-0.50**	0.12	0.31	-0.06	-0.01	0.05	0.02	-0.04	-0.03	-0.18	0.01	-0.01	-0.17	**0.77**	**0.51**	0.11	-0.18	0.35	0.09	0.27	-0.01
Tl	-0.35	**-0.55**	-0.14	-0.10	-0.14	0.31	-0.11	-0.10	0.05	-0.41	-0.38	0.17	0.20	0.40	0.27	0.35	0.17	0.29	0.03	0.21	-0.10	0.20
V	-0.08	-0.26	0.21	0.36	0.00	0.06	0.08	0.12	0.16	-0.15	-0.08	0.07	0.07	0.05	**0.84**	**0.68**	**0.57**	-0.08	0.41	0.35	0.14	0.03
Zn	-0.17	**0.79**	0.08	-0.12	0.27	-0.07	0.08	0.44	**0.59**	0.14	0.07	0.03	0.17	0.35	0.24	0.26	0.19	0.14	0.32	0.12	0.33	-0.15

a.Cannot be computed because at least one of the variables is constant.

Ni	Pb	Rb	Sc	Sm	Sr	Te	Th	Tl	V	Zn
1.00										
-0.17	1.00									
-0.32	**0.61**	1.00								
0.26	0.24	**0.59**	1.00							
-0.09	0.27	**0.58**	**0.79**	1.00						
0.02	-0.04	0.06	0.16	0.21	1.00					
-0.40	-0.05	.(a)	0.01	-0.19	-0.15	1.00				
-0.04	0.24	**0.71**	**0.86**	**0.78**	0.09	-1.00	1.00			
0.19	0.04	0.19	0.17	0.08	-0.03	**-0.57**	0.15	1.00		
0.16	0.49	0.47	**0.64**	**0.53**	-0.10	-0.22	**0.56**	0.28	1.00	
-0.05	0.21	0.01	0.08	0.09	-0.13	**0.97**	-0.05	-0.09	0.08	1.00

Ni Pb Rb Sc Sm Sr Te Th Tl V Zn

Ni	Pb	Rb	Sc	Sm	Sr	Te	Th	Tl	V	Zn
1.00										
-0.16	1.00									
0.21	-0.24	1.00								
0.15	-0.05	-0.18	1.00							
-0.04	0.03	-0.16	-0.08	1.00						
-0.11	0.09	-0.08	-0.03	0.07	1.00					
-0.47	0.32	-0.21	-0.26	**0.89**	0.28	1.00				
-0.05	-0.03	-0.16	**0.54**	-0.01	-0.09	**0.90**	1.00			
-0.14	0.44	-0.36	0.06	0.07	0.09	0.14	0.04	1.00		
0.11	0.38	-0.19	**0.60**	0.00	0.03	-0.28	0.14	0.24	1.00	
0.43	-0.02	0.24	0.22	0.11	-0.12	0.21	0.41	-0.16	0.16	1.00

1.00										
0.04	1.00									
-0.03	-0.01	1.00								
0.11	0.29	-0.01	1.00							
-0.01	0.29	0.05	0.49	1.00						
0.03	0.08	0.11	0.19	0.18	1.00					
0.72	**0.65**	.(a)	**0.90**	1.00	**0.89**	1.00				
0.03	0.28	-0.21	**0.74**	0.33	-0.05	1.00	1.00			
-0.04	0.43	0.13	0.30	0.03	0.14	-0.13	0.13	1.00		
0.13	0.39	-0.23	**0.86**	0.46	0.23	**0.70**	**0.62**	0.36	1.00	
0.34	0.23	0.25	0.28	0.42	0.13	0.40	0.11	0.07	0.20	1.00

APPENDIX I: PEDOGEOCHEMICAL DATASET

	Ag	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu	Eu
	INAA	INAA	INAA	ICP-MS	INAA	ICP-MS	INAA	INAA	ICP-MS	INAA	INAA	INAA	INAA	ICP-MS	INAA
	ppm	ppm	ppb	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DL	2.0	0.50	3.0	0.13	50.0	0.01	0.50	0.10	0.004	1.00	0.50	2.0	0.50	0.005	0.20
S-13	-2.0	1.43	-3.0	5.1	107.0	0.24	2.21	-0.10	0.03	18.20	2.72	22.2	1.27	2.1	0.37
S-15	-2.0	0.99	-3.0	<DL	90.9	0.14	1.32	0.27	0.01	8.81	1.67	9.5	0.56	1.3	-0.20
S-16	-2.0	1.55	-3.0	<DL	73.2	0.16	1.91	0.85	0.02	8.76	2.24	8.7	0.62	2.5	-0.20
S-18	-2.0	3.32	-3.0	<DL	178.0	0.37	7.75	1.82	0.07	31.40	6.70	29.2	2.52	6.2	0.71
S-19	-2.0	1.44	-3.0	<DL	159.0	0.20	2.37	2.01	0.02	10.60	2.31	11.3	1.15	3.5	-0.20
S-20	-2.0	2.53	-3.0	<DL	248.0	0.26	1.65	0.35	0.02	31.70	5.95	26.3	1.40	3.1	0.69
S-22	-2.0	1.55	-3.0	<DL	164.0	0.35	14.80	1.32	0.03	21.80	2.56	23.2	1.40	3.8	0.42
S-23	-2.0	1.89	-3.0	<DL	255.0	0.22	7.96	0.53	0.02	30.30	3.70	34.3	1.79	4.1	-0.20
S-24	-2.0	1.46	-3.0	<DL	150.0	0.26	2.90	0.44	0.03	16.60	3.32	16.1	1.00	3.6	0.39
S-25-1	-2.0	1.91	-3.0	2.6	105.0	0.31	5.67	0.62	0.03	14.40	2.36	17.8	1.24	3.9	0.30
S-25-2	-2.0	2.85	-3.0	5.9	179.0	0.35	15.00	1.95	0.04	21.90	4.49	25.5	1.91	5.9	0.36
S-27	-2.0	1.65	-3.0	<DL	153.0	0.20	4.82	1.01	0.02	14.00	1.93	16.3	0.91	3.9	0.27
S-29	-2.0	8.67	-3.0	6.7	236.0	0.43	17.20	4.22	0.05	30.50	4.65	21.1	1.33	4.5	0.53
S-30	-2.0	2.35	-3.0	2.6	198.0	0.26	16.80	1.82	0.05	29.80	4.29	28.8	1.20	4.5	0.57
S-51	-2.0	2.35	-3.0	18.0	269.0	0.30	64.80	5.27	0.06	32.90	4.31	25.6	1.44	6.0	0.43
S-52	-2.0	3.48	-3.0	6.2	259.0	0.35	15.40	3.09	0.08	42.20	5.76	36.6	2.06	6.3	0.52
S-53	-5.0	5.16	-5.0	2.3	355.0	0.27	11.10	5.15	0.07	44.40	5.01	26.7	1.43	4.7	0.38
S-55	-5.0	1.45	-5.0	<DL	242.0	0.17	5.72	0.99	0.04	46.00	3.68	36.2	1.42	3.0	0.81
S-56	-2.0	17.30	-3.0	<DL	248.0	0.18	5.28	2.06	0.05	20.80	2.32	16.3	1.11	1.4	0.24
S-57	-2.0	2.73	-3.0	<DL	218.0	0.16	8.56	2.34	0.04	23.60	1.92	19.4	1.17	2.1	0.38
S-58	-2.0	1.76	-3.0	<DL	161.0	0.14	4.14	0.12	0.01	13.90	1.23	12.5	0.94	0.5	0.28
S-59	-2.0	0.81	-3.0	<DL	65.5	0.09	0.97	-0.10	0.01	5.53	0.74	7.7	0.58	0.4	-0.20
S-60	-2.0	2.35	-3.0	<DL	174.0	0.35	4.52	0.58	0.03	29.80	4.37	30.6	2.00	2.3	0.53
S-61	-2.0	3.57	-3.0	2.0	238.0	0.40	18.30	2.82	0.07	42.20	7.72	31.3	2.37	5.0	0.84
S-62	-2.0	1.64	-3.0	1.9	71.4	0.31	4.15	0.66	0.03	14.70	2.77	18.5	1.21	4.7	0.31
S-65	-2.0	3.41	-3.0	3.6	404.0	0.40	32.30	4.13	0.33	51.00	7.73	46.2	3.24	7.9	0.87
S-92	-2.0	2.15	-3.0	3.3	192.0	0.43	5.44	0.86	0.06	26.40	4.50	25.8	0.69	5.2	0.63
S-94	-2.0	2.83	-3.0	4.9	232.0	0.25	29.50	2.15	0.10	44.20	6.04	31.1	2.22	8.6	0.88
S-95	-2.0	3.58	-3.0	3.9	232.0	0.31	21.30	4.18	0.12	37.00	5.64	27.9	1.84	4.3	0.73
S-96	-2.0	1.09	-3.0	2.3	192.0	0.25	13.20	0.95	0.08	19.10	2.47	14.4	1.10	2.6	0.48
S-97	-2.0	2.12	-3.0	5.5	169.0	0.35	27.70	2.69	0.10	36.80	5.89	23.1	1.91	4.8	0.70
S-98	-2.0	4.09	-3.0	2.2	163.0	0.31	25.60	4.55	0.30	38.90	8.90	25.9	2.36	4.2	0.76
S-99	-2.0	4.83	-3.0	6.7	267.0	0.37	26.40	3.45	0.17	37.00	7.38	34.9	2.28	7.4	0.69
S-100	-2.0	2.00	-3.0	3.7	152.0	0.26	19.00	8.39	0.15	26.70	5.16	14.0	0.92	11.6	0.51
S-102	-2.0	2.49	-3.0	5.0	232.0	0.31	38.90	4.31	0.14	32.60	7.88	28.8	1.57	10.2	0.44
S-103	-2.0	2.36	-3.0	2.6	235.0	0.44	16.60	1.18	0.06	37.40	6.71	44.4	3.30	2.5	0.57
S-104	-2.0	0.97	-3.0	5.3	172.0	0.20	36.10	6.40	0.06	18.00	3.55	16.8	1.11	3.9	0.39
S-105	-2.0	1.50	-3.0	6.0	106.0	0.23	24.40	5.85	0.10	17.70	3.50	17.5	0.72	2.4	0.41
S-106	-2.0	1.61	-3.0	4.6	109.0	0.18	32.30	12.50	0.05	12.70	4.51	14.3	0.75	1.8	0.26
S-108	-2.0	4.07	-3.0	11.3	165.0	0.31	16.90	4.27	0.09	20.50	3.87	26.2	1.40	4.7	0.39
S-109	-2.0	2.66	-3.0	9.8	184.0	0.35	21.60	4.38	0.11	29.40	5.45	25.1	1.82	5.2	0.72
S-113	-2.0	3.13	-3.0	11.7	200.0	0.40	32.80	3.46	0.05	31.90	5.29	33.8	1.75	5.1	0.72
S-114	-2.0	1.87	-3.0	6.6	107.0	0.48	8.43	0.46	0.04	20.70	4.90	33.2	1.67	5.4	0.52
S-115	-2.0	0.52	-3.0	<DL	-50.0	0.13	4.44	1.89	0.01	5.42	0.96	7.6	-0.50	1.5	-0.20
S-116	-2.0	7.40	-3.0	1.8	261.0	0.23	6.40	1.69	0.14	27.60	21.90	274.0	3.50	26.5	0.65
S-127	-2.0	1.36	-3.0	13.4	141.0	0.44	6.35	1.97	0.03	58.00	10.30	76.5	2.12	4.2	1.10
S-129	-2.0	0.64	-3.0	21.8	158.0	0.34	22.50	3.40	0.02	20.50	5.16	44.7	1.38	14.8	0.36
S-130	-2.0	-0.50	-3.0	1.3	-50.0	0.13	3.50	0.14	0.01	9.60	1.49	13.9	-0.50	0.7	-0.20

S-134	-2.0	-0.50	-3.0	7.4	142.0	0.24	3.77	-0.10	0.01	14.20	2.23	24.6	-0.50	1.6	0.36
S-136	-2.0	4.34	8.6	11.6	136.0	0.20	17.40	4.52	0.08	21.40	16.20	237.0	1.52	25.1	0.54
S-137	-2.0	6.59	13.9	2.0	164.0	0.22	2.32	1.85	0.06	19.90	14.20	561.0	0.78	23.3	0.57
S-138	-2.0	6.59	85.9	6.8	118.0	0.39	6.15	0.50	0.04	26.40	18.80	763.0	1.35	18.8	0.54
S-139	-2.0	9.23	41.0	2.3	183.0	0.33	3.73	0.45	0.07	27.60	19.20	682.0	1.72	17.9	0.70
S-141	-2.0	8.94	14.2	2.7	188.0	0.27	5.90	0.50	0.04	21.30	38.50	#####	2.23	15.2	0.62
S-142	-2.0	59.40	32.5	3.9	249.0	0.17	5.27	0.81	0.07	20.20	16.10	564.0	2.68	10.5	0.63
S-144	-2.0	41.40	11.5	<DL	169.0	0.16	4.61	1.47	0.07	19.30	26.40	938.0	1.32	15.6	0.43
S-145	-2.0	35.00	17.3	<DL	121.0	0.13	6.64	0.46	0.07	18.00	37.10	#####	0.90	22.1	0.23
S-148	-2.0	3.37	-3.0	<DL	84.9	0.26	0.71	0.10	0.04	19.60	6.69	182.0	1.78	9.4	0.40
S-152	-2.0	10.30	17.1	<DL	-50.0	0.10	31.00	5.63	0.32	22.90	27.70	332.0	-0.50	39.3	1.06
S-155	-5.0	1.61	-3.0	<DL	429.0	0.13	5.12	4.11	0.03	29.60	29.90	139.0	1.05	7.8	1.41
S-156	-2.0	1.16	-3.0	1.2	237.0	0.21	18.70	7.20	0.17	23.20	6.58	55.5	0.97	6.8	0.46
S-157	-2.0	3.55	-3.0	12.5	146.0	0.15	29.00	18.60	0.10	19.90	7.48	50.1	1.37	9.9	0.43
S-158	-2.0	2.06	-3.0	<DL	174.0	0.19	18.40	9.67	0.11	25.30	5.00	51.0	1.47	4.9	0.55
S-160	-2.0	2.67	-3.0	8.9	139.0	0.14	56.60	15.80	0.18	20.50	4.31	31.9	0.67	5.7	0.37
S-161	-2.0	1.00	-3.0	3.2	152.0	0.11	57.40	12.00	0.09	14.80	4.11	18.1	-0.50	4.4	0.25
S-162	-2.0	1.68	-3.0	0.9	57.9	0.12	36.80	19.10	0.14	18.70	3.07	26.8	1.12	4.1	0.25
S-164	-2.0	1.21	-3.0	<DL	-50.0	0.12	14.50	7.80	0.04	11.50	2.66	14.1	0.95	3.8	0.42
S-166	-2.0	0.95	-3.0	<DL	72.9	0.08	12.70	10.50	0.05	11.20	1.68	11.2	0.72	2.9	0.32
S-167	-2.0	0.79	-3.0	<DL	212.0	0.09	4.36	1.50	0.06	78.40	2.75	16.6	1.42	1.4	0.67
S-168	-2.0	2.27	-3.0	1.8	67.1	0.19	21.30	6.28	0.09	14.40	3.67	21.5	1.27	3.5	0.42
S-173	-2.0	1.51	-3.0	2.0	215.0	0.17	32.00	14.90	0.05	21.90	2.76	20.6	0.88	2.4	0.58
S-201-1	-2.0	1.86	-3.0	<DL	96.8	0.21	1.61	0.12	0.02	13.00	2.46	13.8	0.97	2.7	0.33
S-201-2	-2.0	3.07	-3.0	<DL	103.0	0.26	2.64	0.20	0.02	25.00	4.61	25.2	1.96	3.3	0.50
S-202	-2.0	1.22	-3.0	<DL	126.0	0.23	3.23	0.22	0.05	14.90	3.28	14.1	1.20	5.9	-0.20
S-203	-2.0	3.64	-3.0	<DL	498.0	0.38	18.10	3.10	0.14	67.40	6.14	39.7	2.06	5.1	0.92
S-204	-2.0	5.03	-3.0	<DL	529.0	0.48	9.05	0.50	0.06	66.10	7.09	43.9	2.75	5.6	0.92
S-205	-2.0	2.29	-3.0	<DL	276.0	0.22	25.80	0.66	0.07	66.10	4.24	39.8	2.72	6.2	0.53
S-206	-2.0	2.23	-3.0	<DL	401.0	0.26	31.30	0.40	0.06	75.10	3.51	35.9	3.49	4.3	0.72
S-207	-2.0	2.63	-3.0	<DL	252.0	0.23	16.80	6.16	0.11	48.90	8.13	41.7	2.73	6.1	0.78
S-208	-2.0	3.56	-3.0	1.1	314.0	0.28	17.90	6.06	0.09	39.20	5.26	37.0	2.50	8.9	0.70
S-209	-2.0	2.15	-3.0	4.6	299.0	0.31	42.30	4.37	0.56	33.60	5.86	34.6	2.93	7.4	0.58
S-210	-2.0	3.45	-3.0	<DL	294.0	0.26	28.60	3.54	0.11	38.80	8.15	47.0	3.15	6.5	0.65
S-211	-2.0	2.50	-3.0	<DL	312.0	0.29	11.20	0.55	0.10	59.30	9.04	49.1	3.02	5.3	0.87
S-212	-2.0	1.80	-3.0	<DL	351.0	0.26	12.30	0.41	0.13	48.90	7.92	41.3	2.20	4.9	1.08
S-213	-2.0	2.28	-3.0	<DL	262.0	0.30	15.20	0.67	0.18	47.50	8.29	51.2	2.76	5.7	1.00
S-214	-2.0	2.47	-3.0	<DL	274.0	0.30	21.00	5.80	0.09	40.10	6.69	37.4	2.68	6.2	0.96
S-215	-2.0	2.36	-3.0	<DL	310.0	0.22	5.25	0.30	0.15	62.80	10.60	48.7	3.13	5.0	0.95
S-216	-2.0	7.43	-3.0	<DL	146.0	0.08	15.50	6.47	0.08	15.60	27.70	405.0	1.21	22.8	0.65
S-217	-2.0	1.85	-3.0	<DL	103.0	0.18	6.07	0.78	0.05	12.40	2.06	20.5	0.82	1.9	0.32
S-218	-2.0	2.68	-3.0	<DL	150.0	0.28	32.50	2.01	0.10	26.80	7.04	30.6	1.94	9.0	0.27

Fe	Ga	Hf	Ir	K	La	Li	Lu	Mn	Mo	Na	Ni	Pb	Rb	Sb	Sc
INAA	ICP-MS	INAA	INAA	INAA	INAA	ICP-MS	INAA	ICP-MS	INAA	INAA	ICP-MS	ICP-MS	INAA	INAA	INAA
%	ppm	ppm	ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm
0.01	0.004	0.20	10.0	0.10	0.20	0.009	0.10	0.003	2.0	0.005	0.003	0.003	5.0	0.10	0.05
0.77	1.9	8.29	-10.0	0.45	8.61	5.2	0.17	46.6	-2.0	0.072	3.1	4.8	20.0	0.20	3.02
0.43	1.5	2.89	-10.0	0.14	4.08	3.2	-0.10	29.7	-2.0	0.027	2.5	3.3	-5.0	0.19	1.57
0.46	2.3	2.40	-10.0	0.29	4.36	2.8	-0.10	64.6	-2.0	0.036	3.3	7.7	13.2	0.27	1.61
1.57	4.1	4.71	-10.0	0.84	14.70	7.7	0.21	180.8	-2.0	0.139	7.5	11.5	37.3	0.32	6.06
0.59	2.9	1.76	-10.0	0.31	5.26	4.5	-0.10	64.3	-2.0	0.067	5.1	11.8	17.9	0.20	2.16
1.16	2.7	6.13	-10.0	0.89	14.90	3.6	0.20	81.2	-2.0	0.242	3.9	5.4	42.8	0.38	4.49
0.92	4.6	5.91	-10.0	0.51	11.20	5.5	0.15	100.0	3.0	0.134	4.5	6.3	33.6	0.28	3.80
1.07	2.7	11.00	-10.0	0.88	15.20	4.1	0.24	103.3	-2.0	0.274	4.2	4.6	49.0	0.29	4.14
0.83	2.4	3.07	-10.0	0.47	7.90	5.3	0.13	77.1	-2.0	0.107	4.6	4.9	29.7	0.27	3.07
1.01	4.2	3.16	-10.0	0.50	7.17	8.1	-0.10	83.9	-2.0	0.079	5.5	4.7	26.5	0.19	3.39
1.42	5.3	3.96	-10.0	0.83	10.80	9.2	0.14	150.9	-2.0	0.121	7.0	5.2	35.8	0.31	4.84
0.63	3.0	4.30	-10.0	0.51	7.00	5.1	0.10	36.6	-2.0	0.100	4.0	2.7	26.4	0.19	2.18
1.43	4.6	5.27	-10.0	0.63	13.00	4.6	0.21	109.9	-2.0	0.167	4.3	5.3	28.6	0.36	3.60
1.03	3.8	7.36	-10.0	1.01	14.30	5.5	0.19	109.3	-2.0	0.236	4.7	4.7	55.6	0.37	3.79
1.27	4.9	7.47	-10.0	0.94	16.70	5.1	0.21	197.6	-2.0	0.530	7.0	6.1	29.5	0.29	4.63
1.68	5.3	10.00	-10.0	1.22	21.80	7.2	0.27	144.6	-2.0	0.326	6.9	7.6	47.6	0.38	6.35
1.47	4.1	7.86	-20.0	1.26	22.30	4.9	0.27	102.8	-5.0	1.230	5.6	6.9	63.1	0.42	5.09
1.69	2.3	9.09	-20.0	0.92	24.20	3.0	0.25	65.6	-5.0	1.530	3.3	2.3	38.0	0.22	5.38
0.88	2.3	3.70	-10.0	0.90	10.30	3.1	0.12	87.3	-2.0	0.372	3.8	4.6	47.6	0.34	2.45
0.58	2.3	7.16	-10.0	0.85	11.80	3.6	0.16	34.3	-2.0	0.315	4.6	10.2	38.8	0.21	2.18
0.45	1.9	6.27	-10.0	0.68	6.65	4.9	0.11	25.5	-2.0	0.159	2.3	2.7	24.9	0.19	1.70
0.28	1.2	3.44	-10.0	0.12	2.55	2.9	-0.10	10.4	-2.0	0.030	1.4	1.1	9.4	0.15	1.02
1.49	4.3	7.25	-10.0	0.65	14.30	15.6	0.21	70.3	-2.0	0.111	7.9	9.2	43.9	0.28	5.48
1.85	4.6	5.02	-10.0	1.07	19.00	7.8	0.26	110.4	-2.0	0.165	6.8	10.2	45.6	0.35	7.23
0.81	3.7	3.79	-10.0	0.34	7.23	6.6	0.12	74.7	-2.0	0.063	6.3	5.4	20.3	0.20	2.84
2.73	8.3	6.83	-10.0	0.96	26.40	7.1	0.27	304.8	-2.0	0.202	9.4	40.4	52.5	0.57	9.08
1.50	5.7	4.40	-10.0	0.64	13.80	8.1	0.17	90.2	-2.0	0.080	5.7	9.4	42.7	0.17	5.34
1.65	3.3	5.78	-10.0	1.14	21.40	5.5	0.23	105.5	-2.0	0.293	4.8	34.6	38.7	0.33	6.01
1.50	4.4	4.72	-10.0	0.98	18.50	6.2	0.21	73.3	-2.0	0.204	4.7	11.0	41.8	0.35	6.10
0.77	2.9	3.12	-10.0	0.75	9.61	5.1	0.11	45.4	-2.0	0.128	3.2	7.7	29.5	0.14	2.96
1.34	4.3	5.89	-10.0	1.04	17.60	6.7	0.20	97.9	-2.0	0.231	4.6	13.6	43.8	0.32	5.19
1.59	3.9	4.19	-10.0	0.92	18.50	5.4	0.20	92.9	-2.0	0.137	4.2	18.1	37.6	0.34	6.17
1.91	5.6	5.62	-10.0	1.11	18.30	6.9	0.24	113.4	-2.0	0.205	6.7	14.4	69.1	0.51	7.84
0.86	3.4	3.34	-10.0	0.62	13.20	4.7	0.16	68.9	-2.0	0.132	4.1	12.5	27.6	0.34	3.58
1.61	5.0	4.85	-10.0	1.17	16.50	4.3	0.20	141.2	-2.0	0.207	5.6	9.9	35.4	0.30	5.79
2.70	7.0	5.18	-10.0	0.87	18.20	8.7	0.26	59.0	-2.0	0.175	5.3	13.5	61.0	0.33	9.51
0.95	3.0	4.19	-10.0	0.70	10.00	2.8	0.13	61.5	-2.0	0.184	3.5	5.7	29.7	-0.10	3.62
0.94	3.4	3.45	-10.0	0.65	9.06	5.0	0.13	42.6	-2.0	0.090	3.7	9.5	29.9	0.19	3.60
0.83	3.5	3.66	-10.0	0.49	7.42	4.7	0.10	50.6	-2.0	0.093	4.7	4.1	21.3	0.21	2.98
1.47	5.0	6.67	-10.0	0.89	10.30	5.7	0.16	79.4	-2.0	0.181	5.7	8.9	40.7	0.32	4.98
1.50	4.8	6.27	-10.0	1.01	14.30	5.6	0.20	108.1	-2.0	0.166	6.5	12.8	55.6	0.35	5.75
1.94	7.9	6.20	-10.0	0.94	15.80	9.1	0.19	82.3	-2.0	0.111	6.0	10.4	45.6	0.24	7.19
1.59	5.9	5.13	-10.0	0.61	10.10	10.3	0.14	80.2	-2.0	0.071	6.1	8.3	27.4	0.22	6.50
0.30	1.9	4.88	-10.0	0.12	2.60	2.5	-0.10	25.2	-2.0	0.022	1.8	1.5	8.1	-0.10	1.20
4.67	4.0	2.99	-10.0	0.84	14.10	5.6	0.21	208.3	-2.0	0.522	26.9	11.2	44.1	0.45	19.50
2.06	5.6	3.15	-10.0	1.17	28.60	15.0	0.16	66.9	-2.0	0.091	17.7	12.1	88.2	-0.10	10.10
1.24	6.7	3.60	-10.0	0.84	10.60	9.6	0.10	85.2	-2.0	0.174	12.6	5.8	26.6	-0.10	5.63
0.43	1.5	5.93	-10.0	0.17	4.75	5.6	-0.10	8.1	-2.0	0.028	4.5	4.6	7.7	-0.10	1.77

0.59	2.2	5.49	-10.0	0.35	6.65	6.5	0.10	23.5	-2.0	0.066	7.3	3.9	25.3	0.11	3.33
2.91	3.4	2.23	-10.0	0.80	10.50	4.8	0.16	332.3	-2.0	0.332	31.6	7.2	33.9	0.34	18.30
5.86	6.2	5.03	-10.0	0.57	9.59	4.2	0.21	202.3	-2.0	0.185	37.0	6.8	22.6	0.54	18.30
6.21	6.2	4.60	-10.0	0.39	12.20	7.8	0.21	131.8	-2.0	0.133	37.6	7.7	38.0	0.50	33.10
6.18	5.6	3.83	-10.0	0.66	15.00	8.0	0.22	235.5	-2.0	0.171	53.9	11.1	37.1	0.97	18.80
7.72	5.1	4.31	-10.0	0.39	10.40	5.7	0.17	228.6	-2.0	0.228	126.8	7.1	34.2	0.80	14.30
4.42	5.2	3.46	-10.0	0.61	11.30	4.7	0.13	154.5	-2.0	0.514	104.2	9.3	18.6	3.90	8.67
5.05	6.0	3.40	-10.0	0.42	10.40	7.0	0.14	243.9	-2.0	0.310	151.2	6.2	26.5	3.31	12.20
6.15	5.2	3.86	-10.0	0.42	8.74	4.4	0.18	328.0	-2.0	0.150	134.4	6.2	30.3	0.77	21.50
2.71	4.9	3.18	-10.0	0.42	10.60	6.4	0.12	121.8	-2.0	0.064	20.0	8.7	31.7	0.24	7.05
4.07	3.2	2.69	-10.0	0.79	10.10	2.2	0.24	206.0	-2.0	0.576	31.1	9.0	-10.0	1.03	16.80
7.23	4.1	6.10	-10.0	0.83	13.30	3.1	0.33	251.2	-2.0	1.090	11.2	2.4	51.7	-0.10	27.60
1.41	4.3	5.28	-10.0	1.01	11.90	6.0	0.11	148.2	-2.0	0.201	13.4	6.1	35.4	0.20	5.17
1.18	4.3	3.48	-10.0	0.58	9.90	4.1	0.11	147.2	-2.0	0.133	11.9	4.8	18.7	0.23	4.50
1.53	5.0	6.98	-10.0	0.79	12.50	4.6	0.17	134.9	-2.0	0.121	9.3	6.6	27.0	0.25	5.72
1.01	4.0	3.05	-10.0	0.59	9.69	3.9	0.11	131.3	-2.0	0.117	6.9	4.3	9.9	0.33	3.98
0.65	3.1	5.50	-10.0	0.31	7.11	3.3	0.13	82.5	-2.0	0.158	5.7	2.9	23.0	-0.10	2.68
0.85	3.0	4.35	-10.0	0.40	9.51	3.6	0.13	88.1	-2.0	0.167	4.9	3.7	18.8	0.16	3.36
0.53	2.6	4.09	-10.0	0.22	5.48	3.4	-0.10	158.1	-2.0	0.078	4.1	2.6	19.6	0.11	2.23
0.40	2.0	4.66	-10.0	0.21	5.04	2.0	-0.10	41.3	-2.0	0.076	3.3	3.4	10.2	-0.10	1.71
1.48	2.0	9.90	-10.0	1.16	41.70	2.5	0.44	59.0	-2.0	0.680	1.5	7.9	56.7	-0.10	4.40
0.96	4.6	3.49	-10.0	0.30	7.64	5.0	0.10	63.9	-2.0	0.150	4.8	4.1	25.1	0.14	4.00
0.85	4.9	2.69	-10.0	1.11	11.00	3.1	0.12	73.0	-2.0	0.127	4.6	4.0	44.3	0.15	3.04
0.82	3.2	2.88	-10.0	0.29	6.73	5.5	-0.10	59.5	-2.0	0.068	4.2	3.9	18.8	0.16	2.81
1.47	3.9	3.93	-10.0	0.55	11.70	6.5	0.16	48.8	-2.0	0.083	4.9	4.4	24.6	0.26	5.23
0.83	3.7	2.26	-10.0	0.46	7.40	6.1	0.10	96.5	-2.0	0.062	6.4	4.4	18.2	0.23	2.98
2.72	7.1	6.82	-10.0	2.06	34.10	5.1	0.33	160.0	-2.0	0.234	5.6	13.7	100.0	0.34	9.00
3.23	7.3	10.80	-10.0	1.80	35.40	10.6	0.41	90.1	-2.0	0.241	6.4	10.8	104.0	0.29	10.70
1.25	5.1	6.42	-10.0	1.64	36.20	3.1	0.22	147.1	-2.0	0.146	3.6	79.1	80.2	0.41	7.57
1.38	5.4	6.57	-10.0	2.07	39.90	3.1	0.19	86.9	-2.0	0.181	3.4	60.1	109.0	0.22	6.30
2.22	5.4	5.25	-10.0	1.54	24.70	3.7	0.24	102.5	-2.0	0.147	7.4	14.6	57.8	-0.10	8.80
2.04	7.7	6.41	-10.0	1.30	20.80	4.5	0.24	89.8	-2.0	0.151	7.1	18.3	60.6	0.23	7.25
1.70	7.8	6.22	-10.0	1.15	16.50	5.0	0.21	120.7	-2.0	0.225	6.9	18.2	52.4	0.48	6.83
2.56	6.1	6.33	-10.0	1.25	20.80	9.1	0.25	180.1	-2.0	0.139	8.2	10.6	75.7	0.44	8.12
2.91	5.1	7.65	-10.0	1.74	28.90	4.5	0.36	160.9	-2.0	0.212	4.6	16.8	78.3	0.35	10.60
2.40	4.0	9.06	-10.0	1.38	24.20	4.5	0.31	166.2	-2.0	0.211	4.7	15.7	87.5	0.25	8.44
2.70	5.1	7.55	-10.0	1.61	24.40	8.6	0.30	156.0	-2.0	0.161	5.7	16.5	78.7	0.27	9.77
2.18	6.4	5.79	-10.0	1.48	21.60	5.0	0.25	114.0	-2.0	0.142	5.4	12.0	61.0	0.28	8.19
2.66	3.5	8.90	-10.0	1.41	29.10	5.3	0.37	166.5	-2.0	0.213	4.2	16.8	87.2	0.27	9.67
4.29	3.9	2.21	-10.0	0.41	7.10	3.6	0.17	281.2	-2.0	0.417	53.0	3.4	22.3	0.28	18.20
1.15	5.1	4.27	-10.0	0.32	6.00	5.2	0.10	31.3	-2.0	0.041	4.3	6.1	20.2	0.16	4.05
1.81	4.9	4.37	-10.0	0.82	13.20	5.0	0.16	122.8	-2.0	0.361	7.8	10.7	54.9	0.18	7.02

Se	Sm	Sr	Ta	Te	Th	Tl	U	V	W	Yb	Zn	Zr
INAA	INAA	ICP-MS	INAA	INAA	INAA	ICP-MS	INAA	ICP-MS	INAA	INAA	INAA	INAA
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
2.0	0.10	0.002	0.50	2.0	0.20	0.001	0.50	0.002	1.00	0.30	20.0	200.0
-2.0	1.77	9.0	0.77	-2.0	4.08	0.06	0.53	7.0	-1.00	1.17	-20.0	379.0
-2.0	0.82	12.9	-0.50	-2.0	1.84	0.03	-0.50	5.8	-1.00	0.47	-20.0	-200.0
-2.0	0.81	53.7	-0.50	-2.0	1.89	0.04	-0.50	9.7	-1.00	0.45	-20.0	-200.0
-2.0	2.98	71.8	-0.50	-2.0	5.77	0.15	0.90	14.1	-1.00	1.55	-20.0	-200.0
-2.0	1.04	105.5	-0.50	-2.0	2.24	0.06	-0.50	9.1	-1.00	0.56	-20.0	-200.0
-2.0	3.06	14.7	-0.50	-2.0	4.90	0.08	0.96	8.3	-1.00	1.45	26.5	-200.0
-2.0	2.07	63.9	-0.50	-2.0	4.80	0.08	-0.50	8.6	-1.00	1.09	-20.0	306.0
-2.0	2.71	34.9	-0.50	-2.0	6.53	0.07	0.85	9.6	-1.00	1.56	-20.0	509.0
-2.0	1.72	22.8	-0.50	-2.0	3.19	0.06	-0.50	8.6	-1.00	0.89	26.9	-200.0
-2.0	1.28	37.2	-0.50	-2.0	3.33	0.09	-0.50	13.7	-1.00	0.67	-20.0	-200.0
-2.0	2.04	87.0	0.71	-2.0	4.70	0.12	-0.50	17.1	-1.00	1.00	30.5	-200.0
-2.0	1.25	77.6	-0.50	-2.0	3.26	0.05	0.71	10.0	-1.00	0.73	-20.0	222.0
-2.0	2.81	187.3	-0.50	-2.0	4.52	0.09	1.01	20.1	-1.00	1.47	20.7	-200.0
-2.0	2.51	54.2	-0.50	-2.0	6.21	0.09	1.01	10.1	-1.00	1.31	-20.0	299.0
-2.0	2.82	179.1	0.58	-2.0	6.49	0.14	-0.50	9.8	-1.00	1.43	-20.0	251.0
-2.0	3.84	44.3	-0.50	-2.0	9.08	0.18	1.29	16.2	-1.00	1.96	-20.0	530.0
-5.0	3.62	94.8	-1.00	-5.0	9.03	0.12	1.26	15.5	-2.00	1.95	-50.0	416.0
-5.0	3.65	16.3	-1.00	-5.0	8.17	0.04	1.12	30.7	-2.00	1.76	-50.0	540.0
-2.0	1.73	46.0	-0.50	-2.0	4.10	0.05	0.81	15.8	-1.00	0.84	-20.0	-200.0
-2.0	1.94	86.0	-0.50	-2.0	5.00	0.05	0.80	9.7	-1.00	1.12	-20.0	-200.0
-2.0	1.19	6.6	-0.50	-2.0	2.80	0.04	-0.50	6.9	-1.00	0.75	-20.0	204.0
-2.0	0.50	4.4	-0.50	-2.0	1.32	0.02	-0.50	4.7	-1.00	0.41	-20.0	-200.0
-2.0	2.93	34.6	-0.50	-2.0	5.57	0.17	0.73	14.6	-1.00	1.49	-20.0	280.0
-2.0	4.51	148.6	-0.50	-2.0	7.30	0.21	-0.50	14.5	-1.00	1.98	28.7	-200.0
-2.0	1.42	59.6	-0.50	-2.0	3.03	0.11	0.60	11.3	-1.00	0.79	-20.0	-200.0
-2.0	4.43	51.4	-0.50	-2.0	8.58	0.17	0.64	22.8	-1.00	2.01	69.1	294.0
-2.0	2.33	30.7	0.55	-2.0	7.74	0.16	-0.50	17.8	-1.00	1.19	25.1	-200.0
-2.0	4.24	39.7	-0.50	-2.0	7.04	0.18	-0.50	9.8	-1.00	1.52	25.6	201.0
-2.0	3.49	114.6	-0.50	-2.0	6.88	0.13	0.96	13.8	-1.00	1.53	-20.0	220.0
-2.0	1.74	41.8	-0.50	-2.0	3.59	0.07	-0.50	8.6	-1.00	0.80	-20.0	-200.0
-2.0	3.28	70.8	0.61	-2.0	6.03	0.16	-0.50	13.2	-1.00	1.49	21.2	-200.0
-2.0	3.87	81.8	-0.50	-2.0	6.30	0.15	-0.50	14.3	-1.00	1.65	34.1	-200.0
-2.0	3.46	87.7	-0.50	-2.0	7.86	0.16	1.04	16.7	-1.00	1.74	31.5	241.0
-2.0	2.55	192.2	-0.50	-2.0	3.98	0.10	1.05	9.5	-1.00	1.10	26.8	-200.0
-2.0	3.00	48.0	0.52	-2.0	6.44	0.14	-0.50	10.9	-1.00	1.46	35.3	-200.0
-2.0	3.50	23.6	-0.50	-2.0	9.91	0.19	1.13	16.6	-1.00	1.82	34.3	-200.0
-2.0	2.05	103.3	-0.50	-2.0	3.88	0.10	-0.50	4.7	-1.00	0.96	-20.0	244.0
-2.0	1.82	93.7	-0.50	-2.0	3.62	0.10	-0.50	6.9	-1.00	0.87	-20.0	-200.0
-2.0	1.39	136.4	-0.50	-2.0	2.89	0.08	-0.50	7.9	-1.00	0.72	-20.0	-200.0
-2.0	1.90	129.8	-0.50	-2.0	5.82	0.13	0.91	18.3	-1.00	1.13	-20.0	344.0
-2.0	2.68	103.1	-0.50	-2.0	6.15	0.13	1.13	11.5	1.49	1.49	34.4	-200.0
-2.0	2.87	81.1	-0.50	-2.0	11.90	0.16	0.93	22.9	-1.00	1.40	-20.0	-200.0
-2.0	1.85	41.6	-0.50	-2.0	7.06	0.15	0.68	20.6	-1.00	1.00	-20.0	-200.0
-2.0	0.53	28.7	-0.50	-2.0	1.63	0.03	-0.50	4.2	-1.00	0.35	-20.0	200.0
-2.0	2.58	14.5	0.72	-2.0	6.89	0.23	-0.50	32.0	-1.00	1.53	156.0	-200.0
-2.0	4.40	43.1	0.83	-2.0	13.60	0.26	-0.50	8.8	-1.00	1.25	-20.0	213.0
-2.0	1.79	110.1	-0.50	-2.0	7.26	0.13	0.68	7.7	-1.00	0.72	-20.0	289.0
-2.0	0.87	5.2	0.57	-2.0	2.23	0.03	0.60	5.9	-1.00	0.49	-20.0	228.0

-2.0	1.32	7.1	-0.50	-2.0	4.60	0.05	-0.50	5.0	-1.00	0.75	-20.0	224.0
-2.0	2.15	46.5	-0.50	-2.0	6.51	0.09	-0.50	20.6	-1.00	1.16	61.7	-200.0
-2.0	2.00	24.0	1.17	-2.0	7.58	0.08	-0.50	58.5	1.69	1.48	34.0	-200.0
-2.0	2.38	14.0	-0.50	-2.0	8.80	0.11	-0.50	63.6	4.25	1.39	-20.0	-200.0
-2.0	2.65	18.4	-0.50	-2.0	8.85	0.15	-0.50	47.8	2.15	1.53	41.0	-200.0
-2.0	1.85	13.2	-0.50	-2.0	7.11	0.09	-0.50	63.3	-1.00	1.20	28.2	-200.0
-2.0	1.90	18.3	1.08	-2.0	6.00	0.06	-0.50	48.4	2.25	0.93	52.1	-200.0
-2.0	1.84	32.3	0.78	-2.0	5.47	0.06	-0.50	61.5	3.17	1.06	35.8	-200.0
-2.0	1.77	12.9	-0.50	-2.0	5.82	0.10	0.76	57.0	-1.00	1.26	37.4	-200.0
-2.0	1.58	8.4	1.12	-2.0	8.00	0.10	-0.50	41.5	1.13	0.87	-20.0	-200.0
-2.0	2.98	60.4	-0.50	-2.0	5.04	0.40	-0.50	25.6	-1.00	1.65	108.0	-200.0
-5.0	3.47	27.7	-1.00	-2.0	2.33	0.04	-0.50	31.1	-1.00	2.37	-20.0	-200.0
-2.0	1.99	90.6	-0.50	-2.0	5.58	0.09	0.54	10.6	-1.00	0.80	33.3	201.0
-2.0	1.75	211.6	0.84	-2.0	4.49	0.12	0.97	17.5	-1.00	0.77	-20.0	-200.0
-2.0	2.22	71.6	-0.50	-2.0	6.66	0.13	0.64	9.4	-1.00	1.21	-20.0	243.0
-2.0	1.76	353.5	-0.50	-2.0	4.12	0.15	-0.50	11.9	-1.00	0.82	20.2	-200.0
-2.0	1.35	308.4	0.59	-2.0	3.35	0.09	-0.50	6.0	-1.00	0.82	-20.0	214.0
-2.0	1.81	432.8	-0.50	-2.0	4.08	0.12	0.86	7.4	-1.00	0.92	-20.0	-200.0
-2.0	1.17	296.6	-0.50	-2.0	2.26	0.09	-0.50	6.1	-1.00	0.63	-20.0	-200.0
-2.0	1.10	366.9	-0.50	-2.0	1.95	0.06	-0.50	4.4	-1.00	0.56	-20.0	216.0
-2.0	5.55	14.5	-0.50	-2.0	17.50	0.09	1.63	3.4	-1.00	3.11	40.5	258.0
-2.0	1.49	189.0	0.57	-2.0	4.10	0.10	-0.50	12.1	-1.00	0.71	-20.0	-200.0
-2.0	1.88	386.0	-0.50	-2.0	4.56	0.12	-0.50	6.0	-1.00	0.84	-20.0	-200.0
-2.0	1.26	14.7	-0.50	-2.0	3.12	0.06	-0.50	15.4	-1.00	0.69	-20.0	-200.0
-2.0	2.39	16.2	-0.50	-2.0	5.14	0.09	-0.50	18.2	-1.00	1.09	-20.0	-200.0
-2.0	1.46	16.2	-0.50	-2.0	2.89	0.09	-0.50	13.3	-1.00	0.73	-20.0	-200.0
-2.0	5.41	46.3	-0.50	-2.0	14.50	0.21	2.59	18.5	-1.00	2.41	32.2	282.0
-2.0	5.63	19.0	1.10	-2.0	14.80	0.25	1.90	24.3	-1.00	3.14	38.0	364.0
-2.0	4.10	41.1	0.92	-2.0	16.10	0.22	2.27	21.9	-1.00	1.51	41.6	202.0
-2.0	4.48	30.1	1.15	-2.0	16.50	0.24	1.47	19.6	-1.00	1.45	96.0	334.0
-2.0	4.53	72.5	0.90	-2.0	9.71	0.22	-0.50	19.4	-1.00	1.79	105.0	-200.0
-2.0	3.28	114.2	-0.50	-2.0	9.78	0.23	1.39	24.7	-1.00	1.67	52.1	-200.0
-2.0	2.82	105.5	1.38	-2.0	7.89	1.28	-0.50	16.3	1.62	1.43	87.1	-200.0
-2.0	3.76	46.1	-0.50	-2.0	12.30	0.24	-0.50	19.3	-1.00	1.83	83.7	411.0
-2.0	5.01	19.5	-0.50	-2.0	13.10	0.23	1.39	14.1	-1.00	2.44	46.3	416.0
-2.0	4.32	15.8	1.01	-2.0	11.60	0.23	2.02	14.9	-1.00	2.15	58.0	334.0
-2.0	4.36	23.4	1.15	-2.0	11.30	0.30	1.41	15.6	-1.00	2.37	85.1	221.0
-2.0	3.90	80.8	0.70	-2.0	9.66	0.21	-0.50	16.0	-1.00	1.84	45.7	210.0
-2.0	5.59	11.8	1.68	-2.0	12.80	0.22	-0.50	12.7	-1.00	2.62	53.1	284.0
-2.0	1.81	63.5	-0.50	-2.0	3.77	0.06	-0.50	47.8	-1.00	1.24	53.8	-200.0
-2.0	1.09	35.3	1.79	-2.0	3.96	0.08	0.75	18.4	-1.00	0.65	-20.0	256.0
-2.0	2.49	67.7	-0.50	-2.0	6.05	0.15	-0.50	18.0	-1.00	1.13	46.2	206.0

APPENDIX K-PEARSON CORRELATION TABLE

	B_bark	Be_bark	Cd_bark	Cu_bark	Ga_bark	Li_bark	Mn_bark	Ni_bark	Pb_bark	Sr_bark	Tl_bark	V_bark	B_leaf	Be_leaf	Cd_leaf	Cu_leaf	Ga_leaf
B_bark	1.00																
Be_bark	-0.10	1.00															
Cd_bark	-0.06	-0.16	1.00														
Cu_bark	0.13	-0.16	0.05	1.00													
Ga_bark	0.06	0.13	0.35	0.03	1.00												
Li_bark	-0.22	**0.60**	0.09	-0.05	0.24	1.00											
Mn_bark	-0.13	-0.21	**0.58**	0.18	0.09	0.02	1.00										
Ni_bark	0.00	-0.17	0.15	0.21	-0.07	-0.20	0.29	1.00									
Pb_bark	-0.07	-0.15	0.13	-0.13	0.22	0.29	-0.16	-0.18	1.00								
Sr_bark	-0.18	-0.33	-0.28	0.05	-0.12	-0.14	-0.14	0.02	-0.06	1.00							
Tl_bark	0.04	0.08	**0.54**	0.08	-0.02	-0.08	0.33	0.19	0.02	-0.04	1.00						
V_bark	0.07	0.04	0.34	0.04	**0.63**	0.15	0.06	0.16	0.48	-0.12	0.27	1.00					
B_leaf	0.34	-0.15	0.27	-0.07	-0.02	-0.12	0.07	-0.17	0.18	-0.01	0.27	0.05	1.00				
Be_leaf	-0.19	**0.75**	0.00	-0.17	0.00	**0.59**	0.01	-0.15	-0.13	-0.21	0.01	-0.15	-0.18	1.00			
Cd_leaf	-0.15	-0.19	**0.67**	-0.04	0.21	0.28	**0.70**	0.21	0.12	-0.26	0.38	0.07	0.30	0.02	1.00		
Cu_leaf	0.08	0.13	0.00	-0.03	-0.12	0.24	-0.10	-0.07	0.28	0.03	-0.07	0.03	0.17	0.02	0.10	1.00	
Ga_leaf	0.15	-0.08	0.06	-0.02	**0.54**	0.18	-0.13	-0.24	0.32	-0.07	-0.08	0.28	0.11	0.10	0.04	0.14	1.00
Li_leaf	0.02	-0.02	-0.08	-0.07	-0.07	0.43	-0.12	-0.13	0.41	0.18	-0.04	-0.05	0.28	0.19	0.18	0.20	0.24
Mn_leaf	0.04	-0.27	0.29	0.15	0.19	-0.03	**0.55**	0.24	-0.07	0.00	0.15	0.12	0.10	0.05	0.34	0.06	0.35
Ni_leaf	-0.15	-0.31	0.26	0.18	-0.09	-0.05	0.37	**0.71**	-0.11	-0.09	0.18	-0.06	-0.08	0.02	**0.55**	0.12	-0.07
Pb_leaf	-0.04	0.13	-0.04	-0.14	0.08	0.11	-0.19	-0.10	**0.53**	-0.07	-0.17	0.13	0.03	0.06	0.23	0.44	0.39
Sr_leaf	0.13	-0.05	-0.14	0.02	-0.01	0.30	-0.18	-0.13	0.37	0.21	-0.05	0.01	0.23	-0.09	-0.05	0.34	0.26
Tl_leaf	0.08	-0.45	-0.11	-0.30	0.07	0.12	-0.31	-0.20	0.22	0.06	-0.09	0.05	-0.14	-0.13	-0.07	0.17	0.31
V_leaf	0.05	**-0.49**	0.09	-0.09	0.28	0.10	-0.13	0.03	0.30	0.11	0.13	0.28	0.19	0.01	0.17	0.07	**0.68**
B_Twig	0.19	-0.14	0.00	0.15	-0.08	-0.15	-0.03	0.28	-0.10	0.11	0.13	-0.08	-0.10	-0.29	-0.09	0.05	-0.08
Be_Twig	-0.21	**0.85**	-0.31	-0.12	-0.15	**0.52**	-0.09	-0.43	-0.36	-0.17	-0.21	-0.32	-0.31	**0.95**	-0.18	-0.17	-0.21
Cd_Twig	-0.13	0.27	**0.76**	-0.05	0.07	-0.06	**0.53**	0.15	0.04	-0.17	**0.53**	0.07	0.26	0.12	**0.69**	0.07	-0.04
Cu_Twig	0.00	**0.57**	0.45	0.21	-0.07	0.14	0.35	0.02	0.10	-0.13	0.30	0.05	0.29	0.06	0.33	0.35	-0.10
Ga_Twig	-0.04	0.32	0.08	0.06	**0.78**	0.18	0.02	-0.03	0.12	-0.12	-0.02	0.35	-0.12	0.16	-0.06	-0.01	**0.51**
Li_Twig	-0.05	**0.62**	-0.01	-0.08	-0.02	**0.69**	0.03	-0.12	0.09	-0.06	-0.02	-0.08	-0.06	**0.76**	0.09	0.05	0.07
Mn_Twig	-0.16	-0.15	0.43	0.03	0.08	-0.03	**0.73**	0.26	-0.15	-0.06	0.14	0.04	-0.06	0.02	0.41	0.01	0.01
Ni_Twig	-0.16	-0.12	0.08	0.12	-0.09	-0.16	0.25	**0.67**	-0.14	-0.10	0.06	-0.08	-0.18	0.00	0.31	-0.01	-0.19
Pb_Twig	-0.02	0.04	0.03	-0.26	-0.03	0.03	-0.23	-0.23	**0.53**	0.07	-0.04	-0.04	0.12	0.01	0.17	0.23	0.23
Sr_Twig	0.18	0.17	-0.27	0.01	0.02	0.25	-0.22	-0.16	0.21	0.39	-0.11	-0.02	0.12	-0.02	-0.23	0.33	0.21
Tl_Twig	0.08	-0.18	0.00	-0.20	-0.09	-0.17	-0.17	-0.15	0.17	0.22	0.13	0.05	0.13	-0.08	-0.10	-0.01	0.06
V_Twig	0.04	-0.28	0.02	-0.05	0.26	-0.10	0.07	0.34	0.05	0.08	0.10	0.17	-0.05	-0.07	0.16	-0.12	0.39

APPENDIX K-PEARSON CORRELATION TABLE

Li_leaf	Mn_leaf	Ni_leaf	Pb_leaf	Sr_leaf	Tl_leaf	V_leaf	B_Twig	Be_Twig	Cd_Twig	Cu_Twig	Ga_Twig	Li_Twig	Mn_Twig	Ni_Twig	Pb_Twig	Sr_Twig	Tl_Twig
1.00																	
0.01	1.00																
0.03	0.31	1.00															
0.16	0.07	0.02	1.00														
0.77	-0.02	-0.02	0.07	1.00													
0.09	-0.10	-0.10	0.43	0.10	1.00												
0.31	0.16	0.05	0.40	0.19	0.35	1.00											
-0.04	0.02	0.20	0.11	-0.07	0.16	-0.07	1.00										
-0.01	-0.11	-0.23	-0.22	-0.05	-0.35	-0.25	-0.27	1.00									
-0.04	0.28	0.33	0.09	-0.10	-0.04	0.06	-0.01	-0.05	1.00								
0.05	0.14	0.13	-0.08	0.16	-0.27	-0.20	0.00	0.02	0.45	1.00							
-0.06	0.31	-0.07	0.20	-0.06	-0.04	0.19	-0.02	-0.02	-0.01	-0.02	1.00						
0.53	0.05	-0.01	-0.04	0.39	0.01	0.05	-0.14	**0.72**	-0.01	0.01	-0.04	1.00					
-0.16	**0.69**	0.37	-0.12	-0.19	-0.24	-0.11	0.11	0.02	0.47	0.24	0.17	-0.03	1.00				
-0.04	0.24	**0.82**	-0.04	-0.06	-0.23	-0.12	0.32	-0.09	0.12	0.08	0.03	-0.10	0.36	1.00			
0.14	-0.18	-0.15	**0.59**	0.07	0.41	0.25	0.07	-0.12	0.09	-0.12	0.01	-0.10	-0.23	-0.17	1.00		
0.54	-0.03	-0.12	0.04	**0.76**	0.14	0.19	0.15	0.03	-0.18	0.17	0.06	0.27	-0.10	-0.10	0.07	1.00	
0.14	-0.09	-0.19	0.20	0.05	0.24	0.26	0.10	-0.14	-0.05	-0.15	-0.21	0.04	-0.18	-0.14	0.42	0.06	1.00
0.02	0.10	0.13	0.20	-0.06	0.28	**0.50**	0.22	-0.38	0.03	-0.23	0.30	-0.11	0.05	0.11	0.33	0.01	0.18

(Cont.)

V_Twig	
	B_bark
	Be_bark
	Cd_bark
	Cu_bark
	Ga_bark
	Li_bark
	Mn_bark
	Ni_bark
	Pb_bark
	Sr_bark
	Tl_bark
	V_bark
	B_leaf
	Be_leaf
	Cd_leaf
	Cu_leaf
	Ga_leaf
	Li_leaf
	Mn_leaf
	Ni_leaf
	Pb_leaf
	Sr_leaf
	Tl_leaf
	V_leaf
	B_Twig
	Be_Twig
	Cd_Twig
	Cu_Twig
	Ga_Twig
	Li_Twig
	Mn_Twig
	Ni_Twig
	Pb_Twig
	Sr_Twig
	Tl_Twig
1.00	V_Twig

APPENDIX N: BIOGEOCHEMICAL DATASET- MENNINNIE DAM

	Ag	As	Au	B	Ba	Be	Br	Ca	Cd	Ce	Co	Cr	Cs	Cu
DL for Plant	0.20	0.10	0.50	0.3	5.00	0.004	0.10	200.0	0.005	0.30	0.10	0.20	0.020	0.03
	ppm	ppm	ppb	ppm	ppm	ppb	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm
B-205	-0.20	-0.10	-0.50	23.19	-5.00	<DL	5.28	20900.0	4.7	-0.30	-0.10	-0.20	-0.020	1.07
B-206	-0.20	-0.10	-0.50	13.25	-5.00	<DL	5.90	20900.0	<DL	-0.30	-0.10	0.27	-0.020	1.40
B-207	-0.20	-0.10	-0.50	14.18	5.11	<DL	8.10	23500.0	<DL	-0.30	-0.10	-0.20	-0.020	1.11
B-208	-0.20	-0.10	-0.50	10.52	-5.00	<DL	3.76	11000.0	<DL	-0.30	-0.10	-0.20	-0.020	0.99
B-209	-0.20	-0.10	-0.50	6.42	11.30	4.4	8.76	9060.0	159.5	-0.30	-0.10	-0.20	-0.020	1.24
B-211	-0.20	-0.10	-0.50	8.44	7.88	<DL	8.00	5940.0	10.4	-0.30	-0.10	-0.20	0.028	0.75
B-212	-0.20	-0.10	-0.50	5.49	-5.00	<DL	9.30	4520.0	27.9	-0.30	-0.10	-0.20	-0.020	0.68
B-213	-0.20	-0.10	-0.50	6.68	-5.00	<DL	5.07	8120.0	19.8	-0.30	-0.10	-0.20	-0.020	0.99
B-214	-0.20	-0.10	-0.50	5.29	5.23	<DL	7.44	4670.0	<DL	-0.30	-0.10	-0.20	0.033	0.65
B-215	-0.20	-0.10	-0.50	6.19	-5.00	<DL	8.74	10700.0	12.7	-0.30	-0.10	-0.20	0.054	1.06
T-205	-0.20	-0.10	0.53	10.5	-5.00	<DL	5.38	18200.0	<DL	0.45	-0.10	-0.20	0.027	5.59
T-206	-0.20	-0.10	-0.50	10.1	-5.00	<DL	7.06	20100.0	8.2	0.40	-0.10	-0.20	-0.020	1.28
T-207	-0.20	-0.10	-0.50	9.8	-5.00	<DL	7.43	18500.0	<DL	0.65	-0.10	-0.20	-0.020	1.18
T-209	-0.20	-0.10	-0.50	11.7	-5.00	4.2	9.72	12800.0	497.2	-0.30	-0.10	0.39	-0.020	2.13
T-211	-0.20	-0.10	-0.50	10.0	-5.00	<DL	10.00	12000.0	34.5	-0.30	-0.10	-0.20	0.022	1.16
T-212	-0.20	-0.10	-0.50	5.6	-5.00	4.4	8.24	8640.0	137.8	-0.30	-0.10	0.62	0.030	2.34
T-213	-0.20	-0.10	-0.50	10.0	-5.00	4.7	8.75	9670.0	28.8	-0.30	-0.10	0.20	0.033	1.51
T-214	-0.20	-0.10	-0.50	4.6	-5.00	<DL	9.72	11000.0	6.7	-0.30	-0.10	-0.20	-0.020	1.66
T-215	-0.20	-0.10	-0.50	7.9	-5.00	7.0	12.20	6770.0	36.2	-0.30	-0.10	-0.20	-0.020	2.83
L-205	-0.20	-0.10	-0.50	108.74	-5.00	4.4	30.90	13000.0	4.2	0.32	-0.10	0.23	0.035	3.14
L-206	-0.20	-0.10	-0.50	111.72	-5.00	5.5	21.80	10900.0	5.5	0.42	-0.10	-0.20	-0.020	2.06
L-207	-0.20	-0.10	-0.50	76.27	-5.00	4.5	32.20	9660.0	3.2	0.51	-0.10	-0.20	-0.020	2.08
L-209	-0.20	-0.10	-0.50	80.35	-5.00	6.2	35.60	4720.0	134.3	-0.30	0.10	-0.20	-0.020	2.59
L-211	-0.20	0.10	-0.50	41.08	-5.00	5.2	39.40	3340.0	7.8	-0.30	0.10	-0.20	-0.020	2.23
L-212	-0.20	-0.10	-0.50	35.68	-5.00	4.9	37.60	4040.0	13.4	-0.30	0.12	-0.20	-0.020	2.22
L-213	-0.20	-0.10	-0.50	98.28	-5.00	21.6	35.30	5260.0	7.9	-0.30	0.12	-0.20	-0.020	1.70
L-214	-0.20	-0.10	-0.50	62.80	-5.00	12.0	30.90	4060.0	<DL	-0.30	-0.10	-0.20	-0.020	1.48
L-215	-0.20	-0.10	-0.50	66.97	6.35	10.8	41.40	5080.0	11.3	-0.30	0.13	-0.20	-0.020	2.67
S-205	-2.0	2.29	-3.0	<DL	276.0	0.22	25.80	0.66	0.07	66.10	4.24	39.8	2.72	6.2
S-206	-2.0	2.23	-3.0	<DL	401.0	0.26	31.30	0.40	0.06	75.10	3.51	35.9	3.49	4.3
S-207	-2.0	2.63	-3.0	<DL	252.0	0.23	16.80	6.16	0.11	48.90	8.13	41.7	2.73	6.1
S-209	-2.0	2.15	-3.0	4.6	299.0	0.31	42.30	4.37	0.56	33.60	5.86	34.6	2.93	7.4
S-211	-2.0	2.50	-3.0	<DL	312.0	0.29	11.20	0.55	0.10	59.30	9.04	49.1	3.02	5.3
S-212	-2.0	1.80	-3.0	<DL	351.0	0.26	12.30	0.41	0.13	48.90	7.92	41.3	2.20	4.9
S-213	-2.0	2.28	-3.0	<DL	262.0	0.30	15.20	0.67	0.18	47.50	8.29	51.2	2.76	5.7
S-214	-2.0	2.47	-3.0	<DL	274.0	0.30	21.00	5.80	0.09	40.10	6.69	37.4	2.68	6.2
S-215	-2.0	2.36	-3.0	<DL	310.0	0.22	5.25	0.30	0.15	62.80	10.60	48.7	3.13	5.0
	ppm	ppm	ppb	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm
DL for Soil	2.0	0.50	3.0	0.13	50.0	0.01	0.50	0.10	0.004	1.00	0.50	2.0	0.50	0.005

Eu	Fe	Ga	Hf	Ir	K	La	Li	Lu	Mn	Mo	Na	Ni	Pb	Rb	Sb
0.020	20.0	0.01	0.010	1.0	500.0	0.020	0.01	0.005	0.01	1.00	10.0	0.01	0.009	0.50	0.020
ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
-0.020	40.4	0.03	-0.010	-1.0	1420.0	0.050	0.06	-0.005	4.57	-1.00	941.0	0.39	0.21	-0.50	-0.020
-0.020	74.2	0.04	0.021	-1.0	1060.0	0.080	0.03	-0.005	1.61	-1.00	954.0	0.12	0.07	-0.50	-0.020
-0.020	27.8	0.02	-0.010	-1.0	1160.0	0.030	0.04	-0.005	1.78	-1.00	1480.0	0.43	0.11	-0.50	-0.020
-0.020	36.7	0.06	-0.010	-1.0	-500.0	0.030	0.03	-0.005	1.57	-1.00	508.0	0.17	0.08	-0.50	-0.020
-0.020	37.7	0.08	0.013	-1.0	-500.0	0.050	0.10	-0.005	2.04	-1.00	955.0	0.18	0.60	-0.50	-0.020
-0.020	44.0	0.11	-0.010	-1.0	629.0	0.070	0.06	-0.005	11.54	-1.00	1230.0	0.16	0.09	0.54	-0.020
0.020	33.3	0.10	-0.010	-1.0	-500.0	0.060	0.04	-0.005	13.07	-1.00	1030.0	0.10	0.09	-0.50	-0.020
-0.020	48.0	0.06	-0.010	-1.0	-500.0	0.050	0.05	-0.005	9.35	-1.00	668.0	0.03	0.11	-0.50	-0.020
-0.020	42.1	0.06	-0.010	-1.0	578.0	0.070	0.06	-0.005	2.72	-1.00	823.0	0.06	0.08	0.66	-0.020
-0.020	55.6	0.04	0.013	-1.0	566.0	0.070	0.05	-0.005	4.30	-1.00	1040.0	0.11	0.06	-0.50	-0.020
-0.020	44.7	0.06	0.012	-1.0	1800.0	0.200	0.15	-0.005	15.2	-1.00	1510.0	0.81	0.13	0.53	-0.020
-0.020	45.1	0.16	-0.010	-1.0	3350.0	0.170	0.03	-0.005	4.4	-1.00	1010.0	0.37	0.15	-0.50	-0.020
0.020	35.2	0.09	-0.010	-1.0	2450.0	0.330	0.05	-0.005	8.2	-1.00	1220.0	0.90	0.14	-0.50	-0.020
0.020	65.3	0.23	-0.010	-1.0	884.0	0.090	0.07	-0.005	8.3	-1.00	3320.0	0.45	0.70	0.58	-0.020
-0.020	40.7	0.37	-0.010	-1.0	2040.0	0.070	0.05	-0.005	44.0	-1.00	1920.0	0.26	0.16	0.65	-0.020
-0.020	30.8	0.37	-0.010	-1.0	2070.0	0.070	0.08	-0.005	299.5	-1.00	1450.0	0.30	0.10	0.84	-0.020
-0.020	41.2	0.08	-0.010	-1.0	2750.0	0.070	0.11	-0.005	34.1	-1.00	1460.0	0.22	0.17	-0.50	-0.020
-0.020	46.4	0.15	0.013	-1.0	3080.0	0.130	0.07	-0.005	6.2	-1.00	1580.0	0.41	0.26	0.74	-0.020
-0.020	50.9	0.14	-0.010	-1.0	3770.0	0.120	0.13	-0.005	11.8	-1.00	3290.0	0.34	0.24	0.92	-0.020
0.020	74.1	0.11	-0.010	-1.0	4050.0	0.120	1.18	-0.005	23.08	-1.00	2610.0	0.60	0.06	0.69	-0.020
-0.020	102.0	0.17	-0.010	-1.0	3900.0	0.180	0.18	-0.005	7.85	-1.00	1910.0	0.18	0.07	0.60	-0.020
-0.020	63.9	0.09	-0.010	-1.0	3630.0	0.210	0.43	-0.005	14.84	-1.00	1950.0	0.65	0.06	0.67	-0.020
-0.020	52.0	0.13	-0.010	-1.0	4250.0	0.050	0.29	-0.005	10.61	-1.00	3350.0	0.52	0.10	0.58	-0.020
-0.020	74.4	0.16	-0.010	-1.0	3760.0	0.030	0.14	-0.005	19.92	-1.00	3590.0	0.28	0.08	1.11	-0.020
-0.020	67.9	0.13	-0.010	-1.0	3310.0	0.030	0.36	-0.005	57.31	-1.00	2700.0	0.37	0.07	-0.50	-0.020
-0.020	61.5	0.10	-0.010	-1.0	2740.0	0.040	0.81	-0.005	25.56	-1.00	3390.0	0.38	0.10	-0.50	-0.020
-0.020	69.1	0.14	0.016	-1.0	3110.0	0.050	0.58	-0.005	10.72	-1.00	2800.0	0.36	0.08	0.64	-0.020
-0.020	60.5	0.13	-0.010	-1.0	4000.0	0.050	0.46	-0.005	22.39	-1.00	3460.0	0.44	0.07	0.67	-0.020
0.53	1.25	5.1	6.42	-10.0	1.64	36.20	3.1	0.22	147.1	-2.0	0.146	3.6	79.1	80.2	0.41
0.72	1.38	5.4	6.57	-10.0	2.07	39.90	3.1	0.19	86.9	-2.0	0.181	3.4	60.1	109.0	0.22
0.78	2.22	5.4	5.25	-10.0	1.54	24.70	3.7	0.24	102.5	-2.0	0.147	7.4	14.6	57.8	-0.10
0.58	1.70	7.8	6.22	-10.0	1.15	16.50	5.0	0.21	120.7	-2.0	0.225	6.9	18.2	52.4	0.48
0.87	2.91	5.1	7.65	-10.0	1.74	28.90	4.5	0.36	160.9	-2.0	0.212	4.6	16.8	78.3	0.35
1.08	2.40	4.0	9.06	-10.0	1.38	24.20	4.5	0.31	166.2	-2.0	0.211	4.7	15.7	87.5	0.25
1.00	2.70	5.1	7.55	-10.0	1.61	24.40	8.6	0.30	156.0	-2.0	0.161	5.7	16.5	78.7	0.27
0.96	2.18	6.4	5.79	-10.0	1.48	21.60	5.0	0.25	114.0	-2.0	0.142	5.4	12.0	61.0	0.28
0.95	2.66	3.5	8.90	-10.0	1.41	29.10	5.3	0.37	166.5	-2.0	0.213	4.2	16.8	87.2	0.27
ppm	%	ppm	ppm	ppb	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm
0.20	0.01	0.004	0.20	10.0	0.10	0.20	0.009	0.10	0.003	2.0	0.005	0.003	0.003	5.0	0.10

Sc	Se	Sm	Sr	Ta	Te	Th	Tl	U	V	W	Yb	Zn	Zr
0.005	0.20	0.010	0.009	0.050	0.20	0.010	0.0005	0.20	0.002	0.20	0.020	1.00	10.00
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb	ppm	ppm	ppm	ppm	ppm	ppm
0.010	-0.20	0.010	120.9	-0.050	-0.20	-0.010	12.73	-0.20	0.05	-0.20	-0.020	4.98	-10.00
0.018	-0.20	0.020	76.2	-0.050	-0.20	-0.010	3.57	-0.20	0.06	-0.20	-0.020	6.47	-10.00
0.008	-0.20	0.010	91.9	-0.050	-0.20	0.017	11.84	-0.20	0.05	-0.20	-0.020	5.83	-10.00
0.009	-0.20	0.010	77.8	-0.050	-0.20	-0.010	6.88	-0.20	0.03	-0.20	-0.020	1.52	-10.00
0.009	-0.20	0.010	68.5	-0.050	-0.20	-0.010	104.72	-0.20	0.11	-0.20	-0.020	50.50	-10.00
0.016	-0.20	0.020	34.7	-0.050	-0.20	0.041	4.33	-0.20	0.05	-0.20	-0.020	5.66	-10.00
0.008	-0.20	0.010	51.3	-0.050	-0.20	-0.010	2.37	-0.20	0.05	0.24	-0.020	22.20	-10.00
0.012	-0.20	0.010	66.7	-0.050	-0.20	-0.010	1.79	-0.20	0.07	-0.20	-0.020	21.20	-10.00
0.016	-0.20	0.020	31.2	-0.050	-0.20	0.016	1.25	-0.20	0.06	-0.20	-0.020	7.94	-10.00
0.016	-0.20	0.020	86.9	-0.050	-0.20	-0.010	4.29	-0.20	0.02	-0.20	-0.020	21.30	-10.00
0.015	-0.20	0.040	97.6	-0.050	-0.20	-0.010	4.3	-0.20	0.07	-0.20	-0.020	13.70	-10.00
0.015	-0.20	0.040	95.2	-0.050	-0.20	0.026	5.3	-0.20	0.08	-0.20	-0.020	12.30	-10.00
0.011	-0.20	0.070	80.4	-0.050	-0.20	0.013	6.0	-0.20	0.09	-0.20	-0.020	26.70	-10.00
0.018	0.21	0.030	85.5	-0.050	-0.20	0.019	6.6	-0.20	0.08	-0.20	-0.020	38.80	-10.00
0.010	-0.20	0.030	76.3	-0.050	-0.20	0.015	3.8	-0.20	0.10	-0.20	-0.020	7.59	-10.00
0.007	-0.20	0.030	48.2	-0.050	-0.20	-0.010	4.0	-0.20	0.08	-0.20	-0.020	22.30	-10.00
0.014	-0.20	0.020	88.9	-0.050	-0.20	0.011	4.1	-0.20	0.09	-0.20	-0.020	19.40	-10.00
0.018	-0.20	0.040	74.6	-0.050	-0.20	0.025	4.3	-0.20	0.10	-0.20	-0.020	16.90	-10.00
0.016	-0.20	0.030	48.5	-0.050	-0.20	-0.010	7.0	-0.20	0.11	-0.20	-0.020	17.50	-10.00
0.021	-0.20	0.050	48.7	-0.050	-0.20	0.015	2.4	-0.20	0.05	-0.20	-0.020	17.60	-10.00
0.020	-0.20	0.050	39.9	-0.050	0.27	0.022	1.6	-0.20	0.08	-0.20	-0.020	11.20	-10.00
0.017	-0.20	0.070	26.3	-0.050	-0.20	-0.010	2.2	-0.20	0.05	-0.20	-0.020	17.80	-10.00
0.014	-0.20	0.020	21.1	-0.050	-0.20	0.019	7.2	-0.20	0.05	-0.20	-0.020	21.60	-10.00
0.019	-0.20	0.030	11.5	-0.050	-0.20	0.014	4.6	-0.20	0.07	-0.20	-0.020	11.60	-10.00
0.015	-0.20	0.030	20.4	-0.050	-0.20	-0.010	5.7	-0.20	0.04	-0.20	0.020	11.30	-10.00
0.020	-0.20	0.020	42.7	-0.050	-0.20	0.018	3.8	-0.20	0.07	-0.20	-0.020	10.90	-10.00
0.018	-0.20	0.030	24.6	-0.050	-0.20	0.024	3.5	-0.20	0.07	-0.20	-0.020	9.25	-10.00
0.014	-0.20	0.020	23.2	-0.050	-0.20	-0.010	3.6	-0.20	0.04	-0.20	-0.020	11.70	-10.00
7.57	-2.0	4.10	41.1	0.92	-2.0	16.10	0.22	2.27	21.9	-1.00	1.51	41.6	202.0
6.30	-2.0	4.48	30.1	1.15	-2.0	16.50	0.24	1.47	19.6	-1.00	1.45	96.0	334.0
8.80	-2.0	4.53	72.5	0.90	-2.0	9.71	0.22	-0.50	19.4	-1.00	1.79	105.0	-200.0
6.83	-2.0	2.82	105.5	1.38	-2.0	7.89	1.28	-0.50	16.3	1.62	1.43	87.1	-200.0
10.60	-2.0	5.01	19.5	-0.50	-2.0	13.10	0.23	1.39	14.1	-1.00	2.44	46.3	416.0
8.44	-2.0	4.32	15.8	1.01	-2.0	11.60	0.23	2.02	14.9	-1.00	2.15	58.0	334.0
9.77	-2.0	4.36	23.4	1.15	-2.0	11.30	0.30	1.41	15.6	-1.00	2.37	85.1	221.0
8.19	-2.0	3.90	80.8	0.70	-2.0	9.66	0.21	-0.50	16.0	-1.00	1.84	45.7	210.0
9.67	-2.0	5.59	11.8	1.68	-2.0	12.80	0.22	-0.50	12.7	-1.00	2.62	53.1	284.0
ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0.05	2.0	0.10	0.002	0.50	2.0	0.20	0.001	0.50	0.002	1.00	0.30	20.0	200.0

APPENDIX P: PEARSON CORRELATION TABLE-MENNINNIE DAM

	CO Leaf	CO Soil	ZN Bark	ZN Leaf	ZN Soil	ZN Twig	Cd_bark	Cd_leaf	Cd_twig	Cd_soil	Cu_bark	Cu_leaf	Cu_twig
CO Leaf	1.00												
CO Soil	0.63	1.00											
ZN Bark	-0.21	0.09	1.00										
ZN Leaf	-0.59	-0.29	0.46	1.00									
ZN Soil	-0.16	-0.19	0.23	0.34	1.00								
ZN Twig	-0.20	-0.01	0.80	0.68	0.50	1.00							
Cd_bark	-0.55	-0.12	0.93	0.65	0.24	0.80	1.00						
Cd_leaf	-0.56	-0.16	0.90	0.69	0.27	0.79	0.99	1.00					
Cd_twig	-0.54	-0.12	0.92	0.62	0.22	0.80	0.99	0.98	1.00				
Cd_soil	-0.49	-0.02	0.94	0.64	0.30	0.83	0.98	0.98	0.96	1.00			
Cu_bark	-0.07	-0.47	0.21	0.51	0.67	0.27	0.28	0.35	0.22	0.29	1.00		
Cu_leaf	-0.06	-0.15	0.18	0.60	-0.27	0.08	0.26	0.29	0.25	0.20	0.35	1.00	
Cu_twig	0.63	-0.30	-0.03	0.33	-0.52	-0.09	-0.01	-0.01	-0.03	-0.07	0.07	0.78	1.00
Cu_soil	-0.62	-0.13	0.49	0.72	0.06	0.67	0.65	0.65	0.59	0.68	0.03	0.15	0.20
Pb_bark	-0.61	-0.31	0.79	0.81	0.22	0.76	0.94	0.96	0.91	0.92	0.37	0.39	0.18
Pb_leaf	-0.47	0.11	0.67	0.02	0.17	0.38	0.63	0.59	0.58	0.68	-0.02	-0.34	-0.37
Pb_twig	-0.50	-0.12	0.84	0.58	0.19	0.74	0.93	0.95	0.90	0.94	0.30	0.16	-0.06
Pb_soil	-0.58	-0.77	-0.35	0.20	-0.09	-0.37	-0.21	-0.17	-0.24	-0.30	0.49	0.54	0.65
	CO Leaf	CO Soil	ZN Bark	ZN Leaf	ZN Soil	ZN Twig	Cd_bark	Cd_leaf	Cd_twig	Cd_soil	Cu_bark	Cu_leaf	Cu_twig

Cu_soil	Pb_bark	Pb_leaf	Pb_twig	Pb_soil
1.00				
0.78	1.00			
0.40	0.50	1.00		
0.71	0.90	0.63	1.00	
-0.15	0.02	-0.44	-0.24	1.00
Cu_soil	Pb_bark	Pb_leaf	Pb_twig	Pb_soil

APPENDIX R: Geographical location of sample sites

No. of Site	Local Name	No. of Site	Local Name
12	W. of Chinkapook	127	Peak Charles
13	S. of Mittyack	129	Salmon Gums
15	N. of Ouyen	130	Scadden
16	N. of Hattah	134	S. of Salmon Gums
18	N. of Nowingi	136	S. of Norseman
19	N. of Carwarp	137	Broad Arrow
20	NW. of Wentworth	138	Ora Banda
22	N. of Wamberra	139	W. Kalgoorlie
23	S. of Pooncarie	141	Bulong
24	Cullulleraine	142	Karowne
25	W. of Cullulleraine	144	Karowne
27	Big orange	145	Bardoc
29	W. of Barmera	148	Menzies
30	N. of Waikerie	152	N. of Norseman
51	S. of Blanchetown	155	Fraser Range
52	SE. of Blanchetown	156	Balladonia
53	Long Ridge	157	W. of Caiguna
55	Black Hill	158	Madura Pass
56	E. of Mannum	160	Hampton
57	Tailem Bend	161	E. Eucla
58	E. of Peake	162	W. Nullarbor
59	SW. of Pinnaroo	164	E. of Ceduna
60	E. of Murrayville	166	Wirrulla
61	E. of Murrayville	167	Yarwondutta Rocks
62	W. of Ouyen	168	SW. of Minnipa
65	Oodla Wirra	173	Mount Wedge
92	E. of Kimba	201	NE. of Renmark
94	Mary Barts Corner	202	E. Siam
95	Kallora	203	W. Siam
96	SE. of Bowmans	204	Menninnie Dam
97	NW. of Blyth	205	Menninnie Dam
98	N. of Bute	206	Menninnie Dam
99	N. of Mundoora	207	Menninnie Dam
100	NE. of Alford	208	E. of Menninnie Dam
102	E. of Moonta	209	Menninnie Dam
103	S. of Arthurton	210	Uno Range
104	S. of Urania	211	Menninnie Dam
105	SE. of Minalton	212	Menninnie Dam
106	NW. of Stansbury	213	Menninnie Dam
108	N. of Pine Point	214	Menninnie Dam
109	NW. of Price	215	Menninnie Dam
113	NW. of Kimba	216	Higginsville
114	Buckleboo-Kyancutta	217	E. of Lock
115	Pinkawillinie	218	W. of Cleve
116	Kambalda		