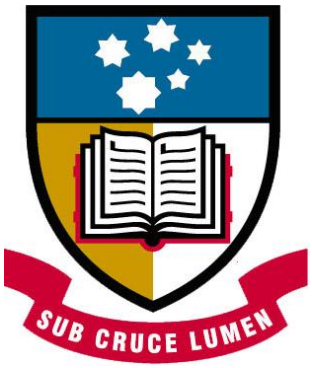

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A Comparison of Regional Plant Biogeochemical and Soil Geochemical Expressions of Buried Mineralization in the Olympic Dam Region, South Australia

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Abstract

Biogeochemical methods can be employed to assist in detecting buried ore deposits. Plant roots can penetrate the bedrock and therefore, as a result of testing their leaves can give a good indication of the buried mineralization in an area. The aim of this study was to support or challenge the findings from the study that was conducted by Wang et al. (1999). It also aimed to compare the biogeochemistry results with traditional soil analysis. Mulga (*Acacia aneura*) and Pearl Bluebush (*Maireana sedifolia*) leaves as well as soil samples were collected and analysed from eighteen different locations at the Olympic Dam (Roxby Downs) region.. The analysis of these plants and soils detected a range of elements including the ones that were relevant to this study (mercury, copper and gold). The vegetation, bulk analysis and partial leach results of this study did not show a similar pattern of mercury, copper and gold concentrations to the results from the Wang et al. (1999) study. Giving this information, this study cannot support the findings from the Wang et al. (1999) study. An important finding of this study was that sample VEG 007 recorded the highest concentrations in the majority of the elements and as a result the area may require further investigation. In addition, vegetation and soil samples that were taken from approximately 5 km south, approximately 10 km south and approximately 15 km north east of Olympic Dam region showed some promising results and as a result these areas may require further investigation. This study showed that biogeochemistry may be useful in locating potential mineral deposits.

Keywords: Biogeochemistry, Mulga (*Acacia aneura*), Pearl Bluebush (*Maireana sedifolia*), Olympic Dam

DECLARATION

I declare that this thesis is the result of my own research, that it does not incorporate without acknowledgement any material submitted for a degree or diploma in any University, and that it does not contain any material previously published, written or produced by another person, except where due reference is made within this text.

Signed……..

Date……..

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1. INTRODUCTION

South Australia is a state that is rich in resources. However the majority of the mineral deposits are buried by regolith. The main challenge for mineral exploration is discovering mineral deposits undercover (Lintern 2007). There is a necessity for low-cost mineral exploration methods by mineral explorers to successfully explore through the cover (Reid & Hill 2010). Stable landscapes and an extensive weathering history in Australia have created a thick regolith generally leached of metals of economic importance (Lintern 2007). Biogeochemistry is a technique used in mineral exploration to provide an expression of buried geological features (Reid & Hill 2007). The Mulga (*Acacia aneura*) and the Pearl Bluebush (*Maireana sedifolia*), through testing their leaves may reveal the expression of buried mineralization in and below the regolith. Previous mineral exploration techniques with-in the Olympic Dam (Roxby Downs) and Andamooka region included: geophysical techniques, mapping from remote sensing and drill hole sampling. The Olympic Dam deposit consists of a significant resource of copper and uranium as well as considerable amounts of rare earth elements, gold and silver (Roberts & Hudson 1983).

In 1999 Wang et al. conducted a regional orientation survey using NAMEG (nanoscale metals in earthgas) and MOMEO (mobile forms of metals in overburden) across the Olympic Dam Cu-U-Au-Ag deposit. Over an area of 2500 km², an earthgas and soil sample was collected from thirty six sites (Wang et al. 1999).

The survey was conducted to employ the above methods in order to determine their suitability for producing regional responses to the deep-seated deposit covered by a thick sequence of post-mineralization sedimentary rocks (Wang et al. 1999).

1.1 Background

Depths (>5 m) of transported or weathered material covering mineralized bedrock often restricts geochemical exploration in deeply weathered environments (Anand et al. 2007). An important method for discovering hidden ore bodies is sampling regolith material in search of anomalous metal concentrations (Anand et al. 2007). Biogeochemical sampling for mineral exploration in Australia is at present a developing science, the reason for this maybe due to discouraging results of earlier work in gold exploration (Anand et al. 2007). Soil and other surface material sampling have known to be reasonably effective in deeply weathered regions but base metal and Au resources in deeply weathered terrains will be below transported cover where soil and lag sampling will have a minor effect (Anand et al. 2007). Biogeochemistry may have a great potential in areas of transported overburden especially if the cover is shallow and the tap roots and lateral roots may access the weathered bedrock and its connecting groundwaters (Anand et al. 2007).

1.2 How biogeochemistry works

Biogeochemistry is an up and coming field in science which is becoming more popular due to its preciseness. It is important to understand the distribution patterns of elements in order to interpret the results (Lintern et al. 1996). The bulk of nutrient uptake is via plant roots (Hulme and Hill 2003). These elements taken up by plants translocate to different plant organs such as the leaves as a result of the various physiological functions in the plant (Hulme & Hill, 2003). Prior to transporting elements to the leaves, plants must first solubilise them (Hulme & Hill 2003). This process is even more complex as a result of the binding properties between the soil particles,

element and antagonistic and synergistic interactions between elements (Hulme & Hill 2003). Factors that can affect the uptake of elements by plants include: pH, elemental species (soil mineralogy), biomass and the plant species (Reid et al. 2008). The ionic size and the microscopic structure of root structures depend on how the elements are taken up by plants (Dunn, 2007). Dunn (2007) states that "some elements can go in and out at will, some elements are physically excluded, some elements are actively pulled through the root walls and some elements are actively excluded". The root system of a specific plant can incorporate the geochemical signature of several cubic metres of soil, groundwater and occasionally the precipitated oxides that coat the surfaces of faults and joints in mineral surfaces and bedrock (Dunn, 2007). Roots are understood to grow in areas that have significant nutrient concentrations and sufficient water potential (Reid et al. 2008). In semi-arid regions the water and nutrient availability is dependent on the plant species and its root structure, the local environmental conditions and competition from other plants nearby (Reid et al. 2008). In order to reach a permanent water source, plant roots may reach depths of 10's to 100's of metres which may penetrate the transported cover to reach underlying bedrock (Reid et al. 2008).

Dunn (2007) states that all 90 naturally occurring elements occur within the majority of plant tissues but these elements would be in low concentrations (Dunn, 2007). Micronutrients including iron, copper, nickel, zinc and manganese are also stored in plants (Graham, 2003). Plants can be tested to reveal the concentrations of these elements and micronutrients.

1.3 Biogeochemistry as an exploration method

Plants are a major component of landscapes and regolith across the majority of terrestrial settings (Hill & Hill, 2003). Although their use as mineral exploration and environmental chemistry sampling media has gained mixed support in past Australian regolith studies, they have many

advantages for use as a result of: being widespread across the landscape, easy to access and collect samples, plants having the ability to construct chemical pathways that penetrate regolith to the underlying bedrock, having the ability to selectively extract and concentrate various elements, having the ability to combine a chemical signature from a large sampling area, causing minimal site disturbance and corrective costs associated with sampling, and have had some proven exploration success for a broad range of elements, mineralization styles and regolith-landform settings (Hill & Hill, 2003).

Lintern et al. (1996) has demonstrated how effective biogeochemistry is at detecting local and regional geochemical dispersion patterns in regions either densely vegetated and/or dominated by regolith.

1.4 Comparison of Soil and Vegetation

Biogeochemistry has a significant advantage over soil sampling because plants and in particular trees due to their root system, have the ability to sample material from considerable depths and wider areas (Lintern et al. 1996). The geochemistry of the soil will be compared with that of vegetation (leaves, phyllodes of the Mulga and minor stems of the Pearl Bluebush (Anand et al. 2007).

2. AIMS AND SIGNIFICANCE OF THE STUDY

This study aims to support or challenge the findings from the study conducted by Wang et al. (1999) in the Olympic Dam (Roxby Downs) and Andamooka area. It also aims to compare regional plant biogeochemical and soil geochemical expressions of buried mineralization. Although Wang et al. (1999) employed low density NAMEG and MOMEO exploration

techniques, this study will include plant samples analysed by ACME analytical laboratories and soil samples analysed by AMDEL. The study conducted by Wang et al. (1999) focused on 17 elements (Au, Ba, Ca, Ce, Co, Cr, Fe, Hf, Hg, Ir, La, Na, Sb, Sc, Ta, Th, Zn). This study will attempt to match these elements. This study will also consider additional elements that appear to have interesting results. Although the main focus will be on the minerals currently mined at Olympic Dam (Iron Oxide – Copper - Gold deposits), extra emphasis will be given to the pattern of elements shown by the study conducted by Wang et al. (1999).

This study aims to show that using biogeochemical techniques may aid in further discoveries of mineralization in areas which have not yet been investigated. A main advantage is that the cost ratio of biogeochemical techniques will be significantly lower compared to the drilling techniques that are currently in use.

More specifically, the main aim of this study is to:

1. Characterize Mulga (*Acacia aneura)* and Pearl Bluebush (*Maireana sedifolia*) leaf samples and soil samples from 18 different locations in the Olympic Dam region (Figure. 1).
2. Compare the plant and soil sample results to those from the study conducted by Wang et al. (1999).
3. Compare the plant samples to the soil samples within this study.
4. Establish any relationships between underlying geological substrate and plant biogeochemistry and soil chemistry.
5. Consider the findings of this study for mineral exploration programs.

3. SETTING

3.1 Geology

The study area is located in the Roxby Downs and Andamooka region which is located on the Stuart Shelf, approximately 563 km north of Adelaide, South Australia- Latitude 30.48 º S, Longitude 136.88 º E. Elevation 99m. It is an area of flat-lying Adelaidean (late Proterozoic) to Cambrian sediments underlain by middle Proterozoic strata which host the mineralization (Roberts & Hudson 1983). These units are divided by the Adelaide geosyncline to the east by a major region of north – south faulting named the Torrens hinge zone (Roberts & Hudson 1983). The sediment cover of the Stuart Shelf laps onto exposed rocks of the Gawler Craton, this is to the west and south – west (Roberts & Hudson 1983). The Stuart Shelf basement is believed to consist of Gawler domain rocks and it is within this basement that the Olympic Dam deposit occurs (Roberts & Hudson 1983). The stratigraphy of the area reveals that basement rock consists of granitic and unmetamorphosed hematite breccias (aged between 1550 and 1450 m.y that are best developed in the Gawler Ranges) siltstones and volcanic rocks, Adelaidean sediments consisting of quartzites, Cambrian sediments consisting of Andamooka limestone, Mesozoic sediments consisting of Bulldog shale and recent sediments which include sand dunes (PIRSA, 2009). The Olympic Dam deposit extends over a west-northwest trending photolineament corridor at the intersection of a major north-northwest-trending gravity lineament (Roberts & Hudson 1983). The Olympic Dam region consists of approximately 350 m of cover sediments which are separated from the underlying basement rocks by a major unconformity (Roberts & Hudson 1983).

The Olympic Dam copper-uranium-gold deposit comprises a significant resource of copper and uranium with an areal extent surpassing 20 km² and vertical thickness of mineralization measured in tens to hundreds of metres (Roberts & Hudson 1983).

The Olympic Dam Formation extends more than 1,000 m in thickness and dips to the southwest at 15° to 20° in the southeastern half of the graben. It consists of five members: Lower Granite Breccia Member, The Black Hematite Member, Whenan Member, Brooks Member and the Upper Granite Breccia Member.

Andamooka consists of limestone which is the oldest unit in the Cambrian sequence on the Stuart shelf (Cowley 1990). It predominantly consists of grey, off-white, buff or pink recrystallised limestone, which is usually dolomitised and locally pyritic and sandy (Cowley 1990). This particular limestone is mainly massive to indistinctly-bedded and vughy, but well-bedded, flaggy areas are infrequently existing in the outcrop (Cowley 1990).

The Olympic Dam deposit holds anomalous concentrations of iron, copper, gold, uranium, silver, fluorine and barium (Hughes 1996). It also contains rare earth elements, especially lanthanum and cerium (Hughes 1996). The recovery of copper, uranium, gold and silver is considered economic at this stage (Hughes 1996).

3.2 Landscape

The landscape of the study region consists of erosional hills and plains. The landform materials in the study area include sand dunes consisting of fine red well sorted unstructured loose sand (Table. 3). The plains surface area consists of well sorted red fine sand. The soil has blocky peds at 15cm depth and becoming finer with depth. Lag is pebble to cobble sized quartzite and silcrete

(mainly quartzite). The Northern and Western areas of Olympic Dam are mostly sand dunes. The Andamooka area consisted of erosional plains.

3.3 Vegetation

The study area was dominated mainly by the Bladder Saltbush (*Atriplex vesicaria*) and scattered grasses. The Mulga (*Acacia aneura)* was found in areas that mainly consisted of sand dunes. Also found in certain areas of the study region was the Pearl Bluebush (*Maireana sedifolia*).

Mulga (*Acacia aneura)* is a small upright tree which can grow up to 14 metres tall, it also forms bushy shrubs 3 – 5 metres tall (Hill, 2009). It is found abundant and widespread in dunefields, particularly on mid-lower dune slopes and along a number of drainage depressions within areas of chenopod shrubland (Hill 2009). At maturity it is estimated to be 100 – 200 years old (Slatyer 1961). Overturned dead trees have shown the Mulga to have a root system that is largely shallow and branching (Hill & Hill, 2003). Mulga technically does not have leaves instead it has modified leaf stems or phyllodes, it adopted to these changes by responding to the dry climate of Australia (Anand et al. 2007). Proximity to variable rainfall occurrences determines flowering and phyllode generation (Hill & Hill, 2003).

Pearl Bluebush (*Maireana sedifolia*) is widespread and perennial throughout the region. It is related to easily broken up/crumbly regolith substrates that permit extensive root penetration, such as areas with regolith carbonates within approximately 60cm depth and fractured bedrock (Cunningham *et al.* 1992). Pearl Bluebush is reported to live at least 150 – 300 years (Irons & Quinlan 1988). They have a tap-root system which can reach depths of up to 3 metres with

shallow deciduous feeding roots (Cunningham *et al.* 1992). Summer generally hosts their flowering and leaf generation (Hill & Hill, 2003). Sampling the leaves is a straightforward procedure.

3.4 Climate

Roxby Downs and Andamooka experience an arid to semi-arid climate. Temperature and rainfall statistics published by the Bureau of Meteorology show recording of Roxby downs for the last 14 years (1997-2011) and recordings of Andamooka for the last 30 years.

The highest recorded temperatures at Roxby downs are in the summer months with the mean annual maximum temperature being 27.6º C and the mean monthly maximum temperature being 37.2 º C in January (BOM 2011). The lowest recorded temperatures are in the winter months with mean annual minimum temperature being 12.6 º C and the mean monthly minimum temperature being 4.5 º C in July (BOM 2011). The mean annual rainfall recorded for Roxby downs over the last 14 years was 153.4 mm, with the mean monthly maximum rainfall being 19.9 mm in February and the mean monthly minimum rainfall being 4.8 mm recorded in March (BOM 2011). The dominant winds in the Roxby Downs area are southerly (BOM 2011).

The highest recorded temperatures at Andamooka are in the summer months with the mean annual maximum temperature being 27.6º C and the mean monthly maximum temperature being 36.7 º C in January (BOM 2011). The lowest recorded temperatures are in the winter months with mean annual minimum temperature being 13.8 º C and the mean monthly minimum temperature being 5.9 º C in July (BOM 2011). The mean annual rainfall recorded for Andamooka over the last 30 years was 181.1 mm, with the mean monthly maximum rainfall being 20.3 mm in October

and the mean monthly minimum rainfall being 10.3 mm recorded in July (BOM 2011). The dominant winds in the Andamooka area are southerly (BOM 2011).

4. METHODOLOGY

Published information on the relationship of plant chemistry to mineralized rock date back to 1898, when a study by the Omai goldmine in Guyana was conducted (Dunn 2007). In 1938 Tkalich published the first report of biogeochemical methodology. He discovered that an arsenopyrite deposit in Siberia could be traced by the iron content of overlying vegetation (Dunn 2007). Investigation into the use of biogeochemistry in mineral exploration was commenced in the 1960's by the Geological Survey of Canada (Dunn 2007). Protocols were developed by the study for how and when to sample, these procedures are still used today (Dunn 2007). In order to match the advances in biogeochemical exploration, the necessity for major advances in analytical instrumentation was required (Dunn 2007). The Inductivity Coupled Plasma Mass Optical Emission Spectrometry (ICP-ES) and Instrumental Neutron Activation Analysis (INAA) was developed in the mid 1970's to provide accurate and precise multi-element data at low-element concentrations at a minimal price (Dunn 2007). In the late 1980's the ICP-MS (Inductively Coupled Plasma Mass Optical Emission Spectrometry) was developed, it was as improvement of the ICP-ES (Dunn 207). The ICP-MS was able to analyse traces many elements at the PPT (part per trillion) level (Dunn 2007).

Biogeochemical studies in Australia are improving. In the past, an identified issue has been the complications that surface in dealing with the large number of species comprising Australia's two main genera of plant - the acacias and the eucalyptus (Dunn, 2007). Australia houses

approximately 850 species of eucalyptus (family *Myrtaceae*) and more than 1,000 species of acacia (family *Mimosaceae*) (Dunn, 2007). At this stage it is not known if there are major differences in metal uptake and accumulation among all these species of each of these genera (Dunn, 2007).

Twenty six of the forty five analysed elements were chosen for discussion in this study. Selection was made to match the elements from the study conducted by Wang et al. (1999) (Table. 2) and also due to those 26 elements displaying interesting results which needed further investigations. The chosen elements included the suite from Wang et al. (1999) (Au, Ba, Ca, Ce, Co, Cr, Fe, Hf, Hg, La, Na, Sb, Sc, Th, Zn) and the additional elements (Ag, Al, Cu, Mg, Mn, Mo, Ni, Pb, Sr, U, Zr). Two additional elements (U & Cu) were selected because they are mined at Olympic Dam. Although certain elements may have shown some interesting results, the main focus of this study will be on iron, copper, gold, uranium and mercury.

This study will sample Mulga (*Acacia aneura)* and Pearl Bluebush (*Maireana sedifolia*) leaf samples as well as soil samples from 18 locations within in the Olympic Dam area. Once collected, the samples will be properly prepared and then sent off for analysis.

This project was designed to compare plant and soil samples to those which were collected by Wang et al (1999). Wang et al. (1999) collected 36 soil samples and the equivalent amount of earthgas samples. The thirty six sites were sampled in an area which covered approximately 2500 km^2 at a density of approximately 1 sample per 60 km^2 (Wang et al. 1999). Not all sites were accessible for this study due to restricted access enforced by the Roxby/Purple Downs pastoral

lease and mining activity. As a result only fifteen of the thirty six sites could only be sampled. Another three sites were added to the total as these sites were at close proximity to three sites sampled by Wang et al. (1999).

The sampling procedure took place over a five day period in the second week of April 2011. This particular occasion was chosen because it was prior to the wet season. It has previously been shown that in other semi-arid regions in Australia that this collection time is associated with biogeochemical characteristics derived from deeper parts of the plants root system (Reid & Hill 2010). As mentioned earlier eighteen locations were able to be sampled and at each spot one plant and one soil sample was taken. Soil samples were taken as close to the plants as possible but care was taken to avoid any damage to the plants.

Soils samples were taken with the aid of a shovel from a depth of approximately 20cm, where the soil is more compact and the lag removed (Wang et al. 1999) therefore allowing for more precision. The soil sample depth was chosen because it is considered that mobile ions might be concentrated at this depth due to the effect of downward-percolating water which moves solutes down the soil profile (Fabris et al. 2009). The soil samples were then put in a labelled large zip locked plastic bag. For identification purposes the location and GPS point (Table. 1) of each site was marked with a permanent marker on each bag. This method helped to avoid any mix up that may occur later on. Powder free latex gloves were worn during this procedure to avoid contamination (Hill 2002). Gloves were necessary because soil that was not able to be scooped up by the shovel was scooped up by hand. Care and precision was also taken when sampling the plants. Mulgas that were healthy and relatively free from disease were selected for sampling. Phyllodes were collected at a uniform height (chest level) of each Mulga tree. The Pearl

Bluebush samples were taken at various points around the circumference of the plant (Hill 2002). This technique would ensure that a representative sample of the entire plant would be taken (Hill 2002) which should result in a more precise outcome. Powder – free latex gloves were also worn and all jewellery including any other metallic items were removed from hands during this procedure therefore preventing contamination (Hill 2002). Following collection, each plant sample was put in individual unbleached brown paper bags as this would allow the samples to air and be kept out of direct light therefore avoiding mould development (Hill 2002). The bags were then sealed by folding the top of them twice (Hill 2002). As with the soil samples each brown paper bag was labelled with location and GPS points for identification purposes. Locations and GPS points of all samples were recorded and stored for future reference. This method was adopted so plant and soil samples could be compared to each other.

In regards to the sampling preparation, plant samples were brought to The University of Adelaide and whilst still in their individual bags were placed in an oven which was set at 60º C, they were kept in there for a period of 48 hours (Hill 2002). Drying plant samples at elevated temperatures (above 80º C) will cause considerable loss of volatile elements and drying them at low temperatures (below 40º C) will not stop mould development or halt metabolic activity (Hill 2002). The vegetation samples were dried for the purposes of preventing the decomposition of material and also for them to be easily separated into leaves and twigs for grinding reasons (Hill 2002). Once dried thoroughly the leaves were milled into a fine powder using the BrevilleTM 'Coffee-n-spice' grinder, CG2. The grinder which has rotating stainless-steel blades was cleaned between every sample with the aid of laboratory-grade ethanol, compressed air and paper towels. The samples were put in small individual paper bags in order to retain their dryness. Paper bags

were used because the analysis procedure requires them to be put in these types of bags. Powder free latex gloves were worn during the entire procedure to avoid contamination, also as with the sampling procedure all jewellery including any other metallic items were removed from hands. For quality control purposes, samples 10 and 19 were duplicated.

Once brought back to The University of Adelaide the soil preparation procedure was initiated. Each sample was sieved (with the aid of an electronic shaker) at a <200µm fraction and put into two plastic bags. One bag was sent off for bulk analysis, the other was sent off for partial leach work. All bags were labelled for identification purposes. The sieve was cleaned thoroughly between samples with laboratory-grade ethanol, compressed air and paper towels. As with the plant sample preparation, in order to avoid contamination the necessary precautions were taken (gloves worn and jewellery removed). As with the vegetation samples, for quality control purposes samples 10 and 19 were duplicated.

4.1 Contamination

There is a possibility that plant tissue may have been contaminated because sections of the sampling area are subject to windblown dust especially during the summer months (Arne et al. 1999). A major cause of these events are mainly due to proximity of unsealed roads (Arne et al. 1999) where vehicles driving past bring up dust particles and anthropogenic activities including mining activities (Arne et al. 1999) such as prospecting, pitting and drilling (Wang et al. 1999). Aeolian transported dust particles from Olympic Dam is another major concern in regards to contamination. Other causes of contamination include animal droppings and films of insect products (Hill 2002).

4.2 Chemical Analytical Methods

The vegetation samples were sent for analysis to ACME Analytical Laboratories Ltd. in Vancouver, Canada. The soil samples were sent for bulk and partial leach analysis to AMDEL Pty Ltd in Adelaide, South Australia.

4.3 Data Presentation

The software programs that were used to present the results were Microsoft Office and Paint. Microsoft Excel was used to design tables which included statistical information. Paint was used to plot the element concentrations on the figures provided by the Wang et al. (1999) s

5. RESULTS

The full set of compiled results is included in Table 4. Not all elements were tested regarding the bulk sample testing and the partial leach process)

Samples; VEG A005/PL S005/BLK S005, VEG A006/PL S006/BLK S006, VEG A007/PL S007/BLK S007 and VEG A009/PL S009/BLK S009 were from Pearl Bluebush (*Maireana sedifolia*). The remainder samples were from Mulga (Acacia aneura).

In general, according to the Munsell colour chart the soils tested in this study were 2.5YR, chroma 6 & 8 and had an average value of 4. The northern and southern section of Olympic Dam consisted of sand dunes, whereas the eastern section (approximately 10 kms east) consisted of plains.

The results from the study conducted by Wang et al. (1999) are included in Table. 2. The proportions of various forms of metals: NAMEG, MOMEO, WEM = water-extractable metals, AEM = absorbed or exchangeable metals, FMM = metals occluded onto Fe-Mn oxides, REM = residual metals, Total = content by aqua regia digestion are included in Appendix . 1.

Gold (Au)

Gold was detected in only 6 of the 18 vegetation samples analysed. The highest gold concentration was recorded from sample VEG A007 at OD and revealed 1.3 ppb. Sample VEG A017 revealed a similar concentration of gold (1.0 ppb). The lowest gold concentration was detected in samples VEG A012 (0.2 ppb) and sample VEG A018 (0.2 ppb). The average of all sample analysed was 0.57 ppm. The standard deviation was 0.45.

Gold was detected in only 4 of the partial leach samples that were analysed. Sample PL S006 had the highest recording. Sample PL S007 had the lowest concentration. The average of all samples tested was 0.28 ppb. The standard deviation was 0.24.

Gold was detected in only 7 of the 18 bulk soil samples that were analysed. The highest concentrations were detected in samples BLK S005 and BLK S006 (2 ppb). Samples BLK S007, BLK S008, BLK S009, BLK S013 and BLK S016 had the lowest concentration of Au (1 ppb).The average of all samples was 1.29 ppb. The standard deviation was 0.49.

Barium (Ba)

Barium was detected in all vegetation samples analysed. Barium recorded its highest concentration in sample VEGA010 (132.3 ppm). Its lowest concentration was revealed in sample

VEGA005 (3.6 ppm). The average of all samples was 66.62 ppm. The standard deviation was 43.26.

Barium was detected in all bulk soil samples analysed. Samples; BLK S006 and BLK S007 had the highest concentration of Ba (390 ppm). The lowest concentration was detected in sample BLK S011 (155 ppm). The average concentration of all samples analysed was 231.67 ppm. The standard deviation was 67.67.

Calcium (Ca)

Calcium was detected in all vegetation samples. The majority of samples recorded approximately 5.5% of calcium. The highest reading was from sample VEG A010 (6.83 % ppm) and the lowest reading was from sample VEG A007 (0.46 % Na). The average of all sample analysed was 4.42. The standard deviation was 2.39.

Calcium was detected in all bulk samples analysed. Sample BLK S006 had the highest concentration of Ca (1.21%). Sample BLK S019 registered the lowest concentration (0.035%). The average of all samples was 0.22%. The standard deviation was 0.29.

Cerium (Ce)

Cerium was detected in all vegetation samples analysed. Sample VEG A007 recorded the highest concentration of Cerium (0.46 ppm). Also sample VEG A006 recorded a relatively high concentration (0.29 ppm). Samples VEG A011 and VEG A021 recorded the lowest concentration (0.03 ppm). The average of all samples recorded was 0.10 ppm. The standard deviation was 0.11.

Cerium was detected in all bulk soil samples analysed. The highest concentration was recorded in sample BLK S006 (29 ppm), whereas sample BLK S011 had the lowest concentration (5 ppm). The average of all samples was 13.28. The standard deviation was 7.60.

Cobalt (Co)

Cobalt was detected in every vegetation sample, except for sample VEG A005. The highest reading was 0.44 ppm from sample VEG A014. There was also a strong presence of cobalt at 3 areas, from samples: VEG A006, VEG A012 and VEG A017. A strong detection of cobalt was also found at sample VEG A016. The average of all sample analysed was 0.15 ppm. The standard deviation was 0.10.

Cobalt was detected in all samples regarding the partial leach process. Sample PL S014 had the highest concentration (0.514 ppm). Sample PL S019 recorded the lowest concentration (0.09 ppm). The average of all samples was 0.25 ppm). The standard deviation was 0.13.

Cobalt was detected in all bulk soil samples that were analysed. The highest concentrations were seen in samples; BLK S006 (6.5 ppm) and BLK S007 (6.5 ppm). Samples BLK S011 and BLK S019 recorded the lowest Co concentrations (1.2 ppm). All samples averaged 2.79 ppm. The standard deviation was 1.84.

Chromium (Cr)

Chromium was detected in all vegetation samples. Chromium recorded its highest concentration in sample VEGA009 (2.6 ppm). Sample VEGA007 also recorded a high concentration of Cr (2.3 ppm). The lowest concentration was in sample VEGA005 (1.0 ppm). All samples averaged 1.42 ppm. The standard deviation was 0.41.

Chromium was detected in all bulk soil samples analysed. Sample BLK S014 recorded the highest concentration of Cr (155 ppm). Sample BLK S015 recorded the lowest concentration (100 ppm). The average of all samples was 126.11 ppm. The standard deviation was 16.94.

Iron (Fe)

Iron was not detected in sample (VEG A011). Two vegetation samples registered the highest concentrations of iron, one was from sample VEG A007 (0.044%) and the other from sample VEG A006 (0.022%) at OD. This site also had the highest concentrations of Cu (18.26 ppm) and highest concentrations of Pb (8.58 ppm). Also silver concentrations were relatively high in this area (10 ppb). The average of all sample analysed was 0.01 ppm. The standard deviation was 0.01.

Iron was detected in all bulk soil samples that were analysed. A significant enrichment of Fe was detected in many samples. The highest Fe concentrations were from sample BLK S007 (2.147 %). Sample BLK S019 recorded the lowest concentration (0.636 %). The average of all samples was 1.15 ppm. The standard deviation was 0.50.

Hafnium (Hf)

Hafnium had almost undetectable readings in the vegetation samples. Only 14 out of the 18 samples registered a reading. The highest recorded concentration was from sample VEG A007 (0.015 ppm) and the lowest recordings were from samples; VEG A005, VEG A011, VEG A013, VEG A015 and VEG A019. The low concentration of Hafnium in these samples was 0.001 ppm. The average of all samples analysed was 0 ppm. They were all below the detection limit. The standard deviation was 0.005.

Hafnium was detected in all bulk soil samples analysed. Sample BLK S018 recorded the highest concentration of Hf (12 ppm), whereas sample BLK S011 recorded the lowest concentration (2 ppm). The average of all samples was analysed was 6.28. The standard deviation was 2.63.

Mercury (Hg)

Sample VEG A005 was the only sample not to show a concentration of Hg. Sample VEG A007 had the highest concentration of mercury (52 ppb) at OD. This site had recorded the highest concentrations of copper, lead, zinc, nickel, manganese, gold and the second highest reading of silver. Sample VEG A018 had the lowest reading (2 ppb). The average of all sample analysed was 10.25 ppm. The standard deviation was 11.73.

Mercury was not analysed for the bulk soil samples.

Lanthanum (La)

Lanthanum was detected in all vegetation samples analysed. The results of Lanthanum revealed sample VEG A007 to be noticeably higher (0.31 ppm). Sample VEG A006 also showed a higher reading (0.12 ppm). The lowest reading was recorded from sample VEG A021 (0.01 ppm). All samples averaged at 0.05 ppm. The standard deviation was 0.07.

Lanthanum was detected in all bulk soil samples analysed. Samples BLK S006 and BLK S020 recorded the highest concentrations of La (14 ppm). Whereas samples BLK S005 and BLK S011 recorded the lowest concentrations (3 ppm). The average of all samples was 7.06 ppm. The standard deviation was 3.59.

Sodium (Na)

Sodium was detected in all vegetation samples although sample VEG A006 recorded >10.000 ppm. Sample VEG A009 registered the highest concentration of Sodium (9.653%). High concentrations were also revealed by samples; VEG A007 (7.882%) and VEG A005 (7.542%). Sample VEG A008 showed the lowest concentration of Na (0.013%). The average of all samples was 1.54%). The standard deviation was 3.28.

Sodium was detected in all bulk soil samples analysed. The highest concentration was recorded in sample BLK S007 (0.148%). Sample BLK S011 recorded the lowest percentage of Na (0.0148%). The average of all samples analysed was 0.05%. The standard deviation was 0.04

Antimony (Sb)

Only three vegetation samples revealed the detection of antimony. Sample VEG A007 had the highest reading (0.26 ppm), sample VEG A021 had the lowest reading (0.02 ppm). The average of all samples was 0.11 ppm. The standard deviation was 0.13.

Antimony was detected in all samples that were sent for analysis for the partial leach process. Sample PL S020 had the highest concentration (0.006 ppm). Sample PL S010 recorded the lowest concentration of Sb (0.002 ppm). The average of all samples was 0 ppm. The standard deviation was 0.001.

Scandium (Sc)

Fourteen of the 18 vegetation samples recorded concentrations of Sc. Sample VEG A007 recorded the highest concentration (0.9 ppm). Samples VEG A009, VEG A014, VEG A016, VEG A020, VEG A021 and VEG A022 recorded the lowest concentrations (0.1 ppm). The average of all samples was 0.21 ppm. The standard deviation was 0.25.

Only 4 of the 18 bulk soil samples analysed detected Scandium. Samples BLK S005, BLK S006, BLK S007, BLK S015 and BLK S020 all registered 5 ppm. The average of all samples was 5 ppm. The standard deviation was 0 ppm.

Thorium (Th)

Thorium was detected in only 4 of the 18 vegetation samples. The highest concentration was detected in sample VEG A007 (0.07 ppm) and the lowest concentration was seen in sample VEG A005 (0.03 ppm). The average of all sample analysed was 0.05 ppm. The standard deviation was 0.02.

Thorium was detected in all the partial leach samples. Sample PL S020 had the highest concentration (0.39 ppm). Sample PL S006 recorded the lowest concentration (0.004 ppm). The average of all samples was 0.10 ppm. The standard deviation was 0.11.

Thorium was detected in all bulk soil samples analysed. Sample BLK S006 had the highest concentration (5.5 ppm). Whereas samples BLK S005 and BLK S011 had the lowest concentrations of Th (1.5 ppm). The average of all samples was 3.11 ppm. The standard deviation was 1.29.

Zinc (Zn)

Zinc was detected in all vegetation samples analysed. Zinc also had the highest recording which was 22.8 ppm from the exact point as Cu and Pb (VEG A007). The other highest reading was from sample VEG A010 recording 17.3 ppm. Sample VEG A009 had the lowest concentration (4.9 ppm). The average of all samples was 11.34 ppm. The standard deviation was 4.60.

Zinc was detected in all the samples that were sent for the partial leach process. Sample PL S011 had the highest concentration (1.39 ppm). Sample PL S015 recorded the lowest concentration of Zn. The average of all samples was 0.39 ppm. The standard deviation was 0.35.

Zinc was detected in all bulk samples that were analysed. Sample BLK S005 had the highest concentration (405 ppm). Also sample BLK S007 had a relatively high reading (95 ppm). The lowest Zn concentration was detected in sample BLK S019 (10.5 ppm). The average of all samples was 52.11 ppm. The standard deviation was 90.63.

The following elements are additional elements of this study:

Strontium (Sr)

Strontium was detected in all vegetation samples analysed. Sample VEG A010 had the highest strontium levels (1247.2 ppm). The lowest recorded level was from sample VEG A007 which recorded 17.3 ppm. The average of all sample analysed was 563.46 ppm. The standard deviation was 384.99.

Strontium was detected in all bulk soil samples analysed. Sample BLK S006 had the highest concentration (90 ppm), whereas sample BLK S011 had the lowest concentration (15 ppm). The average of all samples was 34.44 ppm. The standard deviation was 19.40.

Molybdenum (Mo)

Molybdenum was detected in all vegetation samples. The results show that ample VEG A019 had the highest recorded concentration of molybdenum (10.77 ppm). Sample VEG A007 registered the lowest concentration (0.30 ppm). The average of all values was 4.08 ppm and the standard deviation was 3.32.

Molybdenum was detected in all the samples that were sent for the partial leach process. Sample PL S010 had the highest concentration (0.03 ppm). Sample PL S009 recorded the lowest concentration of Mo (0.002 ppm). The average of all samples was 0.01 ppm. The standard deviation was 0.01.

Molybdenum was detected in only 7 of the 18 bulk soil samples analysed. Sample BLK S014 had the highest concentration. Samples; BLK S006, BLK S007, BLK S013, BLK S019, BLK S020 and BLK S022 registered the lowest concentration of Mo (2 ppm). The average of all samples was 2.14 ppm. The standard deviation was 0.38.

Copper (Cu)

Copper was detected in all vegetation samples. The highest concentration of copper recorded was 18.26 ppm and recorded from sample VEG A007. The other samples were relatively similar, ranging from 1.84 ppm (lowest detection recorded VEG A008) to 6.66 ppm. The average of all samples was 4.61 ppm. The standard deviation was 3.68.

Copper was detected in all the samples that were sent for the partial leach process. Sample PL S007 had the highest concentration (4.8 ppm). Sample PL S011 recorded the lowest concentration (0.37 ppm). The average of all samples was 1.77 ppm. The standard deviation was 1.37.

All bulk soil samples that were analysed detected copper concentrations. The highest copper concentration was detected in sample BLK S021 (31 ppm). Sample BLK S006 also revealed a higher concentration of Cu (24 ppm). The lowest recorded concentration was from sample BLK S019 (3.5 ppm). All samples averaged 9.94 ppm. The standard deviation was 7.50.

Lead (Pb)

Lead was detected in all vegetation samples. As with Copper the highest copper concentration recorded was 8.58 ppm taken from VEG A007. There seems to be an association between Cu and Pb at this exact sampling spot. There was one other high Pb reading from sample VEG A005 (4.01 ppm). Sample VEG A018 recorded the lowest concentration of Pb (0.05 ppm). The average of all samples was 0.87 ppm. The standard deviation was 2.14.

Lead was detected in only 8 samples that were sent for the partial leach process. Sample PL S010 had the highest concentration (0.18 ppm). Sample PL S018 recorded the lowest concentration of Pb (0.013 ppm). The average of all samples was 0.06 ppm. The standard deviation was 0.06.

Lead was detected in all bulk soil samples that were analysed. An abnormally high concentration (compared to all the other samples) was detected in sample BLK S006 (145 ppm). Sample BLK S005 also showed a high detection level (55 ppm). The lowest concentration was seen by samples; BLK S019 (4 ppm) and BLK S021 (4 ppm). All samples averaged 18 ppm. The standard deviation was 33.78.

Silver (Ag)

Regarding silver concentrations, there were 6 recordings above 2 ppb in the vegetation samples. The Highest recorded concentration was 11 ppb taken from sample VEG A009 and the lowest recorded was 2 ppb taken from sample VEG A017. The average of all samples was 6.17 ppb. The standard deviation was 3.76.

Silver was detected in only one sample of the 18 that were sent for the partial leach process. Sample PL S007 recorded 6 ppb.

Silver was detected in only 8 of the 18 bulk soil samples provided. Sample BLK S006 had the highest concentration (400 ppb). Samples BLK S008 and BLK S014 recorded the lowest concentration of Ag (100 ppb). All samples averaged 212.50 ppb. The standard deviation was 99.10.

Nickel (Ni)

Nickel concentrations were detected with only 9 of the 18 vegetation samples. The highest recorded reading was 2.2 ppm taken from sample VEG A007. Two other samples also recorded high concentrations which were located approximately, one was taken from sample VEG A005 (1.4 ppm) and the other taken from sample VEG A006 (1.1 ppm). The lowest concentration was recorded from samples; VEG A019 (0.1 ppm) and VEG A020 (0.1 ppm). The average of all sample analysed was 0.69 ppm. The standard deviation was 0.72.

Nickel was detected in all samples that were sent for the partial leach process. Sample PL S020 recorded the highest concentration (0.53 ppm). Sample PL S011 had the lowest concentration (0.08 ppm). The average of all samples was 0.23 ppm. The standard deviation was 0.13.

Nickel was detected in all bulk soil samples. Sample BLK S006 recorded the highest concentration of Ni (14 ppm). Samples; BLK S005, BLK S011, BLK S018 and BLK S019 recorded the lowest concentration (3 ppm). All samples averaged 6.06 ppm. The standard deviation was 3.51.

Manganese (Mn)

Manganese was detected in all vegetation samples analysed. Manganese showed high concentrations from two samples at OD. These were sample VEG A007 (186 ppm) and sample VEG A006 (139 ppm). The average of all sample analysed was 38.39 ppm. The standard deviation was 47.14.

Manganese was detected in 10 of the 18 bulk soil samples that were analyzed. Samples; BLK S006, BLK S007 and BLK S015 recorded the highest concentration of Mn (232.378 ppm). Whereas samples; BLK S008, BLK S009, BLK S010, BLK S013 and BLK S017 registered the lowest concentration of Mn (77.45933 ppm). The average of all samples was 139.43 ppm. The standard deviation was 71.18.

Uranium (U)

Uranium was detected in only 6 of the 18 vegetation samples. The highest concentration of U was shown by sample VEG A007 (0.04 ppm) and sample VEG A017 (0.04 ppm). Sample VEG A018 had the lowest concentration of U. The average of all samples tested was 0.03 ppm. The standard deviation was 0.01.

Uranium was detected in all the samples that were sent for the partial leach process. Sample PL S020 had the highest concentration (0.05 ppm). Sample PL S005 recorded the lowest concentration of U (0.003 ppm). The average of all samples was 0.02. The standard deviation was 0.01.

Uranium was detected in 14 of the 18 bulk soil samples analysed. Samples BLK S006, BLK S007, BLK S014, BLK S015, BLK S016, BLK S018, BLK S020 and BLK S022 had the highest concentration of U (1 ppm). The lowest concentration was detected in samples; BLK S008, BLK

S009, BLK S010, BLK S017 and BLK S019 (0.5 ppm). The average of all samples was 0.82 ppm. The standard deviation was 0.25.

Magnesium (Mg)

Magnesium was detected in all vegetation samples that were analysed. Magnesium levels were quite low with all samples. The highest levels recorded was from sample VEG A021 (0.526% Mg) and the lowest recorded levels was from sample VEG A008 (0.138 %). The average of all sample analysed was 0.38 ppm. The standard deviation was 0.09.

Magnesium was detected in all bulk soil samples analysed. The highest concentration of Mg was detected in sample BLK S007 (0.778%). Samples; BLK S011 and BLK S019 had recorded the lowest concentration of Mg (0.054%). The average concentration of all samples was 0.20%). The standard deviation was 0.21.

Aluminum (Al)

Aluminum was detected in only 4 vegetation samples, the highest reading was from sample VEG A007 (0.03 %). The lowest recording was from sample VEG A005 (0.01 %). The average of all sample analysed was 0.02 ppm. The standard deviation was 0.01.

Aluminum was detected in all bulk soil samples analysed. Sample BLK S006 had the highest concentration of Al (3.74%) and sample BLK S005 had the lowest concentration (0.751%). The average concentration of all samples was 1.71%. The standard deviation was 1.02.

Zirconium (Zr)

Zirconium was detected in all vegetation samples analysed. Sample VEG A005 recorded the highest concentration (0.22 ppm). Other vegetation samples which recorded elevated concentrations of Zr included: VEG A006 (0.18 ppm), VEG A007 (0.17 ppm) and VEG A009 (0.11 ppm). The average of all samples tested was 0.06 ppm. The standard deviation was 0.06. Zirconium was detected in all bulk soil samples analysed. Sample BLK S018 recorded the highest concentration (500 ppm), whereas sample BLK S011 recorded the lowest concentration (70 ppm). The average of all samples was 250.83. The standard deviation was 108.32.

6. DISCUSSION

Biogeochemistry is an effective exploration method that can reveal multi element haloes at small scale and then be further refined with either additional detail and/or other exploration techniques (Reid & Hill, 2010).

The vegetation samples of this study did not show a similar pattern to Wang et al. (1999) regarding the NAMEG mercury (Hg) results. Wang et al. (1999) showed a high concentration of mercury directly on Olympic Dam, and also 20 km east and 20 km south of this area. Most of the mercury values of this study were less than 16 ppb although sample VEG 007 recorded the highest concentration (52 ppb). The WEM (Hg) results from the Wang et al. (1999) showed high concentrations of mercury directly on the Olympic Dam area and approximately 6 km south of this area.

The following results were recorded from the Wang et al. (1999) study. Regarding the Total Copper (Cu) results, the highest concentrations of copper were located at approximately 10 km

south east of Olympic Dam and moderate to high copper concentrations at approximately 8 km north of Olympic Dam. The AEM copper and WEM + AEM copper results showed that the highest concentrations of Cu were located at approximately 10 km south, 20 km south, 20 km north east and directly on the Olympic Dam area. The WEM copper results showed that the highest concentrations of Cu were located at approximately 9 km north and approximately 20 km south of Olympic Dam.

The vegetation, bulk analysis and partial leach results of this study did not show a similar pattern of copper concentrations to the results from the Wang et al. (1999) study. This study found that from the vegetation, bulk analysis and partial leach results the highest concentrations of copper were located at approximately 10 km south east (VEG 006/BLK 007/PL 007) of Olympic Dam. The bulk sample analysis of this study also recorded moderate to high concentrations of copper located at approximately 7 km south and approximately 20 km north east of Olympic Dam.

The following results were recorded from the Wang et al. (1999) study. The Total gold (Au) results showed that the highest concentrations of gold were located at approximately 15 km north west and approximately 22 km south of Olympic Dam. The NAMEG (Au) and results showed that the highest gold concentrations were located directly on, approximately 5 km south and approximately 20 km south west of the Olympic Dam area. The WEM (Au) results showed that highest gold concentrations were located at approximately 10 km north, approximately 4 km south east and approximately 21 km south west of the Olympic Dam area. The WEM + FMM (Au) results showed that the highest gold concentrations were located at approximately 3 km

south east, approximately 22 km south west and approximately 12 km north east of the Olympic Dam area.

The vegetation, bulk analysis and partial leach results of this study did not show a similar pattern of gold concentrations to the results from the Wang et al. (1999) study.

According to this study, the highest gold concentrations recorded from the vegetation results were located at approximately 10 km south east and approximately 7 km north of the Olympic Dam area. The bulk analysis results showed that the highest gold concentrations were located at approximately 10 km south east and approximately 15 km east of the Olympic Dam area. The majority of the bulk analysis results were not above 1 ppb. The partial leach results recorded the highest gold concentrations at approximately 10 km south east of the Olympic Dam area. Most of the partial leach results were not above 0.22 ppb.

Regarding the WEM Cu + Au + Hg results from the Wang et al. (1999) study, the highest concentrations were located directly on and at approximately 10 km north of the Olympic Dam area.

According to this study the majority of soil sample results displayed higher element concentrations than the vegetation samples.

Sample VEG A007 displays some interesting results regarding element detection and possible element association. It reveals the highest recorded concentrations of the majority of elements (Cu, PB, Zn, Ag, Ni, Co, Mn, Fe, As, U, Au, Th, Cd, Sb, Bi, V, La, Cr, Ti, Sc, Tl, Hg, Te, Cs, Hf, Y,& Li).

The majority of elements (Pb, Ni, Mn, Fe, As, Au, Cd, Sb, P, La, Cr, Ti, Na, K, Sc, S, Hg, Te, Cs, Hf, Rb, Zr, Y, Ce, Re and Li) in the vegetation and soil samples had uniformly low concentration levels which defined the background. However, these samples also had pronounced detection concentration levels which revealed that they were enriched relative to the background. Copper and zinc revealed high concentration levels, however they are also mirrored by manganese and iron.

High levels of Aluminum and Zirconium in vegetation samples may suggest Aeolian transported material.

7. CONCLUSION

The aim of this study was to compare its vegetation results using the Mulga (*Acacia aneura*) and Pearl Bluebush (*Maireana sedifolia*) and soil sample results with the results from the study conducted by Wang et al. (1999) and as a result either supporting or challenging its findings. In addition, it also aimed to compare the vegetation results with the soil results with in this study.

The findings of this study were that the vegetation, bulk analysis and partial leach results did not show a similar pattern of mercury, copper and gold concentrations to the results from the Wang et al. (1999) study. Giving this information, this study cannot support the findings from the Wang et al. (1999) study.

An important finding of this study was that sample VEG 007 recorded the highest concentrations in the majority of the elements and as a result may prove to be a potential mineral deposit. In addition, vegetation and soil samples that were taken from approximately 5 km south,

approximately 10 km south and approximately 15 km north east of Olympic Dam showed some promising results and as a result these areas may require further investigation.

This study demonstrated that biogeochemical sampling is a relatively low-cost exploration method, causes very little disturbance to the environment and can detect relationships between the underlying geological substrate and plant biogeochemistry.

In summary, this study showed the potential usefulness of using biogeochemical methods to locate new mineral deposits.

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TABLES

Table 1: GPS Points (using Datum WGS 084 Zone 53) of Plant Samples

Sample	Plant Type	Eastings	Northings
VEG A005/PL S005/BLK S005	Pearl Bluebush	704455	6627013
VEG A006/PL S006/BLK S006	Pearl Bluebush	693588	6626785
VEG A007/PL S007/BLK S007	Pearl Bluebush	694346	6625914
VEG A008/PL S008/BLK S008	Mulga	684645	6618593
VEG A009/PL S009/BLK S009	Pearl Bluebush	688783	6620413
VEG A010/PL A010/BLK S010	Mulga	683715	6612548
VEG A011/PL S011/BLK S011	Mulga	682975	6606283
VEG A012/PL S012/BLK S012	Mulga	681228	6600549
VEG A013/PL S013/BLK S013	Mulga	678873	6605314
VEG A014/PL S014/BLK S014	Mulga	680236	6617992
VEG A015/PL S015/BLK S015	Mulga	681665	6623910
VEG A016/PL S016/BLK S016	Mulga	682934	6628242
VEG A017/PL S017/BLK S017	Mulga	685087	6636545
VEG A018/PL S018/BLK S018	Mulga	685393	6643465
VEG A019/PL S019/BLK S019	Mulga	689479	6643424
VEG A020/PL S020/BLK S020	Mulga	696503	6643385
VEG A021/PL S021/BLK S021	Mulga	703548	6643208
VEG A022/PL S022/BLK S022	Mulga	702944	6637759

Table 2: Distribution, Background and Threshold of Elements of Earthgas. (Wang et al. 1999).

Please note: µg = PPM (parts per million), ng = PPB (parts per billion, pg = PPT (parts per trillion).

Element			Original	Distribution							
	n	max	min	mean	SD		n	Background		SD	Threshold
Au ng	36	1.67	0.25	0.59	0.32		28	0.45		0.12	0.7
Ba ng	36	765	66.7	205.2	113.2		32	175.3		45	250
Ca µg	36	109	31	61.3	19.1		33	57.4		14.6	90
Ce ng	36	13.3	0.8	6.3	2.3		33	5.7		1	6
Co ng	36	6.2	1.3	2.5	0.8		34	2.4		0.4	2.8
Cr ng	36	134	37.1	67.5	25.2		30	57.9		13.4	85
Fe µg	36	5.5	2.6	3.6	0.7		27	3.3		0.4	4
Hf ng	36	8.4	0.6	1.3	1.3		24	0.9		0.1	1.1
Hg ng	36	49.2	4.2	20.5	11.9		31	15.9		8.3	30
Ir pg	36	415	4.2	55.2	75.8		24	20		11.5	40
La ng	36	7.4	2.1	3.4	1		31	3.1		0.5	4
Na µg	36	7.3	1.2	2.6	1.4		27	1.9		0.3	2.5
Sb ng	36	2.4	0.5	1.3	0.4		27	1.2		0.15	1.5
Sc ng	36	2	1.2	1.5	0.2		32	1.4		0.7	1.7
Ta ng	36	16.3	0.5	3.7	3.8		21	1.8		0.2	3.5
Th ng	36	3.7	1.7	2.1	0.4		31	2		24.7	2.4
Zn ng	36	534	71.4	142	80.1		27	110			150
Metals			WEM	AEM	OBM	FMM	MOMEO	REM		TOTAL	
Cu (PPM)		min	0.1	0.6	0.3	0.	1.6	0.7		5.1	

						4					
		max	0.5	1.4	2.4	3.3	5.7	21.9		24.4	
		mean	0.2	1	1	0.9	3.1	8.7		11.9	
		propport.%	1.7	8.4	8.4	8	26	73			
Au (PPB)		min	0.4	0.1	0.1		1.4	0.1		2.1	
		max	2.2	0.6	1.4		3.8	3.7		5.2	
		mean	0.76	0.3	0.82		2.13	1.25		3.4	
		propport.%	22.4	8.8	24.1		62.6	36.7			

n=number of samples, min=minimum value, max=maximum value, SD=standard deviation

Table 3: Regolith Description of Sample Areas

Sample No.	pH Test	Acid test	Colour (Munsell Chart)	Regolith Landform Unit
BLK S005/PLS005	5-5.5	No reaction	2.5 YR Chroma 8 Value 4	IS-Sand dune. Fine red sand well sorted. 5% cobble size ferricrete. Scattered grasses cypress pine (1%).
BLK S006/PLS006	5-5.5	No reaction	2.5 YR Chroma 6-Value 4	CHep-Plain- Well sorted fine red sand. Soil contains blocky peds at 15 cm depth then become finer with depth. Lag is pebble to cobble size quartz and silcrete. Grass plain with Pearl Blue bush >1%, Copperburr >1%.
BLK S007/PLS007	4.5 -5	No reaction	5 YR Chroma 6-Value 5	CHep-Plain-Well sorted red fine sand. Soil contains blocky peds at 15 cm depth then become finer with depth. Lag is cobble to pebble size (mainly cobble)

				quartzite and silcrete. Grassland including Pearl Blue bush >2% and Copperburr >1%.
BLK S008/PL S008	4.5-5	No reaction	2.5 YR Chroma 8- Value 4&5	IS-Sand dune. Well sorted red fine sand. Open Acacia *aneura* Woodland. Acacia approx. 5% of total area. Grasses and Cypress pines (>1%).
BLK S009/PL S009	5 - 5.5	Yes reacted	2.5 YR Chroma 8- Value 4&5	IS-Sand dune. Red fine well sorted sand. Small amount of blocky peds at 15 cm depth. Open Acacia *aneura* Woodland. Acacia covering approx. 5% of total area. Grasses and scattered Cypress pines (>1%).
BLK S010/PL S010	4.5 - 5	No reaction	2.5 YR Chroma 6 Value 4	ISul-Sand dune. Longitudinal dune. Well sorted red fine sand. Acacia *aneura* dominant area approx. 20%. Grassland with scattered Cypress pines (>1%).
BLK S011/PL S011	4.5 - 5	No reaction	2.5 YR Chroma 8 Value 4	ISul-Sand dune. Longitudinal dune. Well sorted red fine sand. Grassland area including Acacia *aneura* approx. 15%. Scattered Cypress pines (>1%).
BLK S012/PL S012	4.5 - 5	No reaction	2.5 YR Chroma 6 Value 4	ISul-Sand dune. Salt Bush and Acacia *aneura* (approx. 10%). Well sorted red fine sand with blocky peds up to approx. 5 cm depth. Scattered Cypress pines (>1%).
BLK S013/PL S013	5 – 5.5	No reaction	2.5 YR Chroma 8 Value 4&5	ISul-Sand dune. Well sorted red fine sand. Salt Bush and Acacia *aneura* (approx. 10%). Black Bluebush approx. 5% of total area. Scattered grasses and Cypress pines (approx. 1% of total area.
BLK S014/PL S014	5 – 5.5	No reaction	2.5 YR Chroma 6 Value 4 & 5	ISul-Sand dune. Salt bush dominant area (approx. 25%), Acacia *aneura* approx. 10% of total area. Well sorted red fine sand. Scattered grasses and Cypress pines approx. 2% of total area.
BLK S015/PL S015	4.5 - 5	No reaction	2.5 YR Chroma 8- Value 4&5	ISul-Sand dune. Well sorted red fine sand, blocky peds measuring up to 5 cm at approx. 12 cm depth. Sand becomes finer with depth. Acacia *aneura* (approx. 5%. Grass plain with scattered Copperburr >1%.
BLK S016/PL S016	4.5 - 5	No reaction	2.5 YR Chroma 6 Value 4	ISul- Sand dune. Flatter area. Well sorted red fine sand. Grasslands including Salt bush (approx. 20%). Cypress pines (approx. 10%), scattered Copperburr and

				Acacia *aneura* (approx. 30%).
BLK S017/PL S017	5	No reaction	2.5 YR Chroma 8 Value 4	ISul- Sand dune. On a slight rise of sand dune. Well sorted red fine sand. Salt bush approx. 30% and Acacia *aneura* (approx. 30%). Grasslands including Cypress pines (approx. 2%).
BLK S018/PL S018	6 – 6.5	No reaction	2.5 YR Chroma 8 Value 4	ISul-Sand dune. On the crest of the sand dune. Well sorted fine red sand. Grasses including Acacia *aneura* approx. 5% of total area. Scattered Salt bush (approx. 15%).
BLK S019/PL S019	5 – 5.5	No reaction	2.5 YR Chroma 8 Value 4	CHep-Plain. Well sorted fine red sand with large blocky peds (measuring up to 7 cm at approx. 14 cm depth). Quartzite (approx. 10% of: pebbles, cobbles and small amount of boulders). Grasslands including Salt bush (approx. 20% 0f total area) and Acacia *aneura* (approx. 1%).
BLK S020/PL S020	5 – 5.5	No reaction	2.5 YR Chroma 6 Value 5	ISul-Sand dune. Well sorted fine red sand with blocky peds measuring up to 8 cm at approx. 10 cm depth. Sand becomes finer with depth. Grasslands including scatters Salt bush, Acacia *aneura* (approx. 10% of total area).
BLK S021/PL S021	5 – 5.5	No reaction	2.5 YR Chroma 8 Value 4	IS-Sand dune. Area is a plain consisting of grasses including scattered Salt bush (approx. 2%), Cypress pines (approx. 1%) and Acacia *aneura* (approx. 2% of the total area. Well sorted fine red sand.
BLK S022/PL S022	4.5 - 5	Yes Reaction	2.5 YR Chroma 8 Value 4 & 5	IS-Sand dune. At the edge of the Plainand at the Crest of the sand dune. Well sorted fine red sand. Grasslands including Salt bush (approx. 15%), Copperburr (approx. 1%) and acacia *aneura* (approx. 2% of the total area).

Table 4: Summary of Vegetation, Bulk Analysis and Partial Leach Samples (all elements are PPM unless indicated)

Vegetation Samples Results Summarized

Element	Mo	Cu	Pb	Zn	Ag (PPB)	Ni	Co
Minimum	0.30	1.84	0.05	4.9	2	0.1	0.03
Maximum	10.77	18.26	8.58	22.8	11	2.2	0.44
Average	4.08	4.61	0.87	11.34	6.17	0.69	0.15
Standard Deviation	3.32	3.68	2.14	4.59	3.76	0.71	0.10

Element	Mn	Fe (%)	U	Au (PPB)	Th	Sr	Sb	Ca (%)
Minimum	9	0.002	0.01	0.2	0.03	17.3	0.02	0.46
Maximum	186	0.05	0.04	1.3	0.07	1247.2	0.26	6.83
Average	38.9	0.01	0.03	0.57	0.05	563.46	0.11	4.42
Standard Deviation	47.14	0.01	0.015	0.45	0.02	384.99	0.13	2.39

Element	La	Cr	Mg (%)	Ba	Al (%)	Na (%)
Minimum	0.01	1.0	0.14	3.6	0.01	0.01
Maximum	0.31	2.6	0.53	132.3	0.03	9.65
Average	0.05	1.42	0.38	66.62	0.02	1.54
Standard Deviation	0.07	0.41	0.09	43.26	0.01	0.43

Element	Sc	Hg (PPB)	Hf	Zr	Ce
Minimum	0.01	2	0.001	0.01	0.03
Maximum	0.9	52	0.02	0.22	0.46
Average	0.21	10.25	0.00	0.06	0.10
Standard Deviation	0.25	11.73	0.01	0.06	0.11

Bulk Samples Summarized

Element	Mo	Cu	Pb	Zn	Ag (PPB)	Ni	Co	Mn	Fe (%)
Minimum	2	3.5	4.5	10.5	100	3	1.2	77.46	0.64
Maximum	3	31	145	405	400	14	6.5	232.38	2.17
Average	2.14	9.94	18	52.11	212.50	6.06	2.79	139.43	1.15
Standard Deviation	0.38	7.50	33.79	90.63	99.10	3.51	1.84	71.18	0.50

Element	U	Au (PPB)	Th	Sr	Sb	Ca (%)	La	Cr	Mg (%)
Minimum	0.5	1	1.5	15	N/A	0.04	3	100	0.05
Maximum	1	2	5.5	90	N/A	1.21	14	155	0.79
Average	0.82	1.29	3.11	34.44	N/A	0.22	7.06	126.11	0.20
Standard Deviation	0.25	0.49	1.29	19.40	N/A	0.29	3.59	16.94	0.21

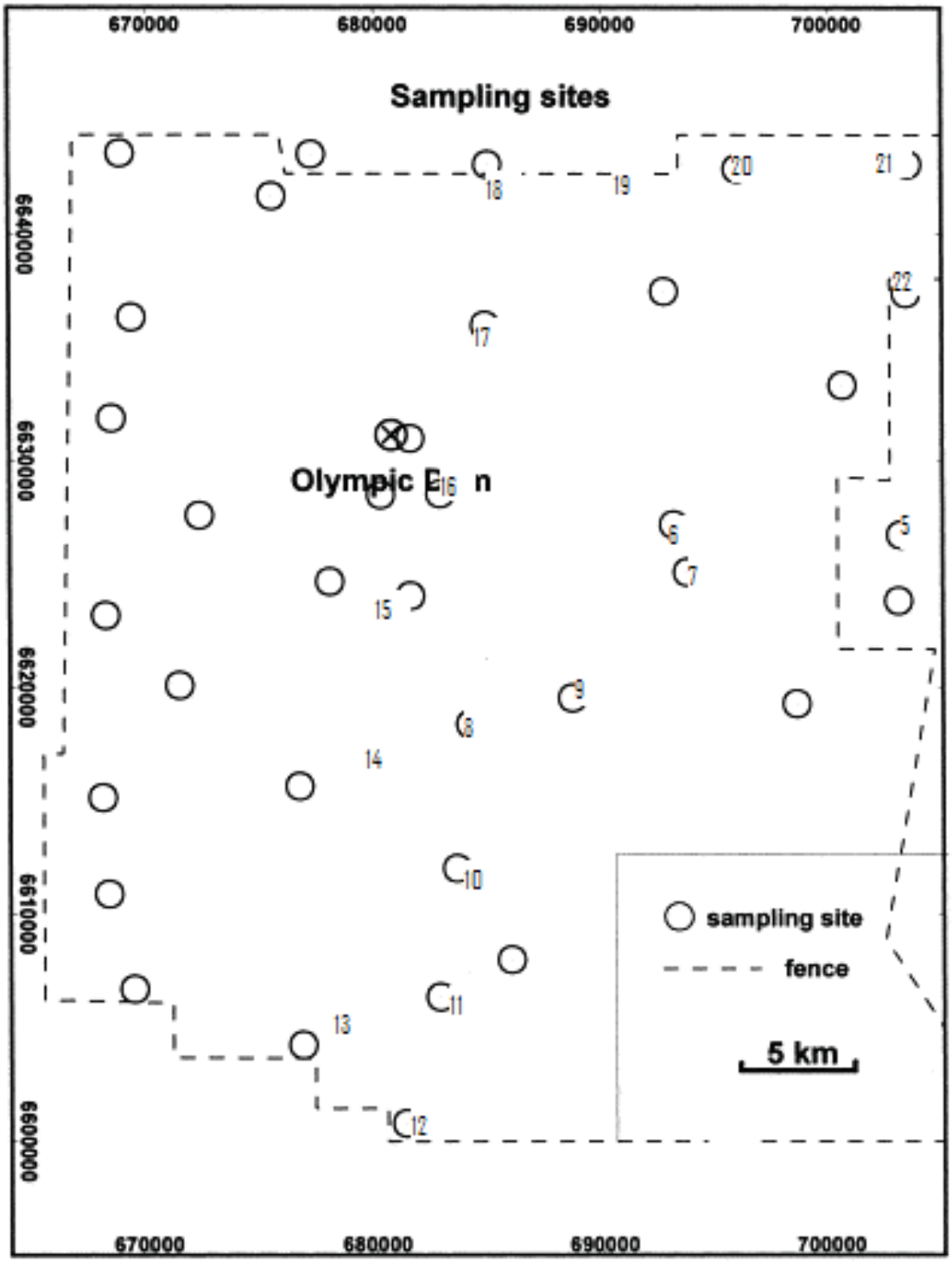
Element	Ba	Al (%)	Na (%)	Sc	Hg (PPB)	Hf	Zr	Ce
Minimum	155	0.75	0.01	5	N/A	2	70	5
Maximum	390	3.74	0.15	5	N/A	12	500	29
Average	231.67	1.71	0.05	5	N/A	6.28	250.83	13.28
Standard deviation	67.67	1.02	0.04	0	N/A	2.63	108.32	7.60

Partial Leach Results Summarized

Element	Mo	Cu	Pb	Zn	Ag (PPB)	Ni	Co	As
Minimum	0.002	0.37	0.013	0.06	6	0.08	0.09	0.02
Maximum	0.03	4.8	0.18	1.39	6	0.52	0.51	0.63
Average	0.01	1.77	0.06	0.39	6	0.23	0.25	0.22
Standard Deviation	0.01	1.37	0.06	0.35	N/A	0.13	0.13	0.01

Element	U	Au (PPB)	Th	Cd	Sb	Bi	Se	Te	Si (%)
Minimum	0.003	0.09	0.004	0.005	0.002	0.0002	2.3	1	4.83
Maximum	0.05	0.64	0.39	0.02	0.006	0.004	42	8	5.16
Average	0.02	0.28	0.10	0.01	0	0	18.26	3.66	4.98
Standard Deviation	0.01	0.24	0.11	0.004	0.001	0.001	10.53	0.08	0.08

Figure. 1 Sampling Spots of This Study in Comparison to the Study Conducted By Wang et. Al. (1999)



Appendix. 1 Compiled Vegetation, Partial Leach and Bulk Analysis Samples

Sample	Eastings	Northings	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppb	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppb
VEGA005	**704455**	**6627013**	0.45	4.78	4.01	12.1		1.4		47	0.005	0.3		
VEGA006	**693588**	**6626785**	0.66	6.66	0.96	6.8	7	1.1	0.25	139	0.022			
VEGA007	**694346**	**6625914**	0.30	18.26	8.58	22.8	10	2.2	0.08	186	0.047	2.3	0.04	1.3
VEGA008	**684645**	**6618593**	0.67	1.84	0.08	9.4	4	0.2	0.03	37	0.002			
VEGA009	**688783**	**6620413**	0.48	4.30	0.93	4.9	11	0.6	0.14	26	0.008			
VEGA010	**683715**	**6612548**	2.66	3.19	0.08	17.3			0.08	13	0.003			
VEGA011	**682975**	**6606283**	6.81	2.85	0.07	9.6		0.3	0.12	13				
VEGA012	**681228**	**6600549**	2.57	4.13	0.10	12.8			0.25	20	0.004			0.2
VEGA013	**678873**	**6605314**	2.70	2.44	0.07	12.3			0.17	16	0.005			
VEGA014	**680236**	**6617992**	8.62	4.39	0.08	9.9			0.44	10	0.005		0.02	0.4
VEGA015	**681665**	**6623910**	5.11	3.12	0.17	8.6			0.14	24	0.007		0.02	0.3
VEGA016	**682934**	**6628242**	8.25	6.12	0.10	11.0			0.20	22	0.011		0.02	
VEGA017	**685087**	**6636545**	3.34	5.35	0.06	12.9	2		0.25	26	0.004		0.04	1.0
VEGA018	**685393**	**6643465**	4.46	3.71	0.05	12.5			0.05	9	0.002	0.3	0.01	0.2
VEGA019	**689479**	**6643424**	10.77	3.14	0.09	11.2		0.1	0.13	45	0.005			
VEGA020	**696503**	**6643385**	8.19	2.07	0.08	10.5		0.2	0.06	26	0.004			
VEGA021	**703548**	**6643208**	2.37	4.34	0.06	8.8	3	0.1	0.03	14	0.006	0.2		
VEGA022	**702944**	**6637759**	5.00	2.33	0.10	10.7			0.05	18	0.005			

Sample	Eastings	Northings	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm
VEGA005	**704455**	**6627013**	0.03	23.5	0.01		0.06	3	0.49	0.061	0.06	1.0	0.399	3.6
VEGA006	**693588**	**6626785**	0.05	43.3	0.07		0.02		0.70	0.064	0.12	1.7	0.362	17.3
VEGA007	**694346**	**6625914**	0.07	17.3	0.34	0.26	0.11	4	0.46	0.095	0.31	2.3	0.308	14.3
VEGA008	**684645**	**6618593**		194.6					1.82	0.161	0.02	1.2	0.138	17.8
VEGA009	**688783**	**6620413**	0.05	26.9	0.07	0.06		2	0.46	0.073	0.03	2.6	0.402	7.8
VEGA010	**683715**	**6612548**		1247.2					6.83	0.063	0.03	1.3	0.423	132.3
VEGA011	**682975**	**6606283**		1167.6					6.61	0.061	0.02	1.1	0.432	79.3
VEGA012	**681228**	**6600549**		816.8	0.01				5.94	0.073	0.02	1.3	0.533	104.8
VEGA013	**678873**	**6605314**		844.5					6.09	0.068	0.03	1.4	0.344	57.5
VEGA014	**680236**	**6617992**		964.7					6.02	0.067	0.02	1.4	0.387	106.4
VEGA015	**681665**	**6623910**		509.7					4.95	0.058	0.05	1.2	0.345	94.2
VEGA016	**682934**	**6628242**		819.8					6.15	0.092	0.04	1.4	0.363	91.4
VEGA017	**685087**	**6636545**		480.4					5.96	0.056	0.04	1.2	0.400	111.4
VEGA018	**685393**	**6643465**		598.2					5.26	0.066	0.03	1.3	0.405	105.9
VEGA019	**689479**	**6643424**		585.8					5.35	0.073	0.03	1.3	0.294	46.3
VEGA020	**696503**	**6643385**		510.3					6.05	0.091	0.04	1.4	0.370	117.2
VEGA021	**703548**	**6643208**		595.5		0.02			4.95	0.055	0.01	1.2	0.526	30.5
VEGA022	**702944**	**6637759**		696.1					5.49	0.066	0.02	1.2	0.455	61.1

Sample	Eastings	Northings	Ti ppm	B ppm	Al %	Na %	K %	Sc ppm	Tl ppm	S %	Hg ppb	Se ppm	Te ppm	Ga ppm
VEGA005	**704455**	**6627013**	5	39	0.01	7.542	1.70		0.02	0.02			0.07	
VEGA006	**693588**	**6626785**	5	28	0.02	>10.000	0.87	0.2	0.03	0.22	8	0.8		
VEGA007	**694346**	**6625914**	9	25	0.03	7.882	1.87	0.9	0.07	0.16	52	1.7	0.12	
VEGA008	**684645**	**6618593**	5	44		0.013	1.36	0.2		0.17	16	0.5		
VEGA009	**688783**	**6620413**	6	48	0.02	9.653	1.50	0.1		0.13		3.7	0.11	
VEGA010	**683715**	**6612548**	2	87		0.080	0.85			3.46	3	1.7		
VEGA011	**682975**	**6606283**	2	82		0.144	0.47	0.2		3.15	9	0.7	0.04	
VEGA012	**681228**	**6600549**	2	146		0.072	0.42			2.70	8	1.2		
VEGA013	**678873**	**6605314**	2	106		0.073	0.90			3.14	8	0.9	0.03	
VEGA014	**680236**	**6617992**	2	125		0.052	0.79	0.1		3.52	10	2.2		
VEGA015	**681665**	**6623910**	2	80		0.056	0.68			2.47	3	2.3		
VEGA016	**682934**	**6628242**	3	68		0.127	0.90	0.1		3.44	11	1.0		
VEGA017	**685087**	**6636545**	2	72		0.025	0.49			2.87	12	0.7		
VEGA018	**685393**	**6643465**	2	125		0.038	0.77			2.90	2	0.6	0.02	
VEGA019	**689479**	**6643424**	2	78		0.070	0.70			2.79	7	1.2		
VEGA020	**696503**	**6643385**	3	104		0.093	0.55	0.1		2.65	6	2.1		
VEGA021	**703548**	**6643208**	2	117		0.154	0.79	0.1		3.06	5	0.4		
VEGA022	**702944**	**6637759**	2	81		0.158	0.58	0.1		2.92	4	0.6		

Sample	Eastings	Northings	Cs ppm	Ge ppm	Hf ppm	Rb ppm	Zr ppm	Y ppm	Ce ppm	Re ppb	Li ppm			
VEGA005	**704455**	**6627013**	0.028	0.07	0.001	9.0	0.22		0.16	8	1.09			
VEGA006	**693588**	**6626785**	0.053	0.03	0.013	11.5	0.18	0.097	0.29	28	1.03			
VEGA007	**694346**	**6625914**	0.192	0.03	0.015	23.2	0.17	0.262	0.46	21	2.80			
VEGA008	**684645**	**6618593**	0.014			3.0	0.03	0.012	0.05	7	0.49			
VEGA009	**688783**	**6620413**	0.022	0.16		9.0	0.11		0.13	16	0.91			
VEGA010	**683715**	**6612548**	0.005	0.03		1.9	0.02	0.025	0.04	11	1.61			
VEGA011	**682975**	**6606283**	0.008		0.001	1.2	0.03	0.019	0.03	2	1.06			
VEGA012	**681228**	**6600549**	0.008			1.2	0.03	0.021	0.04	3	1.97			
VEGA013	**678873**	**6605314**	0.010		0.001	1.8	0.01	0.031	0.04	4	1.58			
VEGA014	**680236**	**6617992**	0.006		0.004	1.6	0.03	0.017	0.04	4	1.49			
VEGA015	**681665**	**6623910**	0.019	0.02	0.001	2.3	0.05	0.019	0.08	7	0.80			
VEGA016	**682934**	**6628242**	0.009		0.003	2.4	0.04	0.024	0.07	8	0.98			
VEGA017	**685087**	**6636545**	0.012			1.3	0.04	0.021	0.10	9	0.40			
VEGA018	**685393**	**6643465**	0.020	0.01		2.5	0.01	0.016	0.04	1	0.92			
VEGA019	**689479**	**6643424**	0.005		0.001	2.1	0.03	0.020	0.04	2	0.78			
VEGA020	**696503**	**6643385**	0.024		0.003	1.7	0.02	0.033	0.06	6	0.56			
VEGA021	**703548**	**6643208**	0.019	0.02		1.7	0.02	0.013	0.03	5	0.91			
VEGA022	**702944**	**6637759**	0.015			1.8	0.04	0.033	0.05	9	1.85			

Sample	Eastings	Northings	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppb	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppb
PLS005	**704455**	**6627013**	0.0027	0.486		0.118		0.097	0.144			0.161	0.0031	0.22
PLS006	**693588**	**6626785**	0.0053	4.14		0.143	6	0.393	0.163			0.633	0.015	0.64
PLS007	**694346**	**6625914**	0.008	4.8		0.361		0.425	0.304			0.299	0.01	0.09
PLS008	**684645**	**6618593**	0.0052	1.68		0.312		0.141	0.32			0.045	0.012	
PLS009	**688783**	**6620413**	0.0024	1.38		0.138		0.171	0.169			0.405	0.031	
PLS010	**683715**	**6612548**	0.029	1.93	0.183	1.39		0.336	0.436			0.172	0.045	
PLS011	**682975**	**6606283**	0.0054	0.369		0.057		0.083	0.099			0.14	0.0076	
PLS012	**681228**	**6600549**	0.0029	0.954		0.302		0.218	0.227			0.123	0.0096	
PLS013	**678873**	**6605314**	0.018	1.27	0.059	0.404		0.26	0.429			0.226	0.02	
PLS014	**680236**	**6617992**	0.023	2.43	0.039	0.69		0.306	0.514			0.314	0.024	
PLS015	**681665**	**6623910**	0.025	4.27	0.024	0.899		0.322	0.307			0.145	0.035	
PLS016	**682934**	**6628242**	0.01	1.1	0.04	0.379		0.178	0.235			0.238	0.016	
PLS017	**685087**	**6636545**	0.0043	1.93		0.248		0.126	0.2			0.215	0.012	0.18
PLS018	**685393**	**6643465**	0.0055	0.734	0.013	0.181		0.142	0.123			0.022	0.012	
PLS019	**689479**	**6643424**	0.0043	0.45	0.034	0.336		0.114	0.093			0.185	0.0097	
PLS020	**696503**	**6643385**	0.0082	2.44	0.106	0.847		0.522	0.475			0.262	0.054	
PLS021	**703548**	**6643208**	0.011	0.721		0.144		0.108	0.154			0.238	0.013	
PLS022	**702944**	**6637759**	0.0093	0.722		0.083		0.131	0.163			0.149	0.0092	

Sample	Eastings	Northings	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	Se ppm	Te ppm	Si %
PL S005	**704455**	**6627013**	0.03		0.005		0.0002	2.3		5.007013
PL S006	**693588**	**6626785**	0.0039		0.0067		0.0007	42		5.16129
PL S007	**694346**	**6625914**	0.036		0.011	0.0017	0.0012	26		5.021038
PL S008	**684645**	**6618593**	0.03		0.0076		0.0012	10		4.978962
PL S009	**688783**	**6620413**	0.012		0.0062	0.00170	0.0011	23		5.15194
PL S010	**683715**	**6612548**	0.331		0.016	0.00160	0.0028	19	2.2	4.88546
PL S011	**682975**	**6606283**	0.06		0.0059	0.00180	0.0017	21	1.7	4.969612
PL S012	**681228**	**6600549**	0.058		0.0082		0.0018	8.3		4.955587
PL S013	**678873**	**6605314**	0.178		0.012	0.0019	0.0023	29		4.936886
PL S014	**680236**	**6617992**	0.172		0.015	0.0028	0.0027	23		4.913511
PL S015	**681665**	**6623910**	0.109		0.024	0.0042	0.0027	4.1		4.941561
PL S016	**682934**	**6628242**	0.098		0.0095	0.0041	0.0035	14		5.035063
PL S017	**685087**	**6636545**	0.025		0.012	0.003	0.0029	12	1	4.983637
PL S018	**685393**	**6643465**	0.058		0.0071	0.0034	0.0034	12		4.983637
PL S019	**689479**	**6643424**	0.076		0.0076	0.0036	0.0042	11		4.969612
PL S020	**696503**	**6643385**	0.392		0.013	0.0057	0.0041	25	8	4.82936
PL S021	**703548**	**6643208**	0.043		0.008	0.005	0.0036	13		5.002338
PL S022	**702944**	**6637759**	0.042		0.0099	0.0051	0.0036	34	5.4	4.960262

Sample	Eastings	Northings	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppb	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppb
BLKS005	**704455**	**6627013**		7.5	55	405	200.000	3	1.4		0.65035	1.5		2
BLKS006	**693588**	**6626785**	2	24	145	65	400.000	14	6.5	232.378	2.146853	6.5	1	2
BLKS007	**694346**	**6625914**	2	17.5	19.5	95	200.000	13	6.5	232.378	2.167832	5	1	1
BLKS008	**684645**	**6618593**		6.5	11.5	47	100.000	5	2.2	77.45933	1.027972	2.5	0.5	1
BLKS009	**688783**	**6620413**		6	9.5	37.5	200.000	6	2.4	77.45933	1.13986	3.5	0.5	1
BLKS010	**683715**	**6612548**		7	9	35		6	2.6	77.45933	1.188811	3	0.5	
BLKS011	**682975**	**6606283**		4	6	22		3	1.2		0.699301	2		
BLKS012	**681228**	**6600549**		6	6	20		4	1.6		0.839161	2		
BLKS013	**678873**	**6605314**	2	8	8	24		5	2.2	77.45933	1.020979	2	1	1
BLKS014	**680236**	**6617992**	3	9	7.5	29	100	6	2.8	154.9187	1.244755	2.5	1	
BLKS015	**681665**	**6623910**		14.5	9.5	38.5	200	10	5.5	232.378	1.727273	2.5	1	
BLKS016	**682934**	**6628242**		6	5.5	17		4	1.8		0.881119	2	1	1
BLKS017	**685087**	**6636545**		7	6	19.5		5	2.2	77.45933	1.062937	2.5	0.5	
BLKS018	**685393**	**6643465**		4	4.5	12.5		3	1.6		0.762238	2.5	1	
BLKS019	**689479**	**6643424**	2	3.5	4	10.5		3	1.2		0.636364	1.5	0.5	
BLKS020	**696503**	**6643385**	2	13	9	37.5	300.000	11	5.5	154.9187	1.874126	3	1	
BLKS021	**703548**	**6643208**		31	4	11		4	1.4		0.755245	2		
BLKS022	**702944**	**6637759**	2	4.5	4.5	12		4	1.6		0.818182	2	1	

Sample	Eastings	Northings	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm
BLKS005	**704455**	**6627013**	1.5	20	1.3		0.2		0.107219	0.00873	3	140	0.066345	250
BLKS006	**693588**	**6626785**	5.5	90	0.2		0.6	80	1.208006	0.021825	14	115	0.669481	390
BLKS007	**694346**	**6625914**	5	60	0.3		0.2	70	0.543245	0.026189	13	135	0.778046	390
BLKS008	**684645**	**6618593**	3	25	0.4		0.2	30	0.164403	0.00873	7	110	0.17491	190
BLKS009	**688783**	**6620413**	3	40	0.1		0.1	45	0.571837	0.00873	6	115	0.193004	270
BLKS010	**683715**	**6612548**	3.5	30	0.1		0.1	35	0.114367	0.013095	7	140	0.126659	180
BLKS011	**682975**	**6606283**	1.5	15				20	0.050036	0.00873	3	105	0.054282	155
BLKS012	**681228**	**6600549**	2	20			0.1	25	0.078628	0.013095	4	110	0.102533	165
BLKS013	**678873**	**6605314**	2.5	25	0.1		0.1	30	0.121515	0.00873	6	150	0.108565	175
BLKS014	**680236**	**6617992**	4	35	0.1		0.1	40	0.150107	0.013095	8	155	0.162847	210
BLKS015	**681665**	**6623910**	5	45	0.2		0.2	45	0.214439	0.026189	11	100	0.3076	225
BLKS016	**682934**	**6628242**	3	25			0.1	25	0.07148	0.013095	5	115	0.084439	170
BLKS017	**685087**	**6636545**	3	30			0.1	30	0.200143	0.00873	7	135	0.144753	205
BLKS018	**685393**	**6643465**	2.5	25				25	0.064332	0.00873	5	105	0.072376	245
BLKS019	**689479**	**6643424**	2	25					0.03574	0.00873	5	125	0.054282	270
BLKS020	**696503**	**6643385**	5	65	0.1		0.1	55	0.150107	0.01746	14	140	0.319662	255
BLKS021	**703548**	**6643208**	2	20			0.1	20	0.078628	0.00873	4	140	0.072376	215
BLKS022	**702944**	**6637759**	2	25				25	0.064332	0.00873	5	135	0.096502	210

Sample	Eastings	Northings	Ti ppm	B ppm	Al %	Na %	K %	Sc ppm	Tl ppm	S %	Hg ppb	Se ppm	Te ppm	Ga ppm
BLKS005	**704455**	**6627013**	5	39	0.01	7.542	1.70		0.02	0.02			0.07	
BLKS006	**693588**	**6626785**	5	28	0.02	>10.000	0.87	0.2	0.03	0.22	8	0.8		
BLKS007	**694346**	**6625914**	9	25	0.03	7.882	1.87	0.9	0.07	0.16	52	1.7	0.12	
BLKS008	**684645**	**6618593**	5	44		0.013	1.36	0.2		0.17	16	0.5		
BLKS009	**688783**	**6620413**	6	48	0.02	9.653	1.50	0.1		0.13		3.7	0.11	
BLKS010	**683715**	**6612548**	2	87		0.080	0.85			3.46	3	1.7		
BLKS011	**682975**	**6606283**	2	82		0.144	0.47	0.2		3.15	9	0.7	0.04	
BLKS012	**681228**	**6600549**	2	146		0.072	0.42			2.70	8	1.2		
BLKS013	**678873**	**6605314**	2	106		0.073	0.90			3.14	8	0.9	0.03	
BLKS014	**680236**	**6617992**	2	125		0.052	0.79	0.1		3.52	10	2.2		
BLKS015	**681665**	**6623910**	2	80		0.056	0.68			2.47	3	2.3		
BLKS016	**682934**	**6628242**	3	68		0.127	0.90	0.1		3.44	11	1.0		
BLKS017	**685087**	**6636545**	2	72		0.025	0.49			2.87	12	0.7		
BLKS018	**685393**	**6643465**	2	125		0.038	0.77			2.90	2	0.6	0.02	
BLKS019	**689479**	**6643424**	2	78		0.070	0.70			2.79	7	1.2		
BLKS020	**696503**	**6643385**	3	104		0.093	0.55	0.1		2.65	6	2.1		
BLKS021	**703548**	**6643208**	2	117		0.154	0.79	0.1		3.06	5	0.4		
BLKS022	**702944**	**6637759**	2	81		0.158	0.58	0.1		2.92	4	0.6		

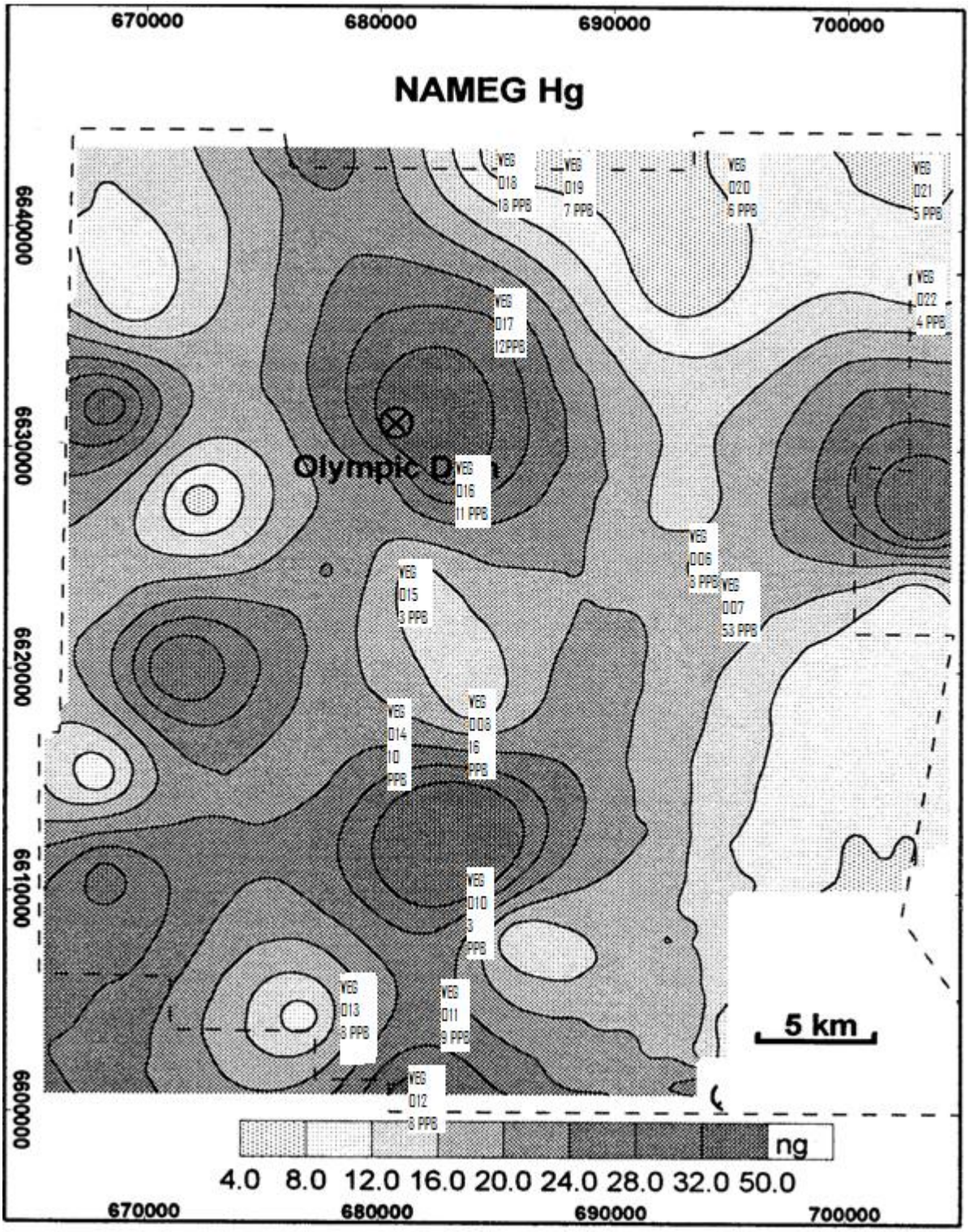
Sample	Eastings	Northings	Ti ppm	B ppm	Al %	Na %	K %	Sc ppm	Tl ppm
BLK S005	**704455**	**6627013**	0.071942		0.75172	0.029674	0.174274		0.1
BLK S006	**693588**	**6626785**	0.248801		3.737427	0.148368	0.647303	5	0.4
BLK S007	**694346**	**6625914**	0.245803		3.642139	0.103858	0.746888	5	0.3
BLK S008	**684645**	**6618593**	0.143885		1.434621	0.04451	0.340249		0.2
BLK S009	**688783**	**6620413**	0.161871		1.646374	0.051929	0.348548		0.1
BLK S010	**683715**	**6612548**	0.164868		1.709899	0.051929	0.373444		0.1
BLK S011	**682975**	**6606283**	0.068945		0.857597	0.014837	0.149378		
BLK S012	**681228**	**6600549**	0.110911		1.180519	0.029674	0.282158		
BLK S013	**678873**	**6605314**	0.131894		1.381683	0.029674	0.298755		
BLK S014	**680236**	**6617992**	0.14988		1.789307	0.066766	0.431535		0.1
BLK S015	**681665**	**6623910**	0.233813		2.959238	0.096439	0.713693	5	0.2
BLK S016	**682934**	**6628242**	0.125899		1.1964	0.037092	0.273859		
BLK S017	**685087**	**6636545**	0.134892		1.476972	0.04451	0.33195		
BLK S018	**685393**	**6643465**	0.140887		0.889359	0.029674	0.215768		
BLK S019	**689479**	**6643424**	0.089928		0.788777	0.022255	0.190871		
BLK S020	**696503**	**6643385**	0.260791		3.499206	0.111276	0.705394	5	0.2
BLK S021	**703548**	**6643208**	0.080935		0.878772	0.022255	0.207469		
BLK S022	**702944**	**6637759**	0.113909		0.963473	0.037092	0.257261		

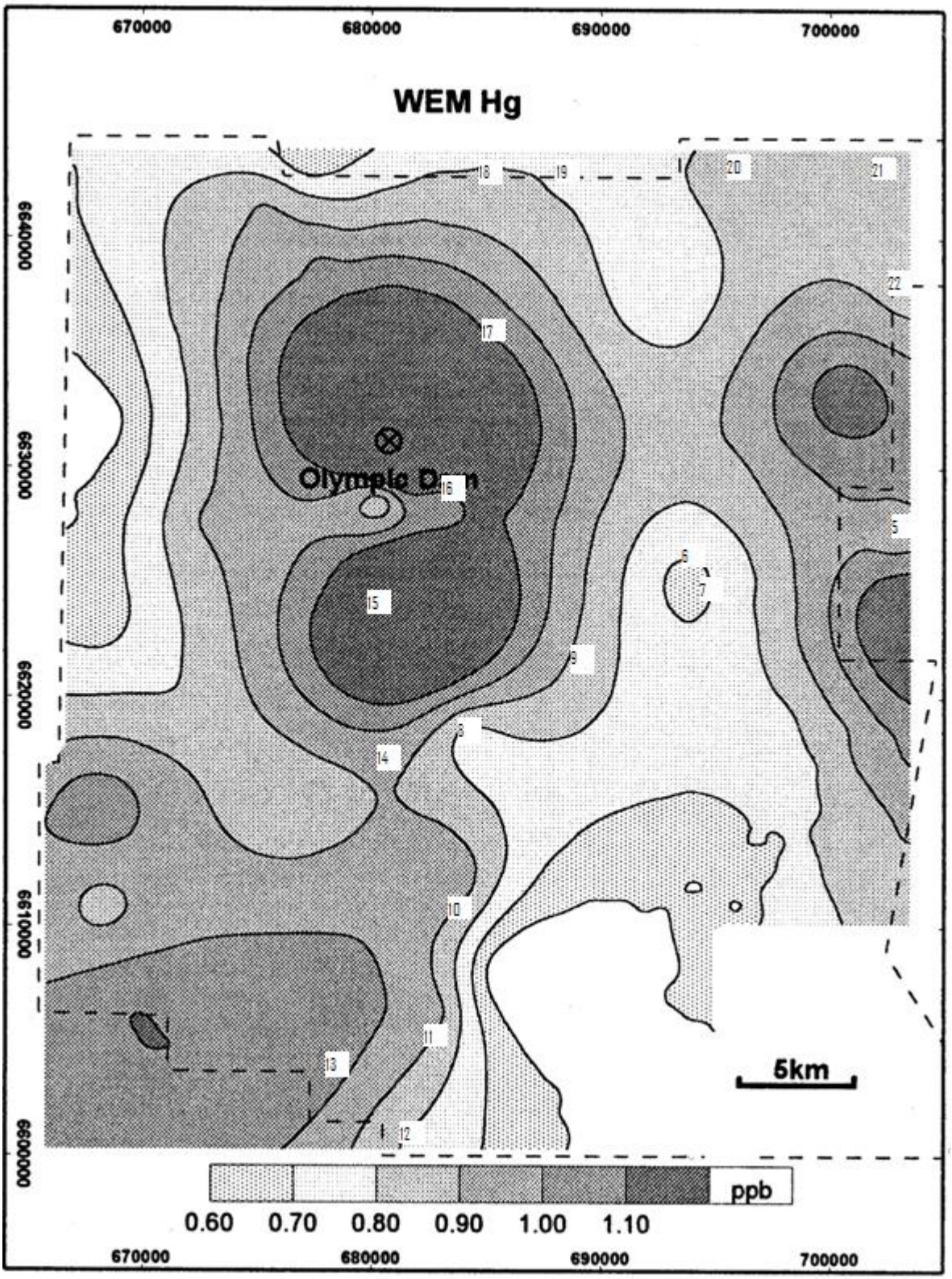
Sample	Eastings	Northings	Se ppm	Ga ppm	Cs ppm	Hf ppm	Rb ppm	Zr ppm	Y ppm	Ce ppm
BLK S005	**704455**	**6627013**		1.4	0.5	5	7.5	190	2	6
BLK S006	**693588**	**6626785**		7.5	2.6	8	33	315	13	29
BLK S007	**694346**	**6625914**		7.5	2.5	8	31.5	325	12	25
BLK S008	**684645**	**6618593**		3	1	8	15.5	340	6	13
BLK S009	**688783**	**6620413**		3.3	1.1	6	16.5	250	6	12
BLK S010	**683715**	**6612548**		3.2	1.1	6	18	215	6	13
BLK S011	**682975**	**6606283**		1.5	0.5	2	7	70	2	5
BLK S012	**681228**	**6600549**		2.3	0.8	3	11	115	4	7
BLK S013	**678873**	**6605314**		2.7	0.9	4	13.5	165	5	10
BLK S014	**680236**	**6617992**		3.6	1.1	7	20	270	7	16
BLK S015	**681665**	**6623910**		6	2	9	30.5	350	11	23
BLK S016	**682934**	**6628242**		2.4	0.8	9	11.5	340	5	9
BLK S017	**685087**	**6636545**		2.8	1	3	15	140	6	12
BLK S018	**685393**	**6643465**		1.9	0.6	12	10	500	5	8
BLK S019	**689479**	**6643424**		1.5	0.5	4	10	170	4	8
BLK S020	**696503**	**6643385**	0.5	7	2.1	7	31.5	305	11	27
BLK S021	**703548**	**6643208**		1.7	0.7	4	8	140	3	7
BLK S022	**702944**	**6637759**		1.9	0.7	8	11.5	315	4	9

Sample	Eastings	Northings	Si %	Dy ppm	Gd ppm	Nd ppm	Pr ppm	Sm ppm
BLK S005	**704455**	**6627013**	44.78728			3		0.5
BLK S006	**693588**	**6626785**	34.78261	2.5	3	15	4	3
BLK S007	**694346**	**6625914**	35.99813	2.5	3	13	4	3
BLK S008	**684645**	**6618593**	42.26274	1		5.5	2	1
BLK S009	**688783**	**6620413**	42.49649	1	1	6	2	1
BLK S010	**683715**	**6612548**	42.54324	1	1	6	2	1
BLK S011	**682975**	**6606283**	45.16129			2.5		
BLK S012	**681228**	**6600549**	43.57176	0.5		4	1	0.5
BLK S013	**678873**	**6605314**	42.8705	1	1	5	1	1
BLK S014	**680236**	**6617992**	42.26274	1	1	7	2	1
BLK S015	**681665**	**6623910**	39.17719	2	3	12	3	2.5
BLK S016	**682934**	**6628242**	43.89902	0.5		5	1	1
BLK S017	**685087**	**6636545**	42.40299	1	1	6	2	1
BLK S018	**685393**	**6643465**	44.46003	0.5		4	1	1
BLK S019	**689479**	**6643424**	45.16129	0.5		3.5		0.5
BLK S020	**696503**	**6643385**	38.99018	2	2	11.5	3	2.5
BLK S021	**703548**	**6643208**	44.17952	0.5		3		0.5
BLK S022	**702944**	**6637759**	43.71201	1		4	1	1

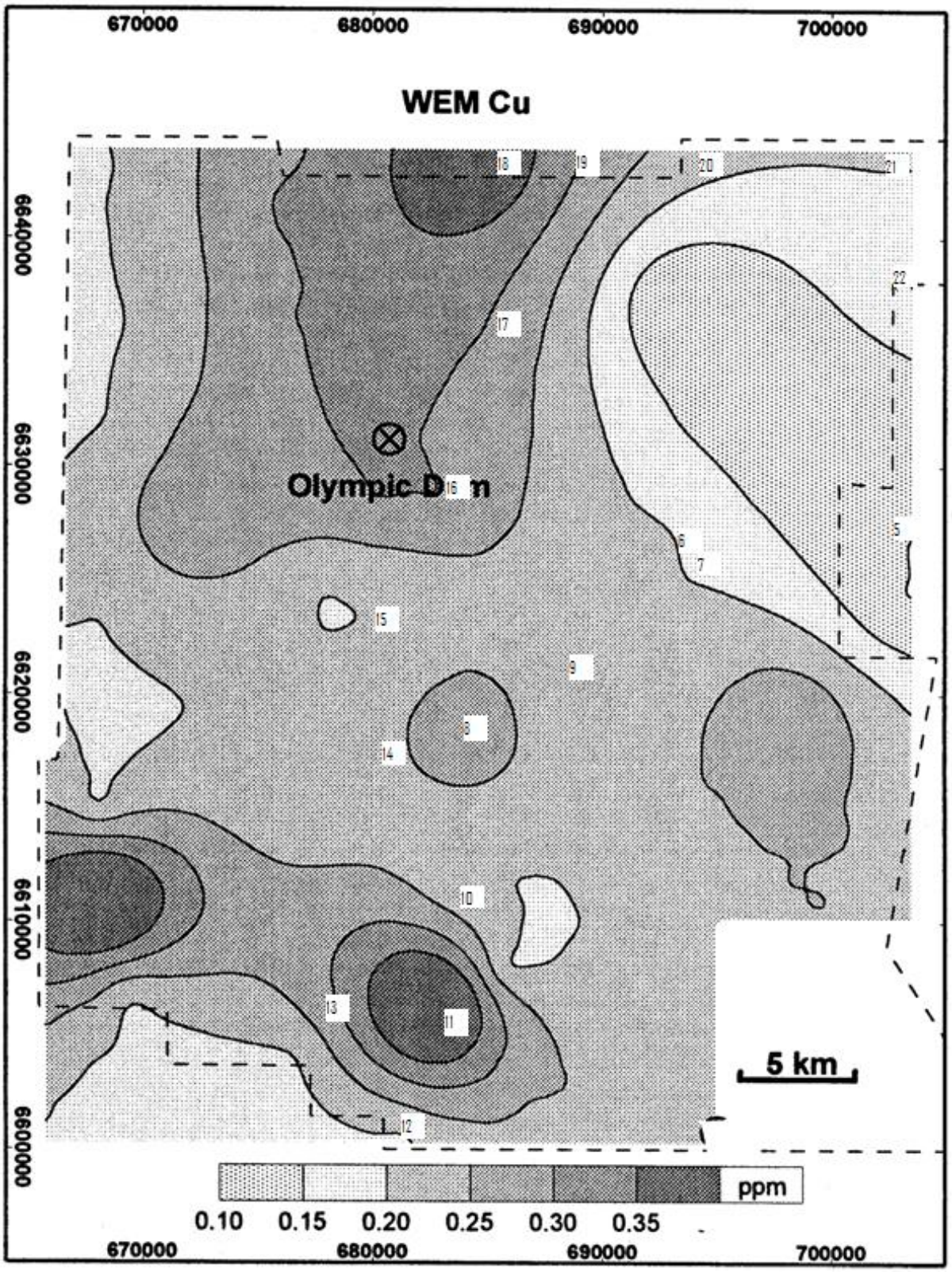
Appendix. 2 (for element concentrations from this study refer to Appendix. 1)

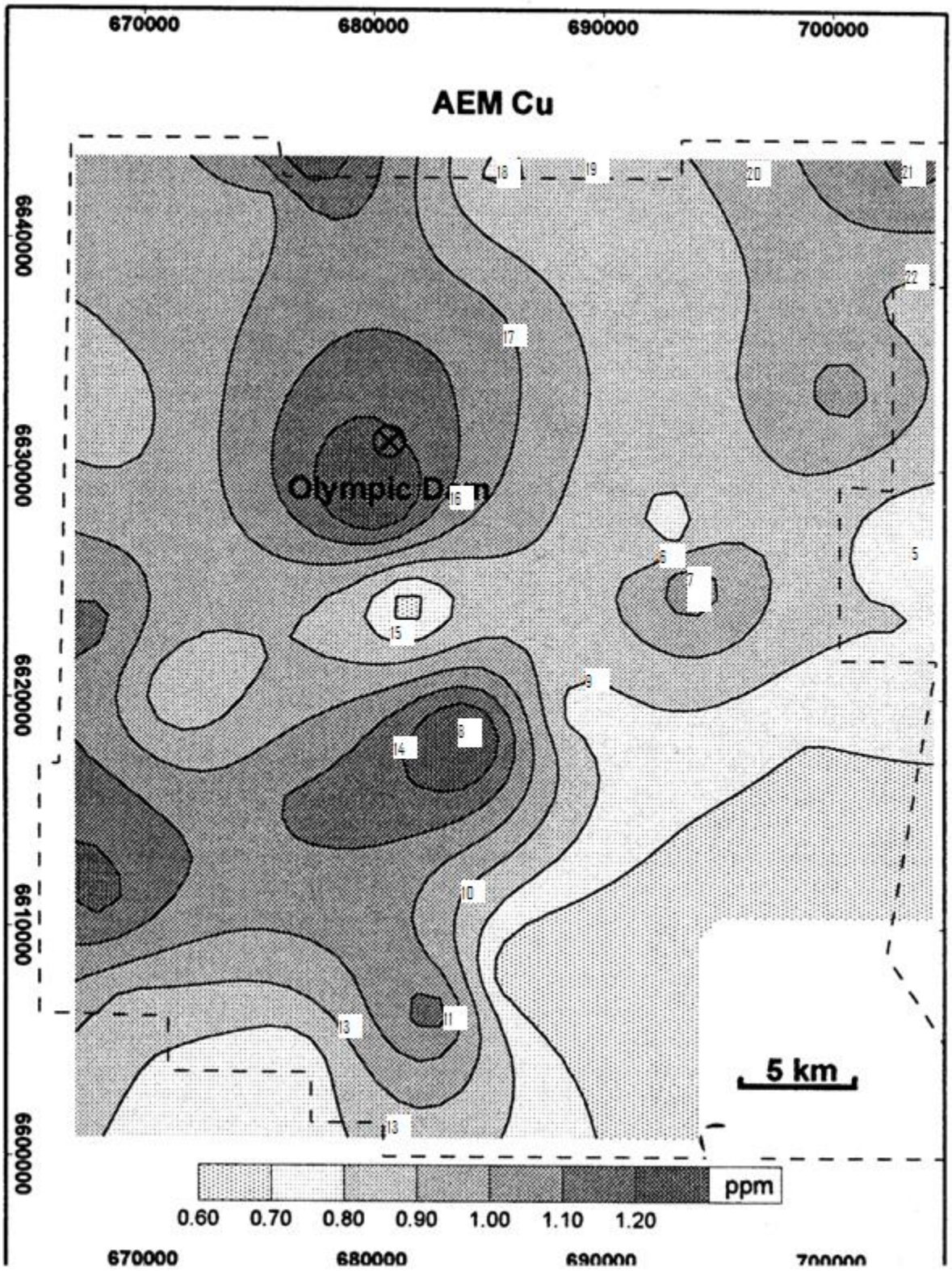
The following element patterns are from the study conducted by Wang et al. (1999)

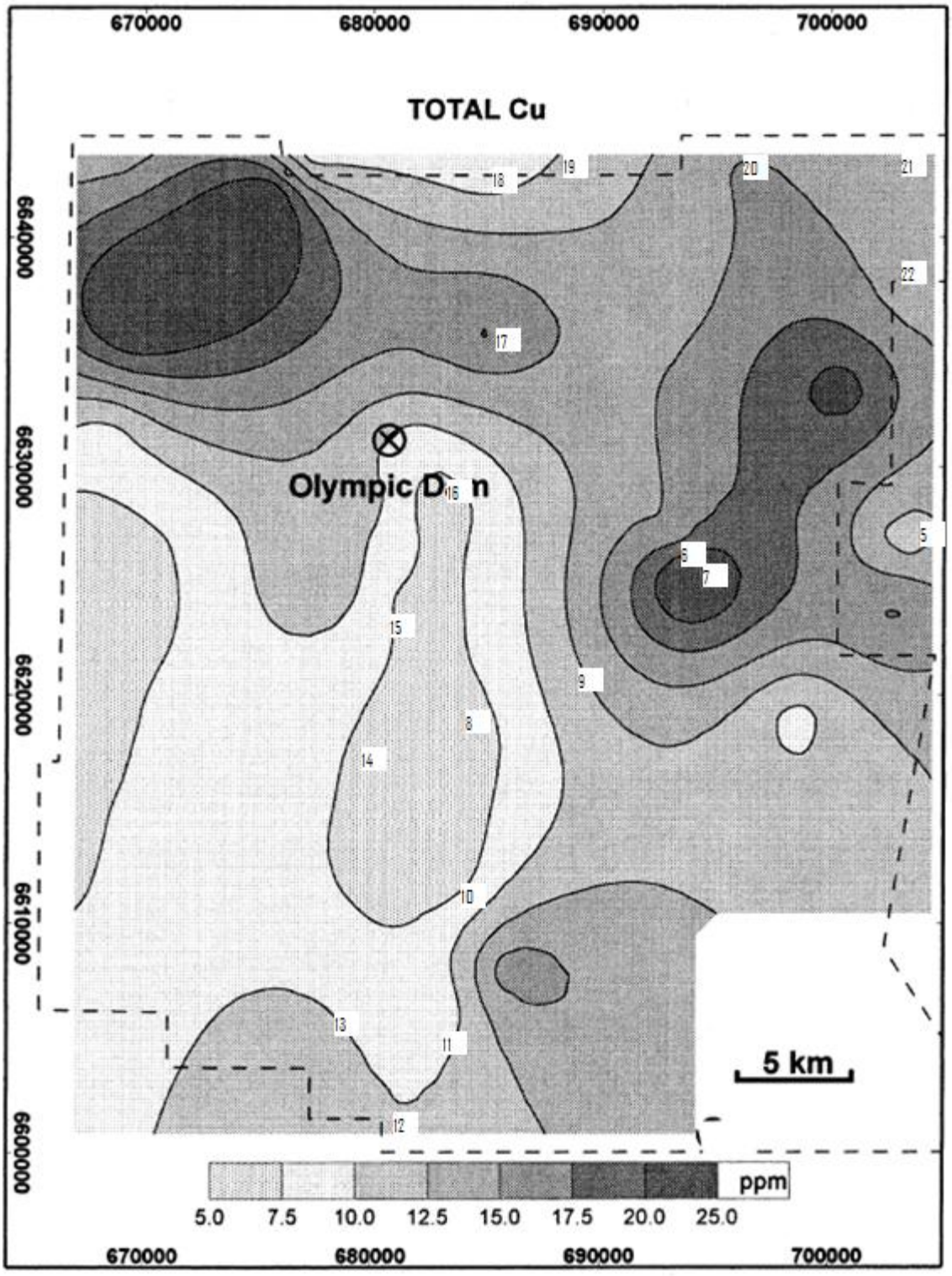


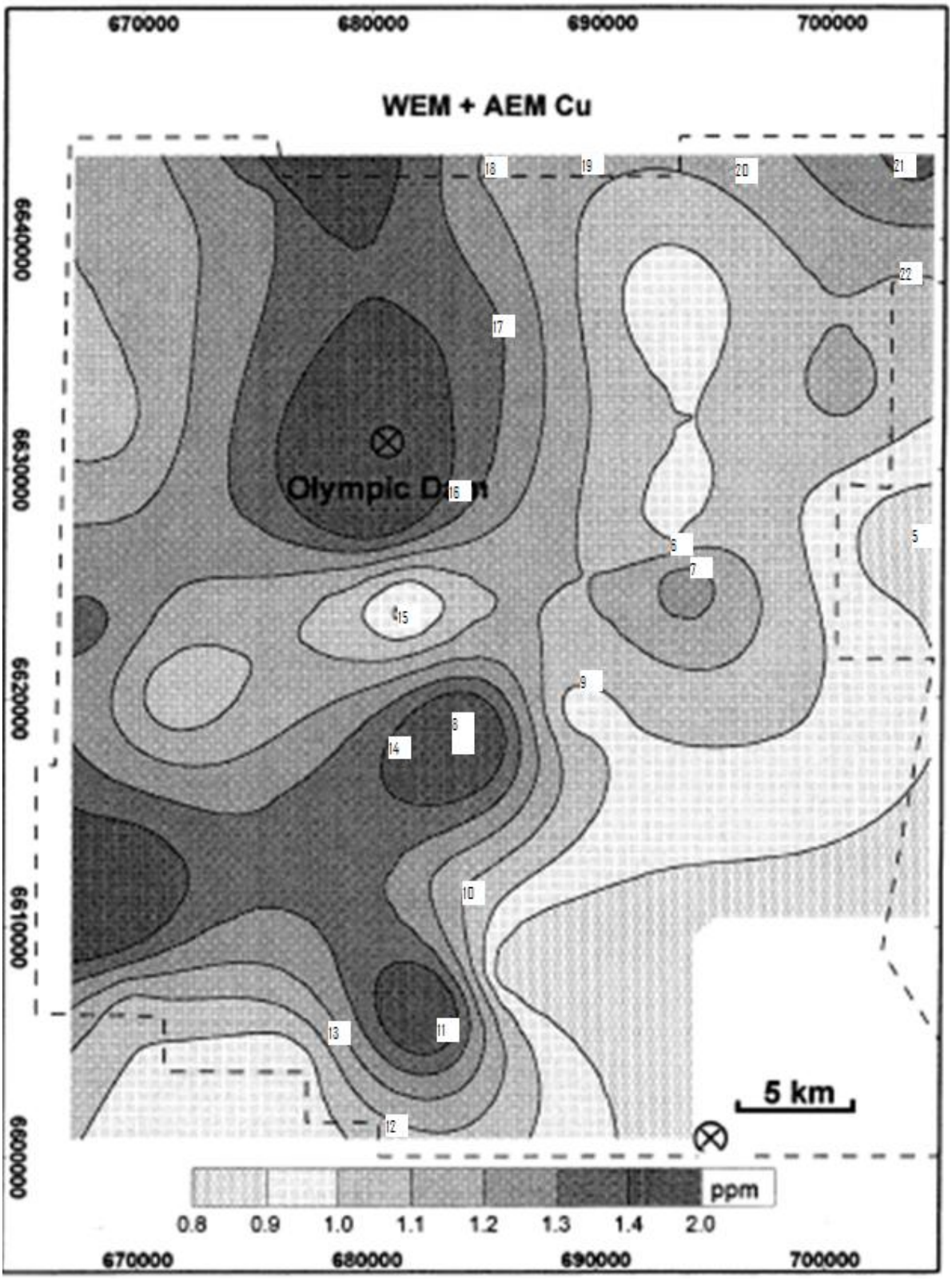

WEM Hg
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic D
5km
ppb
0.60
0.70
0.80
0.90
1.00
1.10

The Following Diagrams Show Copper (Cu) Concentrations

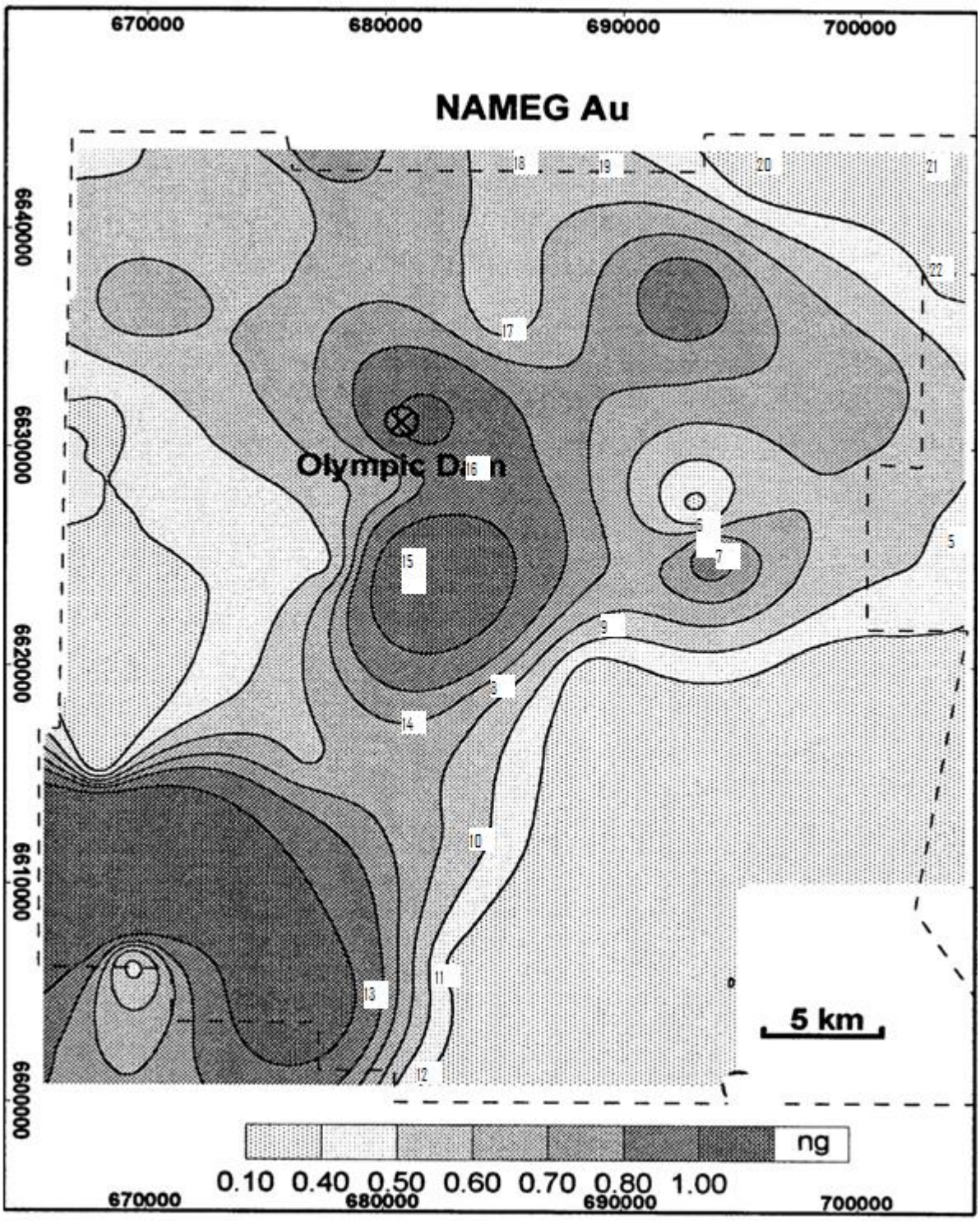


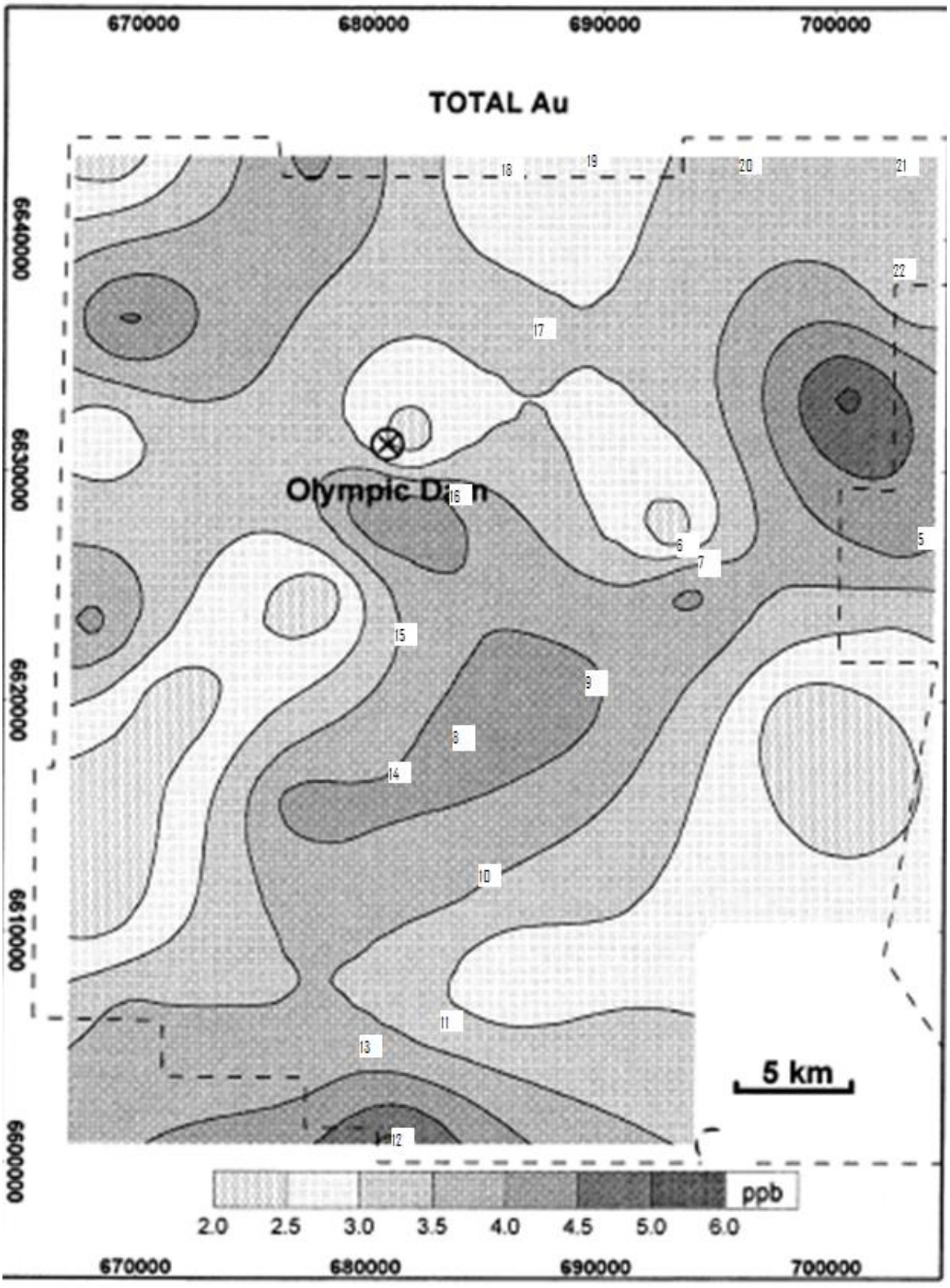

AEM Cu
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic Dam
5 km
ppm
0.60
0.70
0.80
0.90
1.00
1.10
1.20

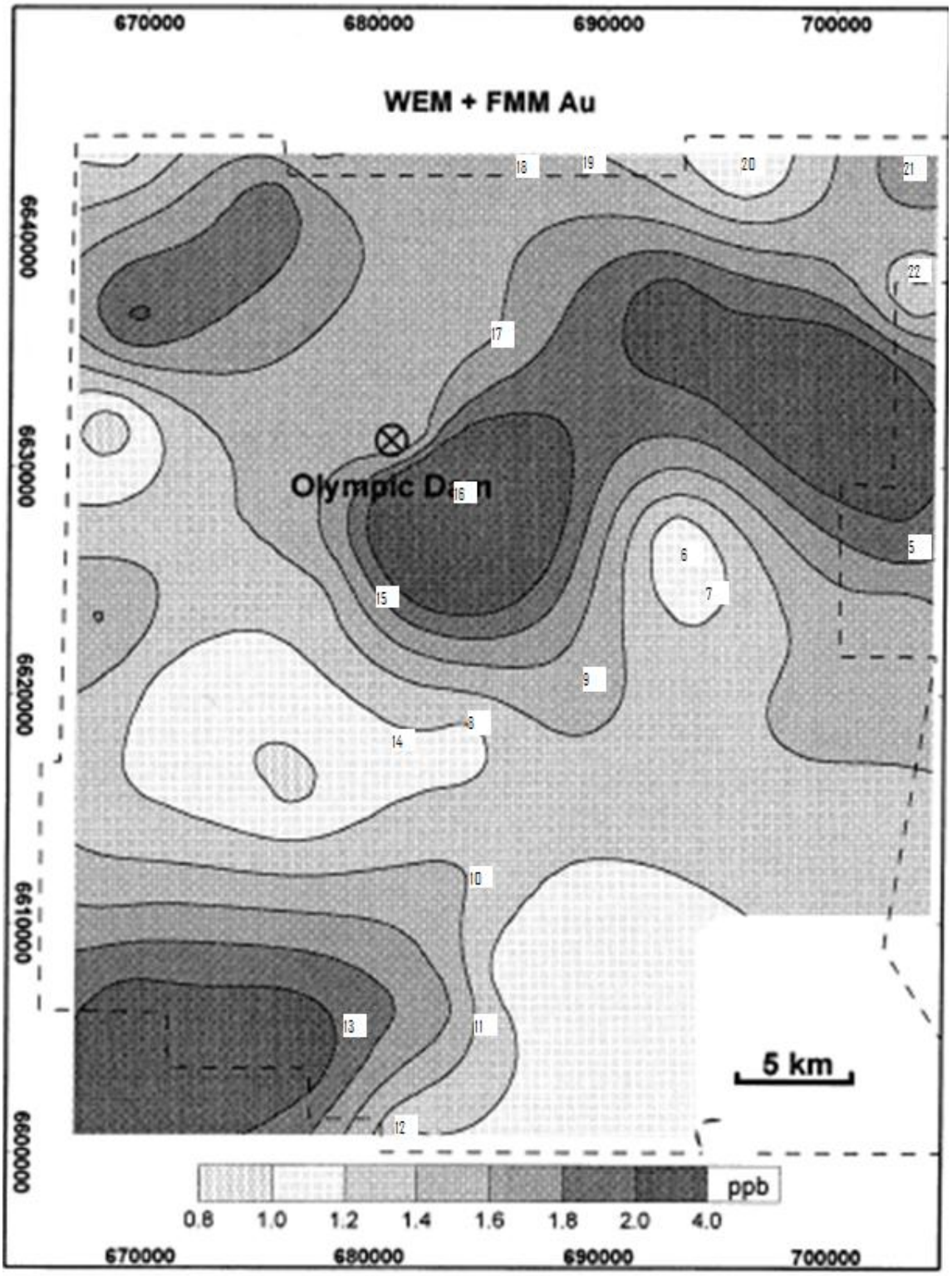

670000
680000
690000
700000
TOTAL Cu
6640000
6630000
6620000
6610000
6600000
Olympic D n
5 km
ppm
5.0
7.5
10.0
12.5
15.0
17.5
20.0
25.0

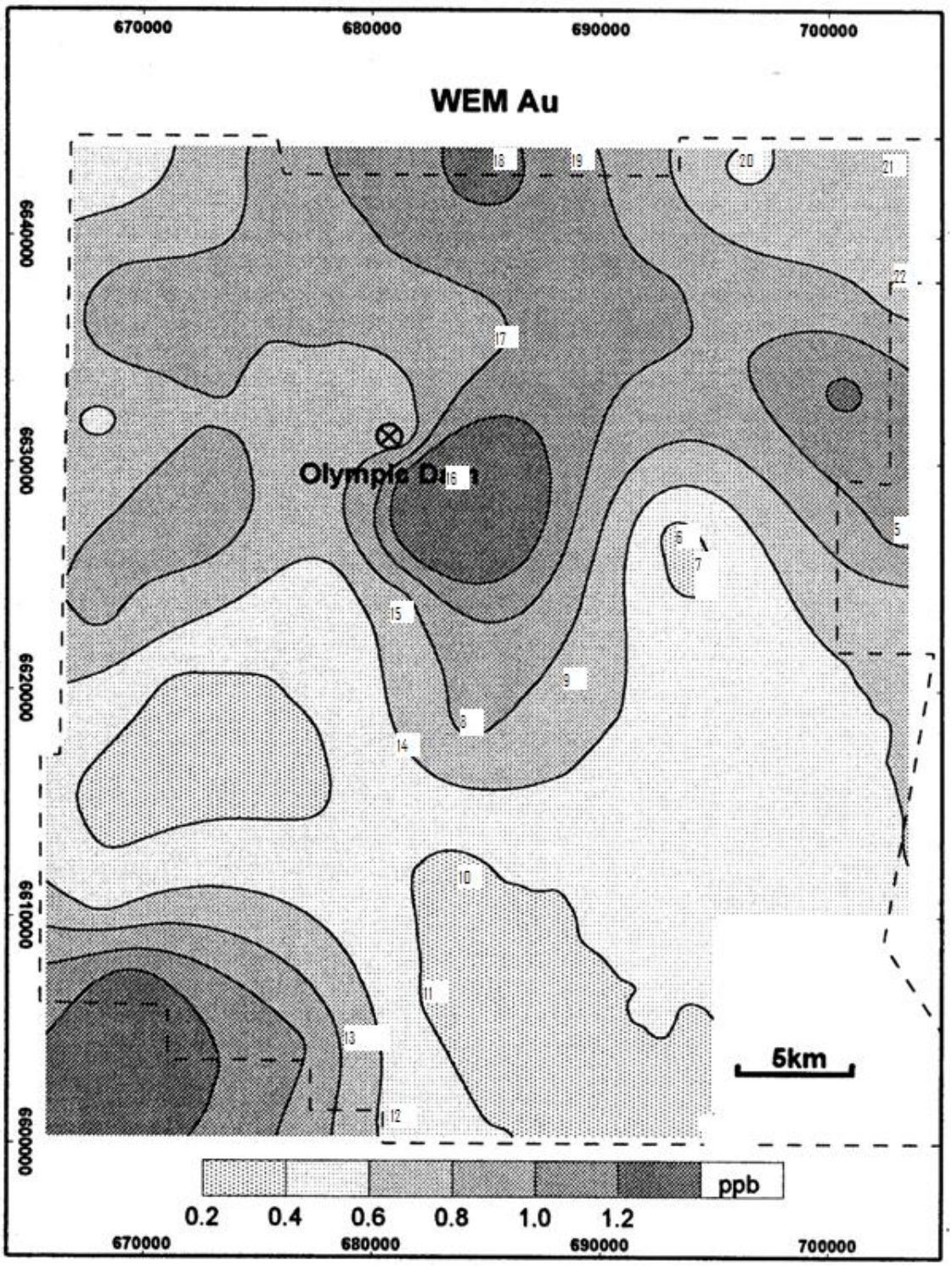

WEM + AEM Cu
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic Dam
5 km
ppm
0.8
0.9
1.0
1.1
1.2
1.3
1.4
2.0

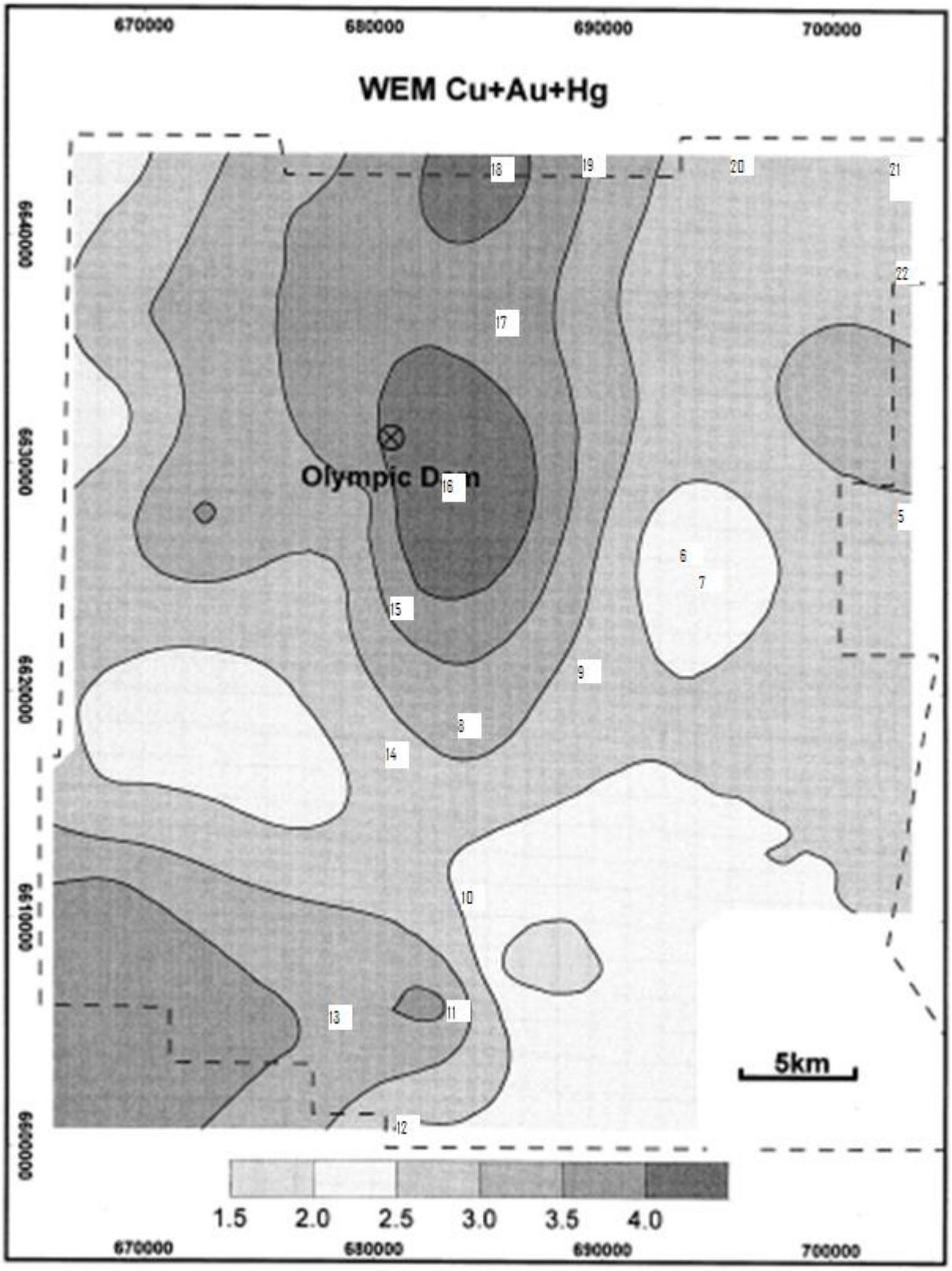
The Following Diagrams Show Gold (Au) Concentrations




670000
680000
690000
700000
TOTAL Au
6640000
6630000
6620000
6610000
6600000
Olympic D
5 km
ppb
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6.0


WEM + FMM Au
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic Dam
5 km
ppb
0.8
1.0
1.2
1.4
1.6
1.8
2.0
4.0


WEM Au
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic Dam
5km
ppb
0.2
0.4
0.6
0.8
1.0
1.2


WEM Cu+Au+Hg
670000
680000
690000
700000
6640000
6630000
6620000
6610000
6600000
Olympic Dam
18
19
20
21
22
17
16
5
6
7
15
9
8
14
10
13
11
12
5km
1.5
2.0
2.5
3.0
3.5
4.0