CRCLEME
Cooperative Research Centre for
Landscape Evolution & Mineral Exploration

CSIRO
EXPLORATION AND MINING

AMIRA
Australian Mineral Industries Research Association Limited ACN 004 448 266

OPEN FILE REPORT SERIES

GEOCHEMICAL STUDIES OF THE SOIL AT THE RUNWAY GOLD PROSPECT, KALGOORLIE, WESTERN AUSTRALIA

M.J. Lintern

CRC LEME OPEN FILE REPORT 95

March 2001

(CRC LEME Restricted Report 26R/
CSIRO Division of Exploration and Mining Report 250R, 1996.
2nd Impression 2001.)

CRC LEME is an unincorporated joint venture between The Australian National University, University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining, established and supported under the Australian Government's Cooperative Research Centres Program.

CRC

GEOCHEMICAL STUDIES OF THE SOIL AT THE RUNWAY GOLD PROSPECT, KALGOORLIE, WESTERN AUSTRALIA

M.J. Lintern

CRC LEME OPEN FILE REPORT 95

March 2001

(CRC LEME Restricted Report 26R/
CSIRO Division of Exploration and Mining Report 250R, 1996.
2nd Impression 2001.)

CRC LEME is an unincorporated joint venture between The Australian National University, University of Canberra, Australian Geological Survey Organisation and CSIRO Exploration and Mining
Headquarters: CRC LEME c/o CSIRO Exploration and Mining, Private Bag No 5, PO Wembley, Western Australia, 6913.

RESEARCH ARISING FROM CSIRO/AMIRA YILGARN REGOLITH GEOCHEMISTRY PROJECTS 1987-1996

In 1987, CSIRO commenced a series of multi-client research projects in regolith geology and geochemistry which were sponsored by companies in the Australian mining industry, through the Australian Mineral Industries Research Association Limited (AMIRA). The initial research program, "Exploration for concealed gold deposits, Yilgarn Block, Western Australia" had the aim of developing improved geological, geochemical and geophysical methods for mineral exploration that would facilitate the location of blind, buried or deeply weathered gold deposits. The program commenced with the following projects:

P240: Laterite geochemistry for detecting concealed mineral deposits (1987-1991). Leader: Dr R.E. Smith.
Its scope was development of methods for sampling and interpretation of multi-element laterite geochemistry data and application of multi-element techniques to gold and polymetallic mineral exploration in weathered terrain. The project emphasised viewing laterite geochemical dispersion patterns in their regolith-landform context at local and district scales. It was supported by 30 companies.

P241: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1987-1991). Leader: Dr C.R.M. Butt.
The project investigated the distribution of ore and indicator elements in the regolith. It included studies of the mineralogical and geochemical characteristics of weathered ore deposits and wall rocks, and the chemical controls on element dispersion and concentration during regolith evolution. This was to increase the effectiveness of geochemical exploration in weathered terrain through improved understanding of weathering processes. It was supported by 26 companies.

These projects represented 'an opportunity for the mineral industry to participate in a multi-disciplinary program of geoscience research aimed at developing new geological, geochemical and geophysical methods for exploration in deeply weathered Archaean terrains'. This initiative recognised the unique opportunities, created by exploration and open-cut mining, to conduct detailed studies of the weathered zone, with particular emphasis on the near-surface expression of gold mineralisation. The skills of existing and specially recruited research staff from the Floreat Park and North Ryde laboratories (of the then Divisions of Minerals and Geochemistry, and Mineral Physics and Mineralogy, subsequently Exploration Geoscience and later Exploration and Mining) were integrated to form a task force with expertise in geology, mineralogy, geochemistry and geophysics. Several staff participated in more than one project. Following completion of the original projects, two continuation projects were developed.

P240A: Geochemical exploration in complex lateritic environments of the Yilgarn Craton, Western Australia (1991-1993). Leaders: Drs R.E. Smith and R.R. Anand.
The approach of viewing geochemical dispersion within a well-controlled and well-understood regolith-landform and bedrock framework at detailed and district scales continued. In this extension, focus was particularly on areas of transported cover and on more complex lateritic environments typified by the Kalgoorlie regional study. This was supported by 17 companies.

P241A: Gold and associated elements in the regolith - dispersion processes and implications for exploration (1991-1993). Leader: Dr. C.R.M. Butt.
The significance of gold mobilisation under present-day conditions, particularly the important relationship with pedogenic carbonate, was investigated further. In addition, attention was focussed on the recognition of primary lithologies from their weathered equivalents. This project was supported by 14 companies.

Most reports related to the above research projects were published as CRC LEME Open File Reports Series (Nos 1-74), with an index (Report 75), by June 1999. Publication now continues with release of reports from further projects.

P252: Geochemical exploration for platinum group elements in weathered terrain. Leader: Dr C.R.M. Butt.
This project was designed to gather information on the geochemical behaviour of the platinum group elements under weathering conditions using both laboratory and field studies, to determine their dispersion in the regolith and to apply this to concepts for use in exploration. The research was commenced in 1988 by CSIRO Exploration Geoscience and the University of Wales (Cardiff). The Final Report was completed in December 1992. It was supported by 9 companies.

P409: Geochemical exploration in areas of transported overburden, Yilgarn Craton and environs, WA.
Leaders: Drs C.R.M. Butt and R.E. Smith.
About 50% or more of prospective terrain in the Yilgarn is obscured by substantial thicknesses of transported overburden that varies in age from Permian to Recent. Some of this cover has undergone substantial weathering. Exploration problems in these covered areas were the focus of Project 409. The research was commenced in June 1993 by CSIRO Exploration and Mining but was subsequently incorporated into the activities of CRC LEME in July 1995 and was concluded in July 1996. It was supported by 22 companies.

Although the confidentiality periods of Projects P252 and P409 expired in 1994 and 1998, respectively, the reports have not been released previously. CRC LEME acknowledges the Australian Mineral Industries Research Association and CSIRO Division of Exploration and Mining for authority to publish these reports. It is intended that publication of the reports will be a substantial additional factor in transferring technology to aid the Australian mineral industry.

This report (CRC LEME Open File Report 95) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 250R, first issued in 1996, which formed part of the CSIRO/AMIRA Project P409.

Copies of this publication can be obtained from:
The Publication Officer, c/- CRC LEME, CSIRO Exploration and Mining, Private Bag 5, Wembley, WA 6913, Australia. Information on other publications in this series may be obtained from the above or from http://leme.anu.edu.au/
Cataloguing-in-Publication:
Lintern, M.J.
Geochemical studies of the soil at the Runway Gold Prospect, Kalgoorlie, Western Australia.
ISBN 0 643 06688 8
1. Regolith - Western Australia - Yilgarn Block 2. Gold ores - Western Australia - Yilgarn Block 3. Geochemistry - Western Australia - Yilgarn Block 4. Geology - Western Australia - Yilgarn Block
I. Title
CRC LEME Open File Report 95.
ISSN 1329-4768

EXECUTIVE SUMMARY

The CSIRO-AMIRA Project "Exploration in Areas of Transported Overburden, Yilgarn Craton and Environs" (Project 409) has, as its principal objective, development of geochemical methods for mineral exploration in areas with substantial transported overburden, through investigations of the processes of geochemical dispersion from concealed mineralization. The Project has two main themes. One of these, *'Surface and subsurface expression of* concealed *mineral deposits'* is addressed by this report, which focuses on the soil geochemistry of the Runway Au prospect (Kalgoorlie Area).

This study is located in the northern part of the Runway Au prospect where the thickness of transported material is less than 2 m, and the depth to mineralization (beneath barren saprolite) is of the order of 50 m. While the thickness of transported material is not substantial, the great thickness of barren saprolite provides an important contrast with depositional terrain environments from the Kalgoorlie area which have similar thicknesses of barren overburden. It is considered that a detailed study of the nature of Au in surficial material from such an environment will enhance our understanding of the processes whereby Au may (or may not) be enriched in the surficial environment in areas of substantially transported material.

The results for this study are summarized below:

1. Surficial samples (0 - 2 m) are anomalous in Au, As, Sb and W. Multi-element geochemistry may be a useful adjunct exploration tool in this area since data from KCGM indicate that As, Sb and W are associated with mineralization.

2. Gold appears to be associated with carbonate in surficial material, but it is also present in saprolite, which occurs close to the surface.

3. Partial extraction techniques indicate that the proportions of water-soluble Au are lower and iodide-soluble Au higher than for areas of deeply transported cover.

4. Biogeochemical data indicate that some Au is present in bluebush samples overlying mineralization but that the data are close to detection.

5. Selection and analysis of components within samples may be used to enhance concentrations in excess of the bulk sample concentration for selected elements; Au concentrations may be higher in the calcareous and/or ferruginous granule component of the sample.

C.R.M. Butt
R.E. Smith
Project Leaders
September 1996

TABLE OF CONTENTS

1. INTRODUCTION

Previous AMIRA Projects (P240, P240A, P241, P241A) investigated the geochemical expression of primary and supergene Au mineralization in the regolith. These studies demonstrated that in relict and erosional landform regimes, carefully directed, shallow sampling is usually more cost- and technically-effective than routine drilling to deep saprolite in regional- and prospect-scale exploration. In some locations, it was found that there was a surface expression of mineralization concealed by up to 40 m of barren sediments and/or apparently leached saprolite. In this project (P409), outcomes of the previous projects are being further tested to determine whether similar procedures can be routinely applied in depositional regimes. This report summarises studies undertaken at the Runway Au prospect (Kalgoorlie Area).

Two groups of sample media have particular value for Au exploration in the Yilgarn Craton:

(i) ferruginous materials, particularly lateritic residuum and lag;

(ii) calcareous soil horizons, which are widespread in the semi-arid parts of the southern Yilgarn. Gold concentrations are often much greater in pedogenic carbonate, compared with immediately adjacent horizons. It has been shown in previous studies in relict and erosional areas that failure to sample this horizon in an exploration programme will result in ineffective soil surveys.

In the Kalgoorlie area, the work programme has been to investigate potential sample media in the transported regolith above mineralization. Specifically the study to date has analysed for:

(i) Au in surficial horizons;

(ii) Au below surface in transported overburden;

(iii) pathfinder elements in transported and residual regolith and bedrock.

Several sites were offered by P409 sponsor companies for pilot studies (Table 1). All sites were visited and a preliminary set of samples was taken at most locations. Sites were assessed using various criteria (see Table 1) and the most suitable sites were selected for more detailed investigations of the geochemistry of regolith materials, vegetation and groundwater.

At Runway, the presence of Au in surficial material had been noted by previous exploration activity by KCGM and is the subject of further investigation here. Anomalously high concentrations of Au in excess of 250 ppb occur in the soil directly overly mineralization and appear to be separated from it by many tens of metres of barren saprolite. Although the thickness of transported material is not substantial, the great thickness of barren saprolite provides an important contrast with other sites from the Kalgoorlie area that have similar thicknesses of barren (sedimentary) overburden. It is considered that a study of the nature of Au in surficial material from such an environment will enhance our understanding of the processes whereby Au may (or may not) be enriched in the surficial environment in areas of substantially transported material.

Table 1: Advantages and disadvantages of study sites examined during the P409 pilot study and previous AMIRA projects.

Site	Type of mineralization	Advantages	Disadvantages
Sites chosen			
Apollo	*In saprolite , beneath 5 -10 m of transported sediments and 10 m of saprolite.*	*Extensive drilling available. Strong mineralization. Distant from upslope Au deposit. Proximity to Argo deposit facilitates comparisons. Reported weak surficial anomaly.*	*Poor condition of drill material in top 10 m.*
Argo	*At interface and saprolite, beneath 20 m or more of lacustrine sediments.*	*Extensive drilling available. Strong mineralization. Exposed pit. Distant from upslope Au deposit.*	*Surficial sampling not com-pleted, due to pit excavation. Poor condition of drill material in top 10 m.*
Challenge Swordsman Mitchell (Higginsville)	*At base of transported material beneath 35 m to 50 m of transported sediments.*	*Strong mineralization. Distant from upslope Au deposit. Reported surficial anomaly.*	*Ground partly disturbed before sampling took place.*
Kat Gap (Forrestania)	*Little information available.*	*Moderate drilling available. Distant from upslope Au mineralization.*	*Depth of transported material not determined - may be thin.*
Kurrawang	*Little information available.*	*Known surficial anomaly. Exposed pit (at a later stage).*	*Surface regolith mostly residual. Little drill spoil.*
Lake Cowan	*Various deposits associated with palaeochannel and underlying saprolite.*	*Known surficial anomaly. Extensive drilling available.*	*Known upslope mineralization.*
Kurnalpi	*At interface and saprolite, beneath 60 m of transported sediments.*	*Moderate drilling available. Distant from known Au mineralization.*	*Not scheduled to be mined. Weak mineralization.*
Mt Celia	*Beneath 5 to 15 m of transported deposits.*	*Extensive drilling available. Distant from upslope Au mineralization.*	*Not scheduled to be mined. Not typical of regolith in Kalgoorlie area.*
Panglo (I)	*In saprolite, beneath <1 m to 2 m of transported soil and 40 m of saprolite.*	*Reported strong surficial anomaly overlying strongly leached saprolite above mineralization. Distant from upslope Au deposit. Pit face available to sample.*	*Not deeply buried.*
Runway	**In saprolite, beneath 1 m of possibly transported soil and 50 m of saprolite.**	**Reported strong surficial anomaly overlying strongly leached saprolite above mineralization. Distant from upslope Au deposit. Moderate drilling available.**	**Not scheduled to be mined. Not deeply buried.**
Steinway	*In saprolite, 5 m beneath 30 m of transported sediments.*	*Known surficial anomaly. Extensive drilling available. Distant from known Au mineralization.*	*Not scheduled to be mined. Weak mineralization.*
Wollubar (Enigma)	*At interface and saprolite, beneath 55 m of transported sediments.*	*Moderate drilling available. Distant from upslope Au deposit.*	*Not scheduled to be mined. Weak mineralization.*

Table 1: (continued)

Site	Type of mineralization	Advantages	Disadvantages
Sites not chosen			
Gindalbie	*With sulphides at interface, beneath 60 m of transported sediments.*	*Moderate drilling available. Distant from upslope Au deposit.*	*Poorly mineralized. Not scheduled to be mined.*
Lady Bountiful Extended	*At interface beneath 25 m of transported deposits, and also in underlying quartz veins.*	*Moderate drilling available. Distant from upslope Au deposit. Exposed pit (at a later stage). Strong mineralization.*	*Severe surficial disturbance.*
Samphire	*Little information available.*	*Exposed pit.*	*Surface regolith mostly residual.*
Previous studies in earlier CSIRO-AMIRA projects			
Baseline	*Beneath 20 m of transported sediments.*	*Exposed pit. Known surficial anomaly.*	*Samples not available.*
Panglo (II)	*Located in saprolite 20 m beneath base of 15 m of transported sediments.*	*Extensively studied in earlier project. Known surficial anomaly.*	*This part of deposit not scheduled to be mined.*
Matt Dam	*At interface and saprolite, 15 m beneath 10 m of transported sediments.*	*Extensively studied in earlier project. Known surficial anomaly.*	*This part of deposit not scheduled to be mined.*
Zuleika	*At interface and saprolite, beneath 20 m of transported sediments.*	*Exposed pit. Extensively investigated in earlier project.*	*Known upslope mineralization. No further surface samples available.*

The methodology behind this study, as with other studies in the Kalgoorlie area, was primarily concerned with the collection and analysis of high quality surficial samples. Results (particularly those of partial extractions) from this site of predominantly *in situ* regolith are compared with those from sites having substantial transported overburden. In addition, information and knowledge on geochemical relationships between elements, and appropriate sampling techniques for exploration in terrain with a shallow sedimentary cover, will be advanced.

2. SITE DESCRIPTION

The Runway prospect is located on KCGM Ltd tenements approximately 10 km north of Kalgoorlie, Western Australia. It is located in north-striking, steeply west-dipping, sedimentary sequence within the Black Flag Beds. There are four main units which are, from west to east: volcanic sandstone, interbedded conglomerate-sandstone, black shales and siltstones, massive sandstone (R. Hutchison, KCGM, written communication, 1996).

Mineralization at Runway comprises a thin, sub-horizontal zone of supergene Au enrichment close to the weathering front, beneath 50 m of leached or barren saprolite. Underlying, primary mineralization occurs as sporadic, narrow quartz veins, with minor sulphides, including pyrite, arsenopyrite, sphalerite and galena and resulting in significant Au, As, Ag, Cu, Pb and Zn anomalism (e.g., see Figures 1 and 2). The veins appear to be generally restricted to the interbedded conglomerate-sandstone unit, which exhibits pervasive carbonate-sericite alteration and disseminated pyrite and arsenopyrite (R. Hutchison, KCGM, written communication, 1996).

Soils are calcareous red clays with a veneer of sandy clay on the surface. Soils are less than 1 m in places and grade into saprolite. Soil samples (0.3 - 1.3 m) were collected by KCGM and analysed for Au. Soil Au values appear to be associated with underlying mineralization along strike with a peak value of 270 ppb (Figure 1). Vegetation is open eucalypt woodland over the residual areas, and large trees, less common, and smaller shrubs, more dominant, in the depositional terrain.

3. SAMPLING AND ANALYSIS

3.1 Sample collection

Forty-three (1 - 2 kg) soil samples were collected from the top 1 - 2 m along traverse 62200N, using a vehicle-mounted vacuum drilling rig. The design of the drilling rig enabled accurate sub-metre sampling to take place, although sampling deeper than 1 m was difficult to achieve due to the clay-rich nature of the regolith. Multiple samples collected from the first metre were analysed separately e.g. sample intervals 0.0 - 0.3 m, 0.3 - 0.8 m and 0.8 - 1.0 m, and were composited to make a 0 - 1 m sample used in the partial extraction experiments.

Three soils with high Au concentrations were split (200 g) and wet sieved for more detailed analysis of the coarse (> 1 mm) size fraction by INAA only.

Six samples of bluebush were collected from mineralized and background sites from the traverse.

3.2 Sample preparation and analysis

Soil samples were dried at 70°C, split and jaw-crushed (as required) before a 100-200 g sub-sample was pulverized in a K1045 steel ring mill to nominal <75µm.

(i) Au, Sb, As, Ba, Br, Ce, Cs, Cr, Co, Eu, Hf, Ir, Fe, Au, La, Lu, Mo, K, Rb, Sm, Sc, Se, Ag, Na, Ta, Th, W, U, Yb and Zn were determined on a 10 g sub-sample by Instrumental Neutron Activation Analysis (INAA) at Becquerel Laboratories, Lucas Heights;

(ii) Calcium and Mg was determined on 1 g sub-samples by atomic absorption spectrophotometry (AAS) after first digesting in 5M HCl for 15 minutes and then diluting to 1M HCl; this procedure is aimed at dissolving the Ca and Mg in carbonates.

Vegetation samples were washed with hot water and deionised water before drying at 90°C. The samples were then dried at 105°C for at least 24 hours, to prevent smearing during milling, before being passed through a four-bladed cross-beater mill twice - firstly without, and secondly with, a 1 mm mesh screen in place to ensure a suitably homogenized and macerated sample. The samples were then weighed, step-wise-ashed to 550°C before being re-weighed and sent for analysis; they were analysed for the INAA suite of elements.

3.3 Partial extractions

Three in-house partial extraction solutions, discussed in detail in Gray and Lintern (1993), were used to test the solubility of Au. In all cases, a 25 g portion of unpulverized sample material was mixed with 50 mL of extractant in a screw-cap polyethylene plastic bottle, and then gently agitated for one week, after which the total Au extracted was determined. Total Au was measured by adding a 1 g carbon sachet with the sample and analyzing the carbon using INAA; in-house experiments have shown that the carbon sachet procedure reduces re-adsorption of the dissolved Au on components within the sample. The three solutions are:

(i) deionised water: dissolves the most soluble Au;

(ii) iodide: a 0.1 M KI solution dissolves more Au than water alone;

(iii) cyanide: 0.2% KCN / 0.2 M NaOH solution dissolves all but the most refractory Au such as large particles of Au and that encapsulated within resistant material such as quartz.

The partial extraction tests were performed as a sequential extraction using 3 different carbon sachets, commencing with deionised water and finishing with cyanide.

4. RESULTS

4.1 Soils

The data for traverse 62200N indicate that:

(i) Au, As, Sb and, possibly, W are anomalous in soil overlying mineralization (Figure 1);

(ii) compared with the top 0.5 m, soils below 0.5 m are moderately more concentrated in As, Sb and W, and, over mineralization alone, Au (Figure 1);

(iii) samples are more calcareous (Ca- and Mg-rich) over mineralization (Figure 1);

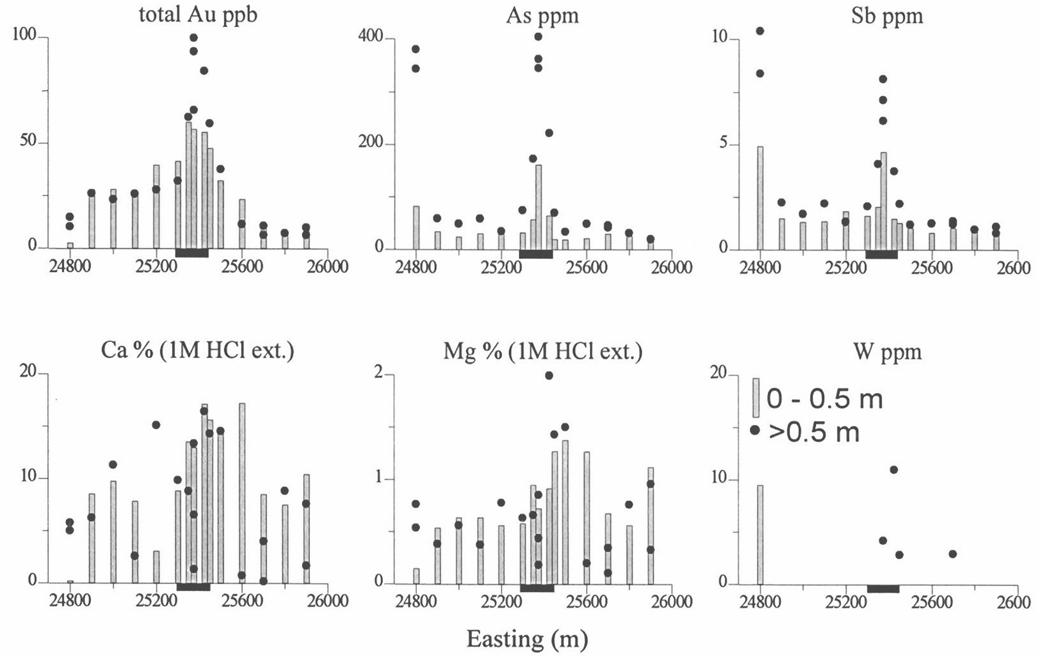

Figure 1: Elemental abundances for selected elements from 62200N at Runway. Black area beneath X axis locates mineralization.

The data for a profile sampled from the vacuum rig drill cuttings at approximately 0.25 m depth intervals from directly over mineralization (25400E 62200N) indicate that:

(i) Au, Ca and Mg appear to be weakly associated only in the top 1.3 m, and that the most Au (80 ppb) and least Ca and Mg are found below 1.5 m (Figure 2);

(ii) highly anomalous concentrations of As (2700 ppm), Sb (42 ppm) and W (45 ppm) are found in the deepest sample (1.75 m to 2.0 m) (Figure 2, see also Appendix Figure A1).

Data from KCGM indicates that As, Sb and W are associated with Au mineralization (Figures 3 to 6).

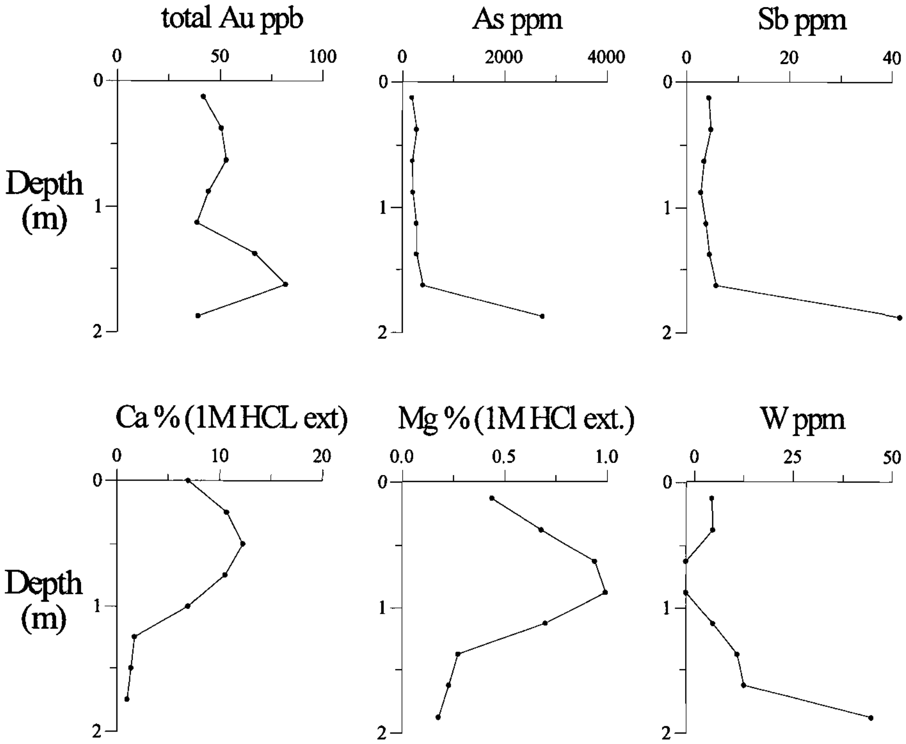

Figure 2: Elemental abundances for selected elements for Profile 1 at Runway.

4.2 Vegetation

The vegetation data indicate that most samples are below detection for many of the elements analysed for. One sample (above mineralization) had detectable Au (1.9 ppb) although this value is close to detection. Two samples had detectable As, with one above mineralization and the other from background (Appendix Figure A4).

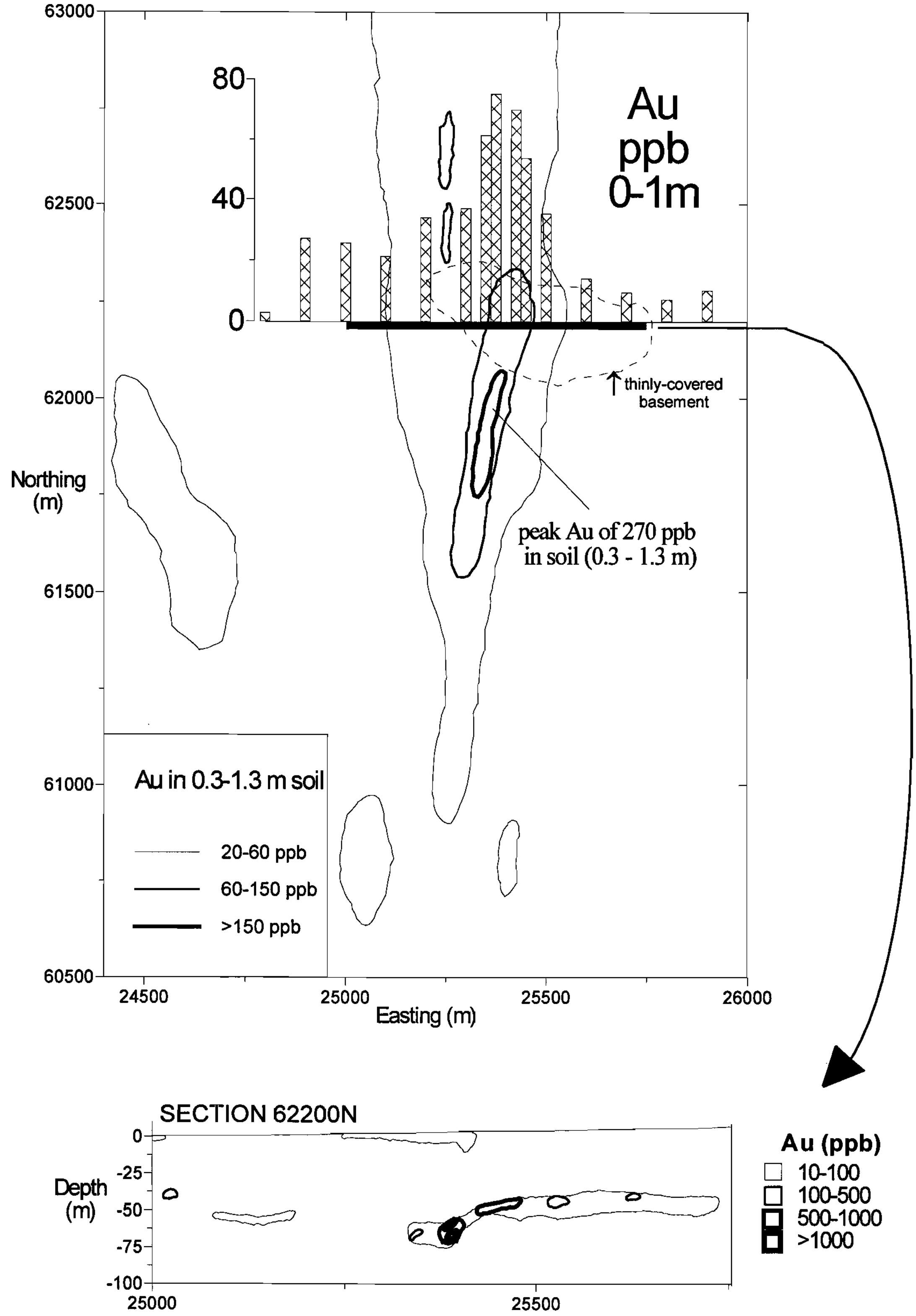

Figure 3: Plan and section showing location of sampling traverse and Au data for soil (0.3 - 1.3 m, 0 - 1 m) and deeper regolith samples (after data supplied by KCGM).

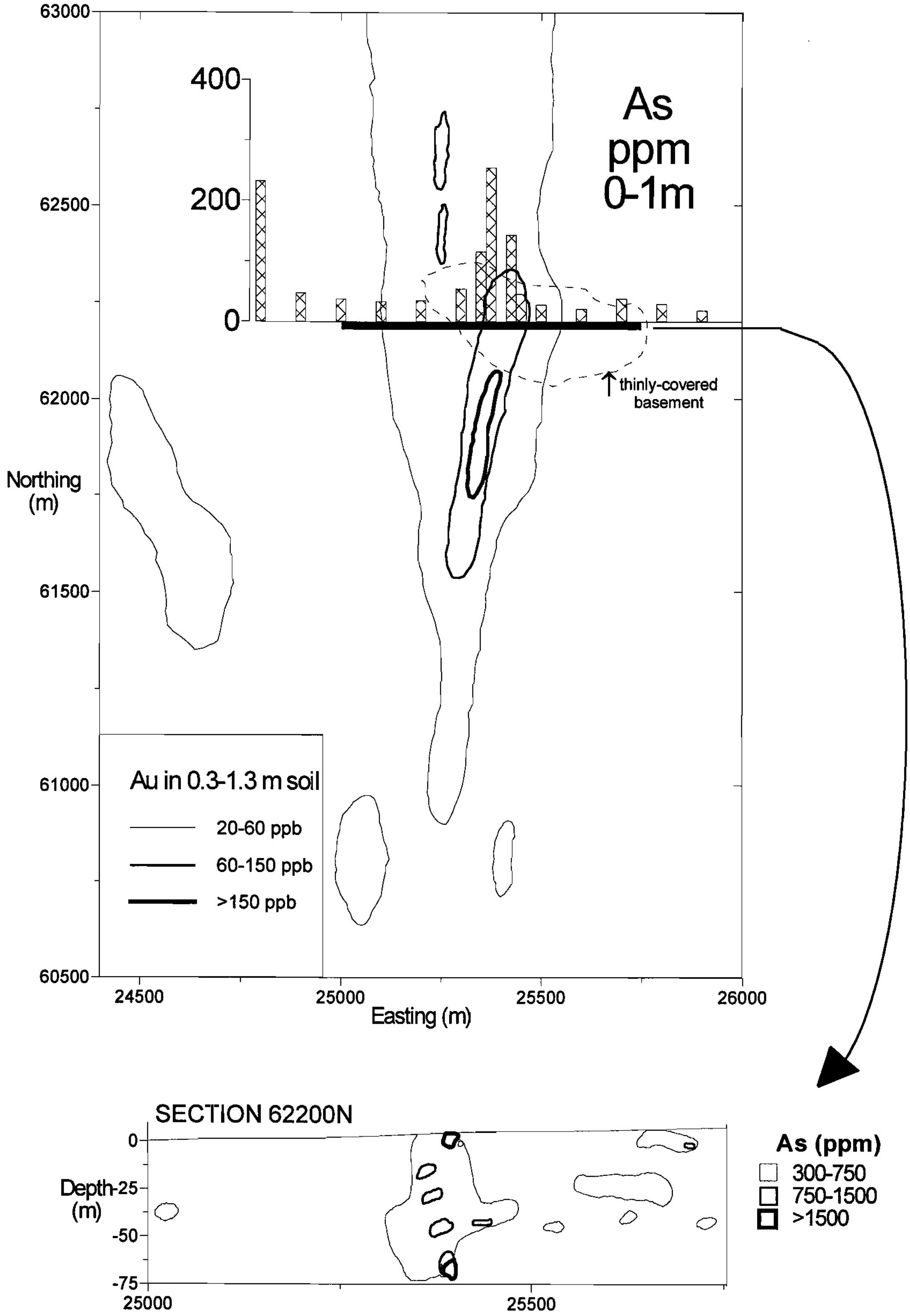

Figure 4: Plan and section showing location of sampling traverse and As data for soil (0 - 1 m) and deeper regolith samples (after data supplied by KCGM). Contoured Au data for soil (0.3 - 1.3 m) also shown.

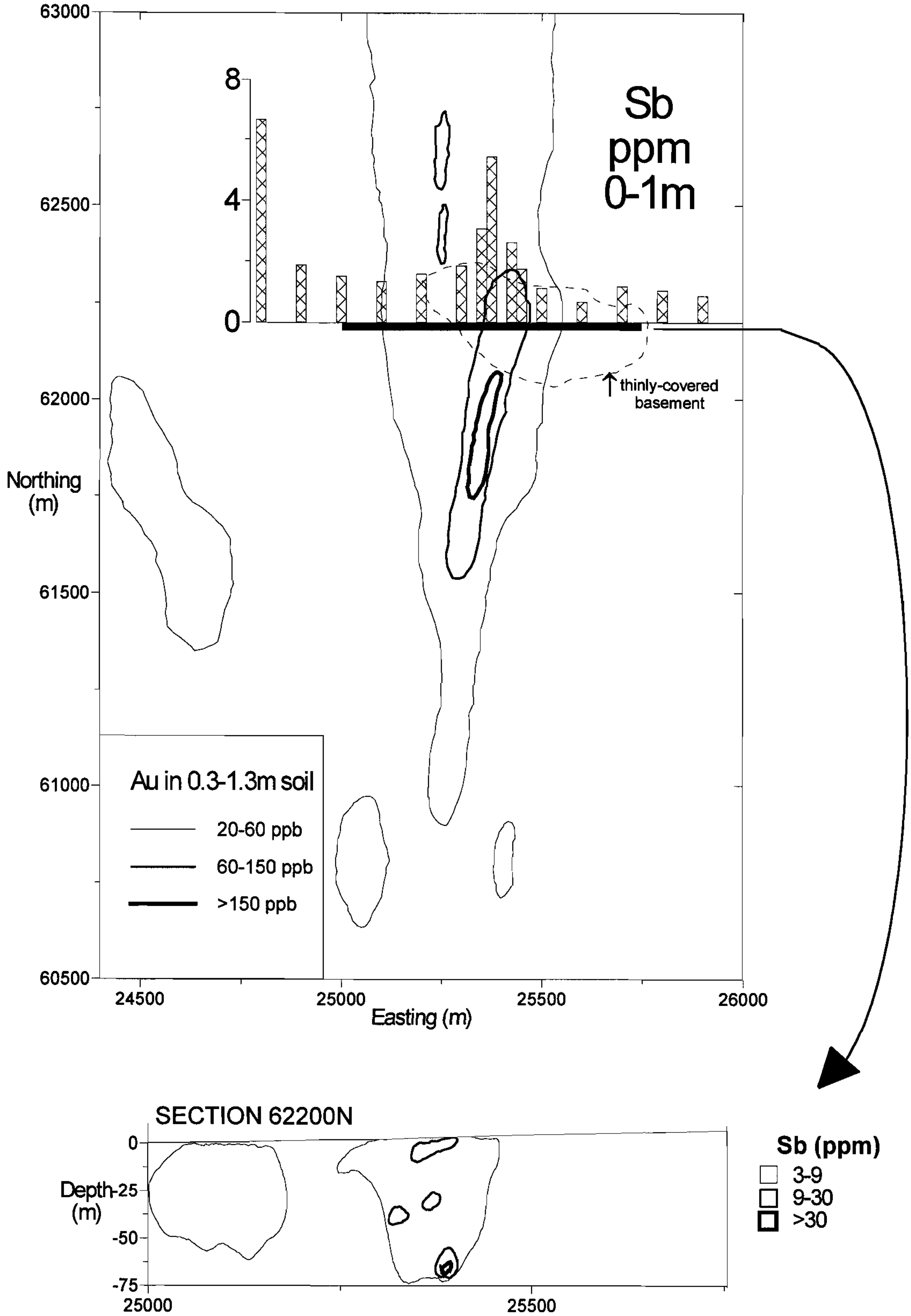

Figure 5: Plan and section showing location of sampling traverse and Sb data for soil (0 - 1 m) and deeper regolith samples (after data supplied by KCGM). Contoured Au data for soil (0.3 - 1.3 m) also shown.

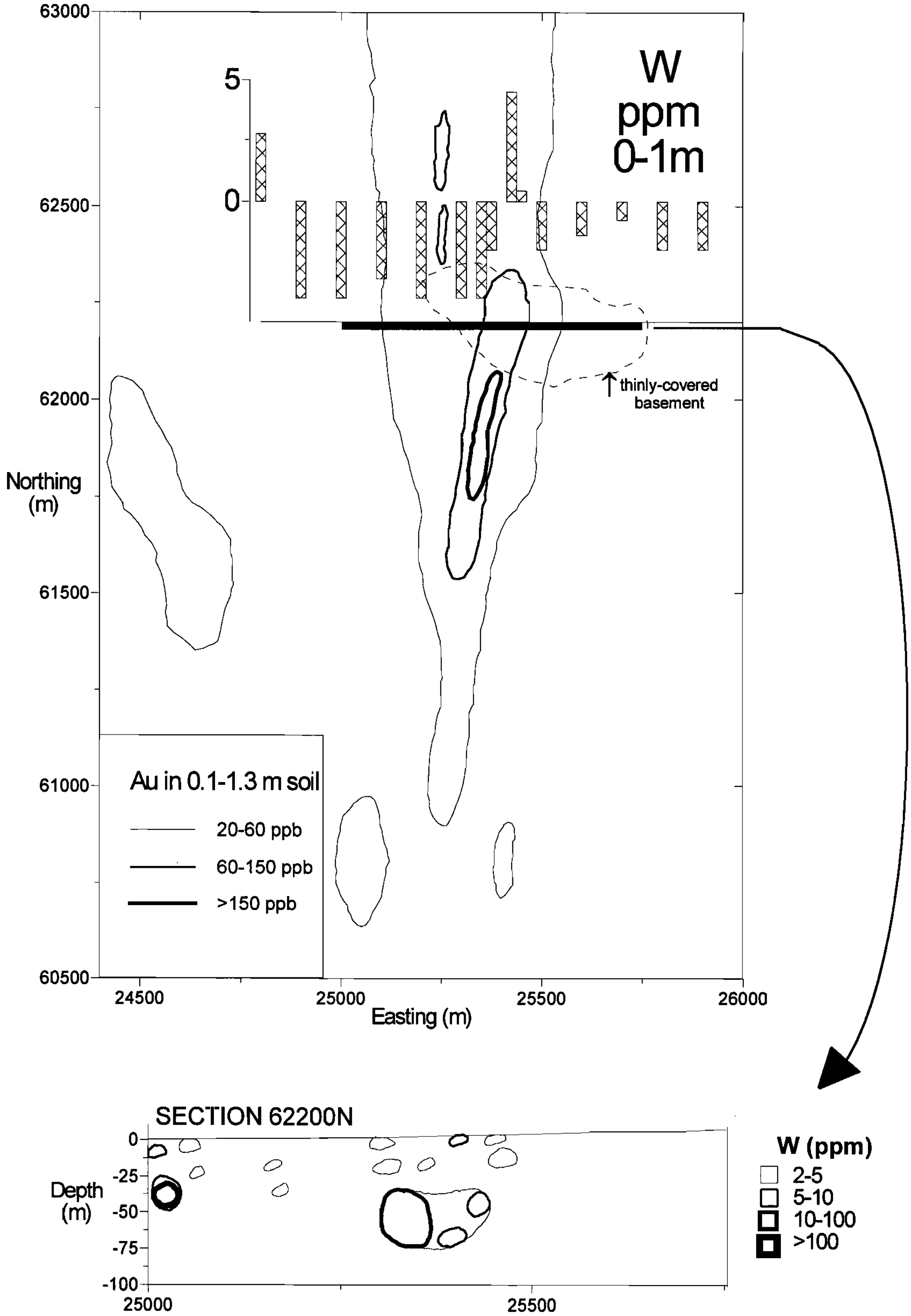

Figure 6: Plan and section showing location of sampling traverse and W data for soil (0 - 1 m) and deeper regolith samples (after data supplied by KCGM). Contoured Au data for soil (0.3 - 1.3 m) also shown.

4.3 Partial extractions

The partial extraction results are dominated by the high proportion of iodide-extractable Au (mean of 87%, Figure 7). Relatively low proportions of water-extractable Au are present (10%) compared with most sites with transported overburden (Figure 8), particularly in two samples over mineralization (4%). The nature of the Au extracted by the three extraction techniques has not been specifically determined, but low extractability in water may reflect the coarser nature of Au closer to the deposit source.

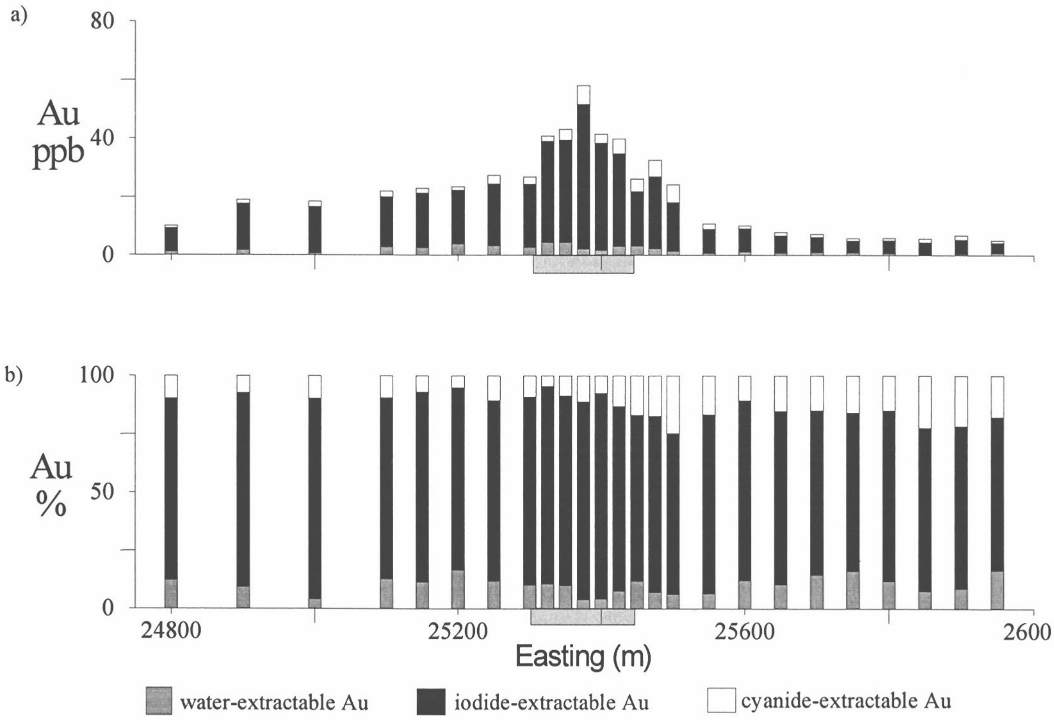

Figure 7: Cumulative Au concentrations for partial extractions expressed as (a) Au concentration and (b) % of total extractable Au across mineralization at Runway. Stippled area underneath X axis is the approximate location of mineralization.

When compared with data from areas of substantial transported overburden (i.e., Argo, Kurnalpi, Steinway, Wollubar Enigma, and Zuleika), the Runway data indicates that concentrations of (i) water-extractable Au are low, (ii) iodide-extractable Au are high and (iii) iodide-extractable Au are the least variable of any site (Figure 8). The presence of higher proportions of water-extractable Au in depositional terrain, particularly areas with substantial transported overburden (Argo, Steinway, Kurnalpi and Wollubar-Enigma), may reflect higher cumulative levels of chemical/biological processes, i.e., Au present in depositional terrain may have been chemically re-worked (dissolution-precipitation-re-dissolution etc.) more frequently than Au derived directly from mineralization. A similar situation occurs at Zuleika Sands Au deposit 20 km south of Ora Banda; this site also has a low proportion of water-soluble Au, where some of the Au present in the surficial depositional terrain is coarse and contains Ag. However, at Zuleika, there is a higher proportion of Au that is soluble in cyanide, compared with Runway.

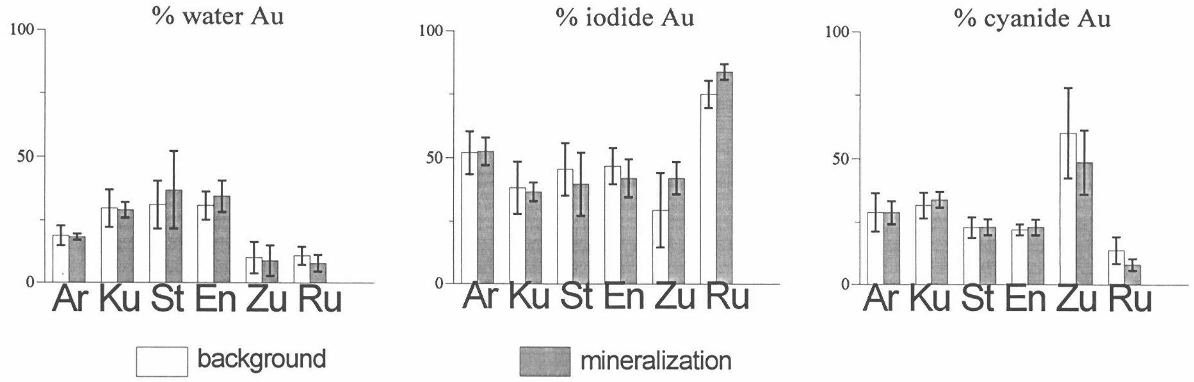

Figure 8: Comparison of partial extraction techniques at 6 sites from the Kalgoorlie area. Mean (histograms) and standard deviations (bars) are shown. Ar - Argo, Ku - Kurnalpi, St - Steinway, En - Wollubar Enigma, Zu - Zuleika and Ru - Runway.

Partial extraction data for the soil profile indicates an increasing proportion of water- and, in particular, iodide-soluble Au with depth compared with the cyanide-extractable Au (Figure 9). The reason for this may be due to the presence of Au in the top metre being present as coarser Au grains compared with the sub-surface. At about 1 m depth, lithic fragments become markedly visible in grab samples (see Appendix Table A1).

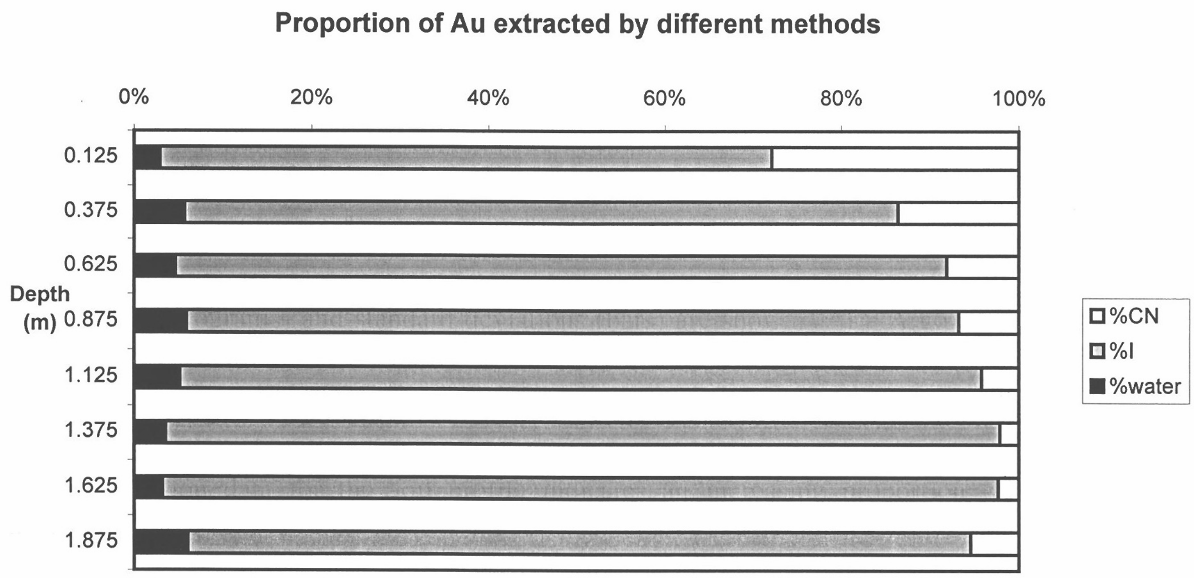

Figure 9: Partial extraction of the profile samples at Runway Prospect.

4.4 Coarse size fraction.

Three samples (09-4325, 09-4333 and 09-4336) from the top 2 m over mineralization were wet sieved and their coarse size fraction retained and analysed for the INAA element suite. The 3 coarse samples were further sub-divided according to component type:

(i) 09-4325: a highly calcareous sample from which 4 components were separated: (1) calcareous nodules of various types (pisoliths, angular and rounded fragments); (2) conspicuous green lithic fragments; (3) assorted saprolitic/mottled zone fragments of various types; (4) a few (<10) magnetic ferruginous granules;

(ii) 09-4333: a highly ferruginous sample containing ferruginous saprolite, quartz and very few calcareous fragments from which 5 components were separated: (1) calcareous nodules and pisoliths; (2) conspicuous green lithic fragments; (3i) pale saprolite; (3ii) ferruginous saprolite; (4) magnetic ferruginous granules;

(iii) 09-4336: a highly calcareous sample from which 4 components were separated: (1) calcareous nodules and pisoliths; (2) conspicuous green lithic fragments; (3) pale saprolite; (4) magnetic ferruginous granules.

The results (Figure 10) indicate:

1. Gold occurs in all components of all samples; the highest Au concentrations are found in the calcareous size fraction for sample 09-4325 and 09-4336 (over 500 ppb) and in the ferruginous granules for sample 09-4333.

2. Antimony (and Ba, Br, Ce Th and Co) is associated with Fe and is most concentrated in saprolite and ferruginous granules.

3. Chromium, Cs, K, Na and Rb are most concentrated in the green lithic fragments which are probably fuchsitic.

4. Tungsten was not detected in calcareous material; most W and As are either associated with ferruginous granules or saprolite.

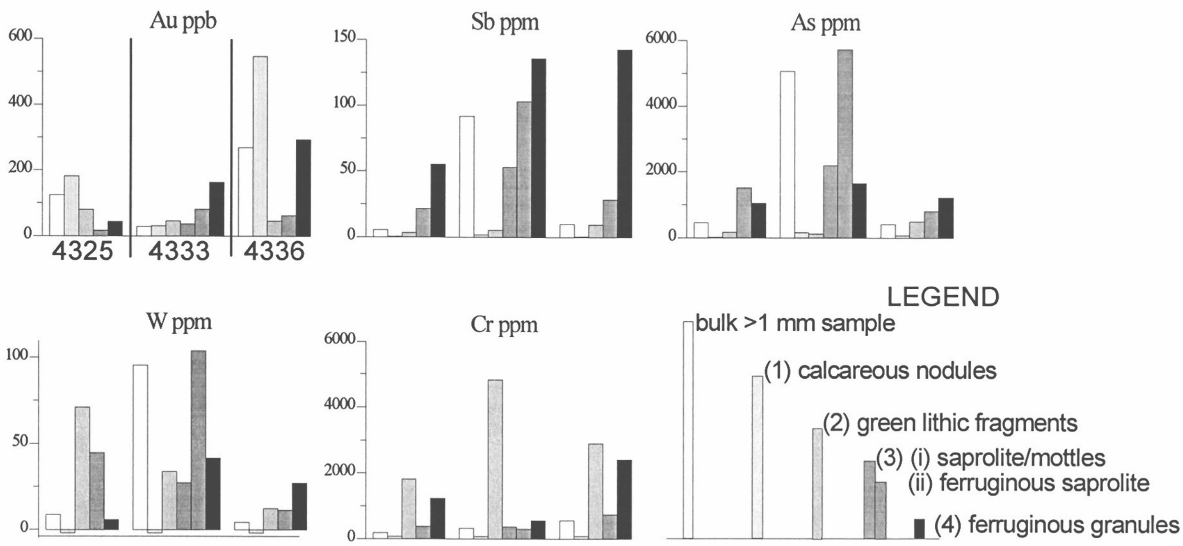

Figure 10: Selected elemental concentrations for bulk coarse size fraction (>1 mm) and components (>1 mm) (1 to 4) in 3 wet sieved samples (09-4325, 09-4333 and 09-4336) above mineralization at Runway.

5. SUMMARY

1. Surficial samples (0 - 2 m) are anomalous in Au, As, Sb and W. Multi-element geochemistry may be a useful adjunct exploration tool in this area since data from KCGM indicate that As, Sb and W are associated with mineralization.

2. Gold appears to be associated with carbonate in surficial material, but it is also present in saprolite, which occurs close to the surface. The saprolite is probably the immediate source of Au in the soils and may itself be relict, following salinization of groundwater and depletion of Au from deeper zones of the regolth.

3. Partial extraction techniques indicate that the proportions of water-soluble Au are lower and iodide-soluble Au higher than for areas of deeply transported cover.

4. Biogeochemical data indicate that some Au is present in bluebush samples overlying mineralization but that the data are close to detection.

5. Selection and analysis of components within samples may be used to enhance concentrations in excess of the bulk sample concentration for selected elements; Au concentrations may be higher in the calcareous and/or ferruginous granule component of the sample.

6. ACKNOWLEDGEMENTS

The following people and companies are thanked for their support and expertise in preparation of this report: KCGM Pty Ltd for allowing access to the site, supplying a vacuum rig and operator for the day, geological plans, regolith geochemistry and Au in soil geochemical data. In particular, I would like to thank R. Hutchison (KCGM) for his assistance. J.F. Crabb and R. Bilz for sample preparation; K. Lim and S. Derriman for sample preparation and selected analyses. A. Britt and G. Ashton for document proofing and formatting. C.R.M. Butt and D.J. Gray gave advice in the preparation of this report.

APPENDIX

Soils

Table A1: Profile description for Runway Prospect Profile 1 (of 1) 25400E 62200N. Erosional terrain.

Table A2: Tabulated geochemical data for profile samples from Runway Prospect.

Figure A1: Elemental abundances for Profile 1 at Runway Prospect

Figure A2: Elemental abundances for 0 - 0.5 m and >0.5 m samples from 62200N at Runway Prospect.

Table A3: Tabulated geochemical data for 0 - 2 m samples from 62200 N Runway Prospect.

Figure A3 Elemental concentrations for coarse size fraction (>1 mm) components (1 to 4) in 3 wet sieved samples (09-4325, 09-4333 and 09-4336) above mineralization at Runway.

Vegetation

Figure A4: Elemental abundances for vegetation (bluebush) samples from 62200N at Runway Prospect.

Table A1: Profile description for Runway Prospect Profile 1 (of 1) 25400E 62200N from erosional terrain. Colours expressed using Munsell notation.

Depth (m)	Description
0 - 0.25	Sandy clay with carbonate nodules (< 1 cm). Vegetative material present. Calcareous. Bright reddish brown (7.5YR 5/6) with some orange (7.5YR 7/6).
0.25 - 0.5	Silty sandy clay with carbonate nodules up to several centimetres. Highly calcareous. Orange (7.5YR 6/6) with some orange (7.5 YR 7/6).
0.5 - 0.75	Silty sandy clay with carbonate nodules (< 1 cm). Calcareous. Orange (7.5YR 6/6-7/6).
0.75 - 1.0	Silty sandy clay with carbonate nodules (< 1 cm). Calcareous. Orange (7.5 YR 7/6) with some yellow (2.5Y 8/6).
1.0 - 1.25	Clayey silt with friable nodules of saprolite and lithic fragments. Calcareous. Orange (7.5 YR 7/6) with some yellow (2.5Y 8/6).
1.25 - 1.5	Clayey silt with friable nodules of saprolite and lithic fragments. Calcareous. Yellow (2.5Y 8/6) with some pale yellow (5Y 8/3).
1.5 - 1.75	Clayey silt with friable nodules of saprolite and lithic fragments. Calcareous. Light yellow orange (10YR 8/4) with some pale yellow (2.5YR 8/4).
1.75 - 2.0	Clayey silt with friable nodules of saprolite and lithic fragments. Calcareous. Bright yellowish brown (10YR 6/6) with some light yellow orange (10YR 8/4) and greyish yellow brown (10YR 4/2).

Table A2: Tabulated geochemical data for profile samples from Runway Prospect. For all samples Ag (5), Ir (0.02), Lu (0.2), Mo (5), Se (5) and Ta (1) were at or below detection indicated in parentheses (ppm).

Sample	depth (m)	water-ex Au (ppb)	iodide-ex Au (ppb)	CN-ex Au (ppb)	moisture %	Ca (%)	Mg (%)	Au (ppb)	As (ppm)	Ba (ppm)	Br (ppm)
09-4326	0.125	0.88	20.84	8.4	5.3	7.0	0.44	41.8	183	226	9
09-4327	0.375	2	28.52	4.8	5.6	10.7	0.68	50.5	278	253	9
09-4328	0.625	1.6	30.12	2.8	7.9	12.3	0.94	53.0	195	298	8
09-4329	0.875	1.92	28.36	2.2	5.9	10.6	1.00	44.3	208	416	8
09-4330	1.125	1.72	30.28	1.4	6.3	6.9	0.70	38.7	273	518	7
09-4331	1.375	1.92	51.2	1.16	6.4	1.7	0.27	67.0	280	769	5
09-4332	1.625	2.44	71.6	1.76	7.0	1.4	0.23	81.8	403	749	7
09-4333	1.875	2.28	33.32	2.04	5.7	1.0	0.18	39.4	2740	880	9
Sample	**depth (m)**	**Ce (ppm)**	**Co (ppm)**	**Cr (ppm)**	**Cs (ppm)**	**Eu (ppm)**	**Fe (%)**	**Hf (ppm)**	**K (%)**	**La (ppm)**	**Na (%)**
09-4326	0.125	27	11	255	3	0.5	4.4	2.4	<0.5	14	0.16
09-4327	0.375	23	11	211	2	0.6	4.2	2.0	0.7	12	0.13
09-4328	0.625	22	10	202	2	<0.5	3.1	2.0	<0.5	11	0.15
09-4329	0.875	22	9	252	3	<0.5	2.7	2.3	0.5	11	0.20
09-4330	1.125	23	8	311	5	<0.5	2.8	2.5	0.8	11	0.25
09-4331	1.375	24	5	311	7	<0.5	2.0	3.0	1.5	12	0.34
09-4332	1.625	18	5	310	8	<0.5	2.4	3.3	2.1	9	0.39
09-4333	1.875	24	10	362	7	0.6	13.3	1.9	1.2	10	0.33
Sample	**depth (m)**	**Rb (ppm)**	**Sb (ppm)**	**Sc (ppm)**	**Sm (ppm)**	**Th (ppm)**	**U (ppm)**	**W (ppm)**	**Yb (ppm)**	**Zn (ppm)**	
09-4326	0.125	40	4	8	2.4	6	<2	5	1.1	<100	
09-4327	0.375	27	5	7	2.1	6	<2	5	0.9	<100	
09-4328	0.625	34	3	8	1.8	5	<2	<2	0.9	<100	
09-4329	0.875	31	3	8	1.8	5	<2	<2	0.7	<100	
09-4330	1.125	43	4	10	1.6	5	2	5	1.0	<100	
09-4331	1.375	71	4	13	1.3	6	2	11	1.1	<100	
09-4332	1.625	68	6	15	1.4	6	<2	13	1.2	104	
09-4333	1.875	70	42	18	2.0	10	5	45	1.0	177	

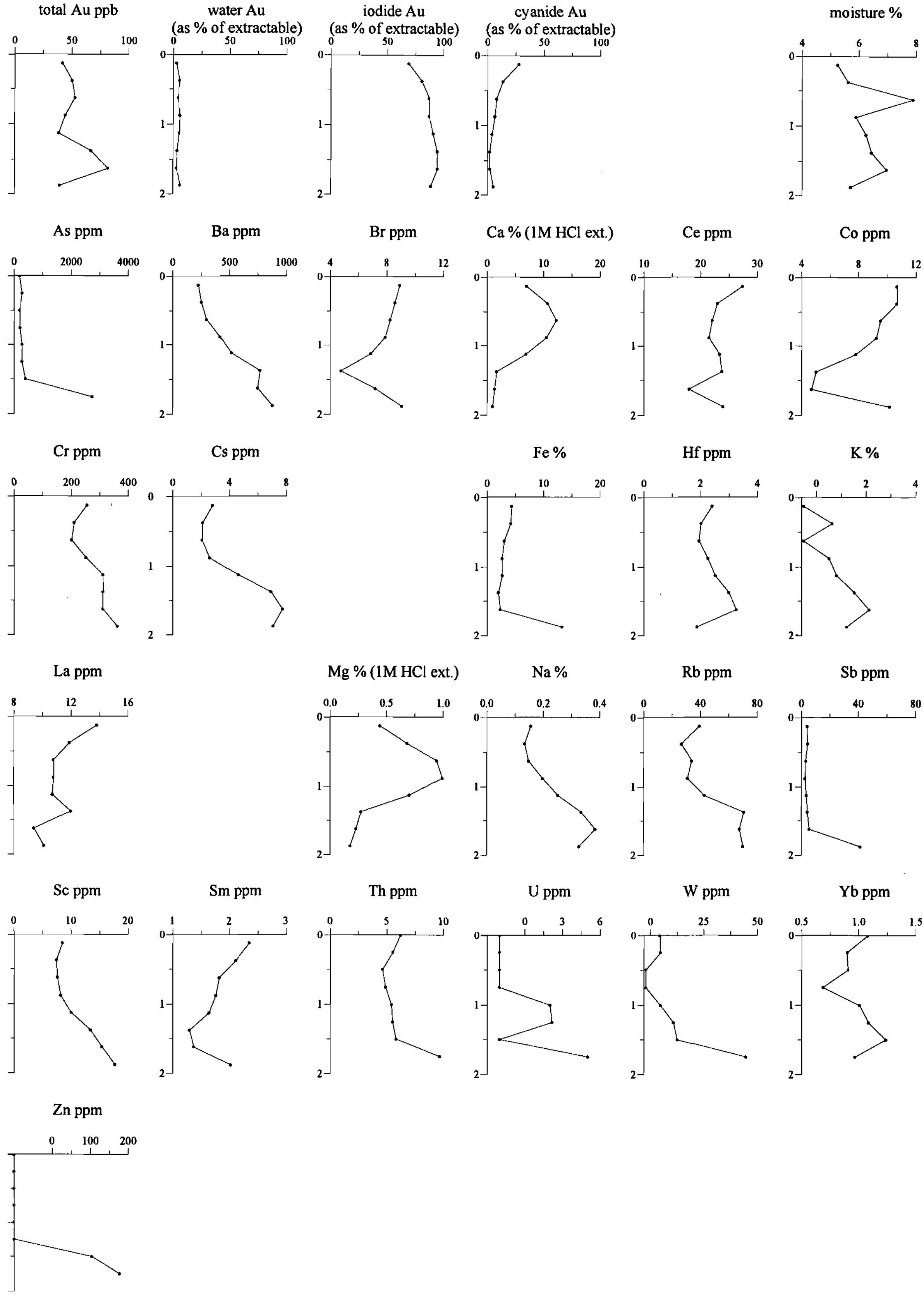

Figure A1: Elemental abundances for Profile 1 at Runway Prospect. For all samples, Ag (5), Eu (0.5), Ir (0.02), Lu (0.2), Mo (5), Se (5) and Ta (1) were at, near or below the detection limits indicated in parentheses (ppm). Y axis is depth (m).

RUNWAY

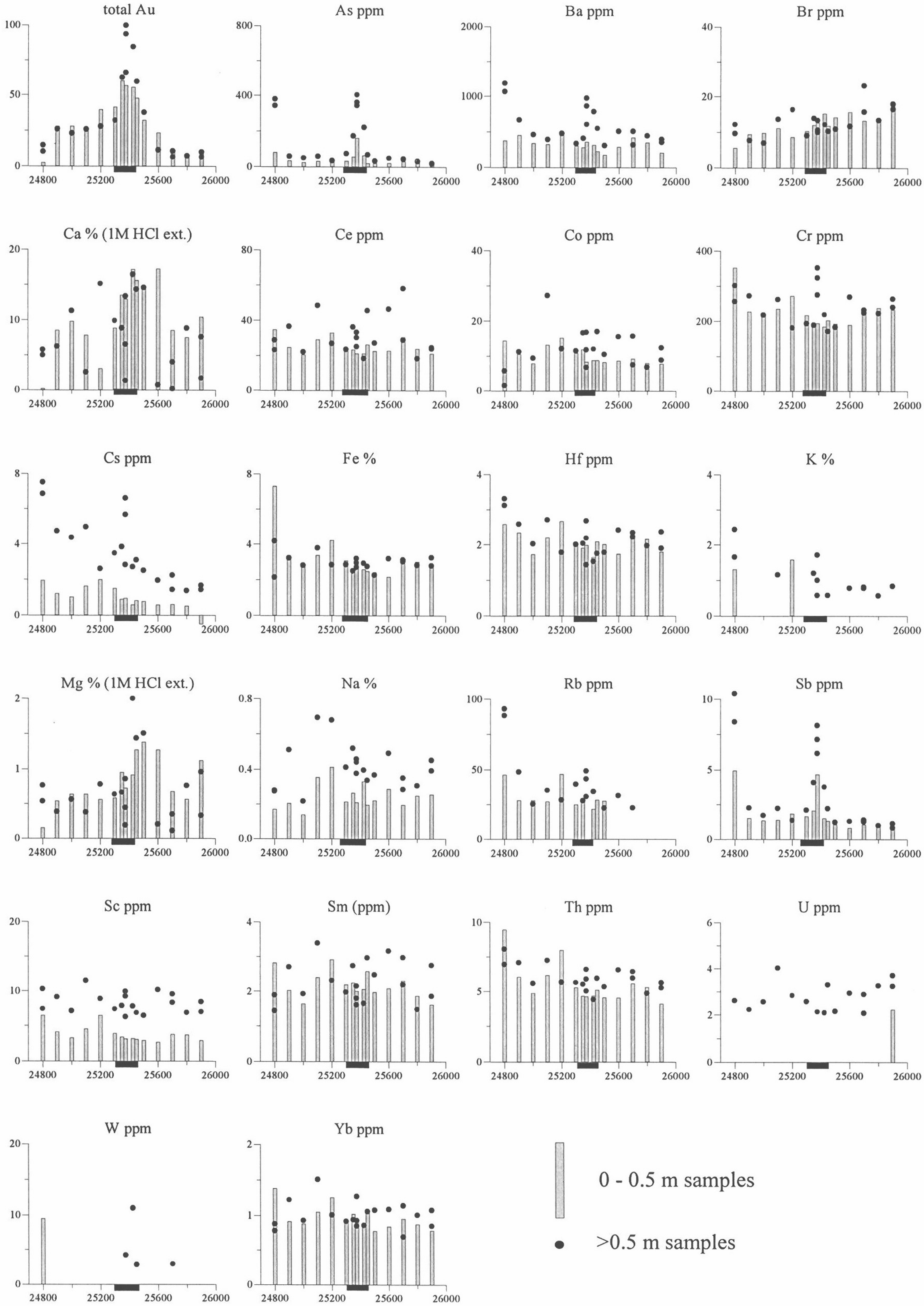

Figure A2: Elemental abundances for 0 - 0.5 m and >0.5 m samples from 62200N at Runway Prospect. Black area beneath x axis (easting) indicates position of mineralization. For all samples, Ag (5), Eu (0.5), Ir (0.02), Lu (0.2), Mo (5), Se (5) and Ta (1) were at, near or below the detection limits indicated in parentheses (ppm).

Table A3: Tabulated geochemical data for 0 - 2 m samples from 62200 N Runway Prospect.

Sample	E m	N m	D m	Ca %	Mg %	Au ppb	As ppm	Ba ppm	Br ppm	Ce ppm	Co ppm	Cr ppm	Cs ppm	Eu ppm	Fe %	Hf ppm	K %	La ppm	Na %	Rb ppm	Sb ppm	Sc ppm	Sm ppm	Th ppm	U ppm	W ppm	Yb ppm	Zn ppm
09-4298	25900	62200	0.25	10.4	1.1	12	16	211	18	21	8	234	<1	<0.5	2.7	1.8	<0.5	10	0.25	<20	1	6	2	4	2	<2	1	<100
09-4299	25900	62200	0.65	7.6	1.0	10	20	361	17	24	9	242	2	<0.5	2.8	1.9	<0.5	13	0.39	<20	1	7	2	5	4	<2	1	<100
09-4300	25900	62200	0.9	1.7	0.3	7	21	400	18	25	13	265	1	0.7	3.3	2.4	0.9	16	0.45	<20	1	8	3	6	3	<2	1	<100
09-4304	25800	62200	0.25	7.5	0.6	7	26	353	14	24	8	239	1	<0.5	3.0	2.2	<0.5	12	0.25	<20	1	7	2	5	<2	<2	1	<100
09-4305	25800	62200	0.75	8.9	0.8	7	32	452	14	19	7	224	1	0.5	2.8	2.0	0.6	11	0.31	<20	1	7	1	5	3	<2	1	<100
09-4308	25700	62200	0.25	8.5	0.7	10	30	420	13	31	9	220	1	<0.5	2.9	2.3	<0.5	15	0.19	<20	1	8	2	6	<2	<2	1	<100
09-4309	25700	62200	0.625	4.0	0.4	11	43	513	16	29	8	226	1	<0.5	3.0	2.4	0.8	18	0.29	<20	1	8	2	6	2	3	1	<100
09-4310	25700	62200	0.875	0.2	0.1	7	47	322	23	58	16	234	2	0.7	3.1	2.2	0.8	23	0.35	23	1	10	3	6	3	<2	1	<100
09-4314	25600	62200	0.25	17.2	1.3	23	21	291	16	23	9	190	1	<0.5	2.2	1.7	<0.5	12	0.29	<20	1	5	2	5	<2	<2	1	<100
09-4315	25600	62200	0.9	0.8	0.2	12	50	513	12	47	16	270	2	0.9	3.2	2.4	0.8	22	0.49	31	1	10	3	7	3	<2	1	<100
09-4318	25500	62200	0.25	14.8	1.4	32	19	178	14	23	8	193	2	0.5	2.4	2.0	<0.5	11	0.22	27	1	6	2	5	<2	<2	1	<100
09-4319	25500	62200	0.75	14.6	1.5	38	35	312	11	27	11	184	3	<0.5	2.3	1.8	<0.5	13	0.37	22	1	6	2	5	2	<2	1	<100
09-4322	25450	62200	0.25	15.6	1.3	48	20	229	12	26	9	202	2	0.6	2.5	2.1	<0.5	14	0.19	28	1	6	3	5	<2	<2	1	<100
09-4323	25450	62200	0.75	14.3	1.4	60	70	551	10	46	17	172	3	0.7	2.8	1.8	0.6	18	0.34	<20	2	7	3	6	3	3	1	<100
09-4324	25425	62200	0.25	17.2	0.9	56	64	316	15	21	9	185	1	<0.5	2.6	1.7	<0.5	11	0.33	22	1	6	2	5	<2	<2	1	<100
09-4325	25425	62200	0.75	16.5	2.0	85	223	787	12	19	12	220	3	<0.5	3.0	1.5	<0.5	9	0.40	34	4	8	2	4	2	11	1	<100
09-4334	25375	62200	0.25	13.0	0.7	57	162	361	13	21	8	194	2	<0.5	2.9	2.0	<0.5	12	0.21	<20	5	6	2	5	<2	<2	1	<100
09-4335	25375	62200	0.75	13.4	0.9	94	346	607	13	25	12	276	3	0.6	3.2	1.4	0.6	11	0.38	31	6	6	2	5	2	<2	1	<100
09-4336	25375	62200	1.25	6.6	0.4	100	363	866	10	33	17	353	6	<0.5	2.7	2.2	1.0	15	0.44	49	7	9	2	6	<2	4	1	<100
09-4337	25375	62200	1.75	1.4	0.2	66	405	977	11	30	7	324	7	<0.5	3.0	2.7	1.7	16	0.46	44	8	10	2	7	<2	<4	1	<100
09-4338	25350	62200	0.25	13.5	1.0	60	57	284	12	23	12	193	2	<0.5	2.7	1.9	<1	13	0.26	28	2	7	2	5	<2	<4	1	<100
09-4339	25350	62200	0.75	8.9	0.7	63	174	414	14	36	17	190	4	0.6	2.5	2.1	1.2	22	0.52	28	4	8	3	6	<2	<4	1	<100
09-4343	25300	62200	0.25	8.8	0.6	42	32	306	10	24	11	218	3	<0.5	3.1	2.0	<1	13	0.21	25	2	8	2	5	<2	<4	1	<100
09-4344	25300	62200	0.75	9.9	0.6	32	76	342	9	24	12	194	3	<0.5	2.9	2.0	<1	14	0.41	40	2	7	2	6	3	<4	1	<100
09-4347	25200	62200	0.25	3.1	0.6	40	33	478	9	33	15	272	4	0.8	4.2	2.7	1.6	18	0.41	47	2	13	3	8	<2	<4	1	127
09-4348	25200	62200	0.75	15.1	0.8	28	36	483	16	27	12	182	3	0.5	2.9	1.8	<1	14	0.68	28	1	9	2	6	3	<4	1	<100
09-4351	25100	62200	0.25	7.8	0.6	27	31	327	11	29	13	236	3	<0.5	3.4	2.2	<1	14	0.35	27	1	9	2	6	<2	<4	1	<100
09-4352	25100	62200	0.65	2.6	0.4	26	60	396	14	49	27	263	5	0.8	3.8	2.7	1.2	19	0.69	35	2	12	3	7	4	<4	2	<100
09-4353	25000	62200	0.25	9.8	0.6	28	25	342	10	21	8	219	2	<0.5	2.9	1.7	<1	10	0.14	28	1	7	2	5	<2	<4	1	<100
09-4354	25000	62200	0.75	11.4	0.6	23	50	466	7	22	9	219	4	<0.5	2.8	2.0	<1	12	0.22	25	2	7	2	6	3	<4	1	<100
09-4355	24900	62200	0.25	8.5	0.5	28	35	454	9	25	11	228	2	0.5	3.4	2.3	<1	13	0.20	28	1	8	2	6	<2	<4	1	<100
09-4356	24900	62200	0.75	6.3	0.4	26	60	671	8	37	11	273	5	0.5	3.2	2.6	<1	17	0.51	48	2	9	3	7	2	<4	1	<100
09-4357	24800	62200	0.25	0.2	0.1	<5	82	377	6	35	14	352	4	0.6	7.3	2.6	1.3	17	0.17	46	5	13	3	9	<2	9	1	124
09-4358	24800	62200	0.75	5.8	0.8	11	381	1070	12	23	6	302	7	0.5	4.2	3.3	1.7	12	0.28	88	8	10	2	8	<2	<4	1	101
09-4359	24800	62200	1.25	5.0	0.5	15	344	1190	10	29	2	257	8	0.5	2.2	3.1	2.4	18	0.28	93	10	7	1	7	3	<4	1	<100

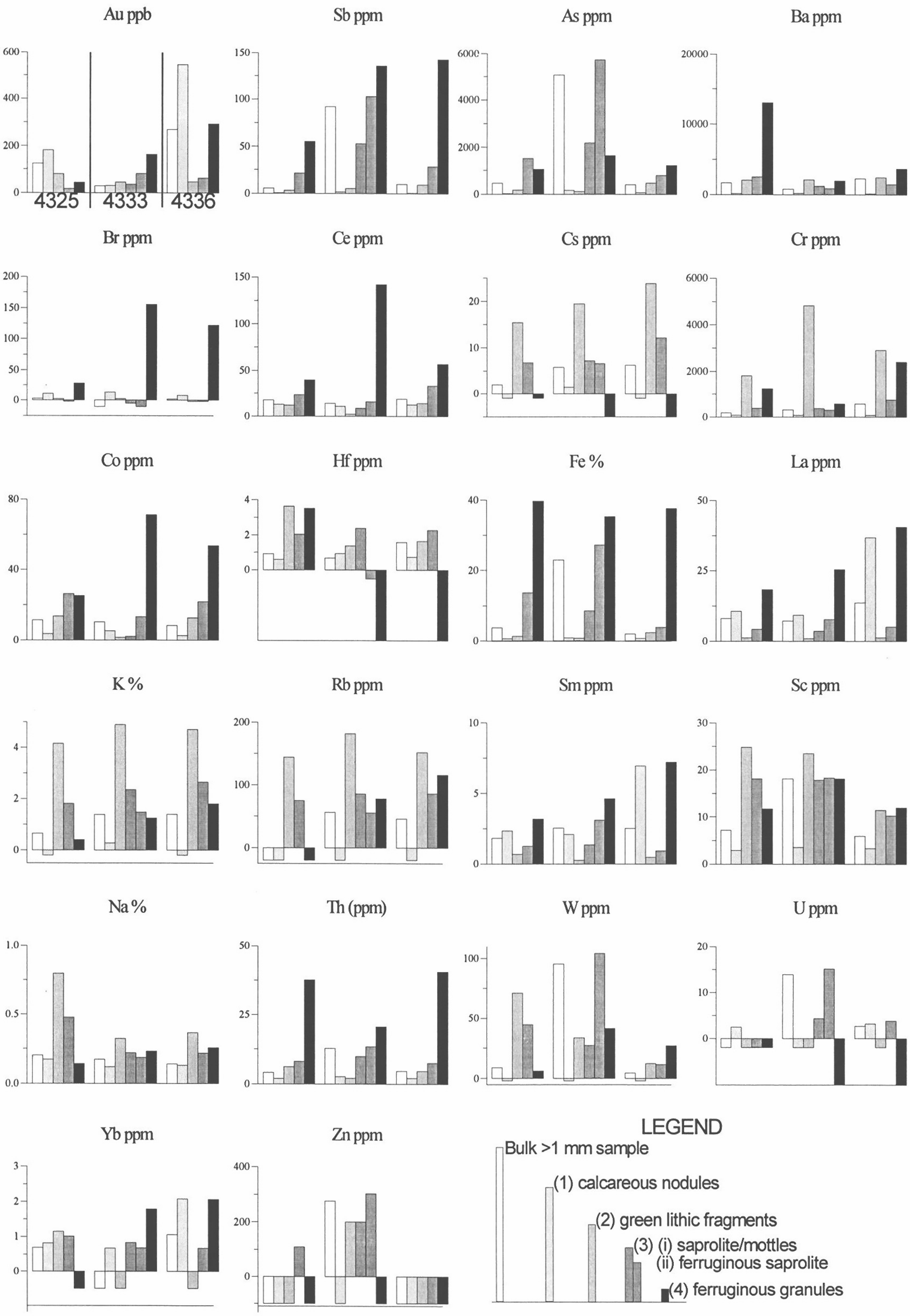

Figure A3: Elemental concentrations for coarse size fraction (>1 mm) components (1 to 4) in 3 wet sieved samples (09-4325, 09-4333 and 09-4336) above mineralization at Runway. Eu (0.5), Lu (0.2), Mo (5), Se (5), Ag (5) and Ta (1) near or below the detection limits (ppm, in parentheses) for all samples.

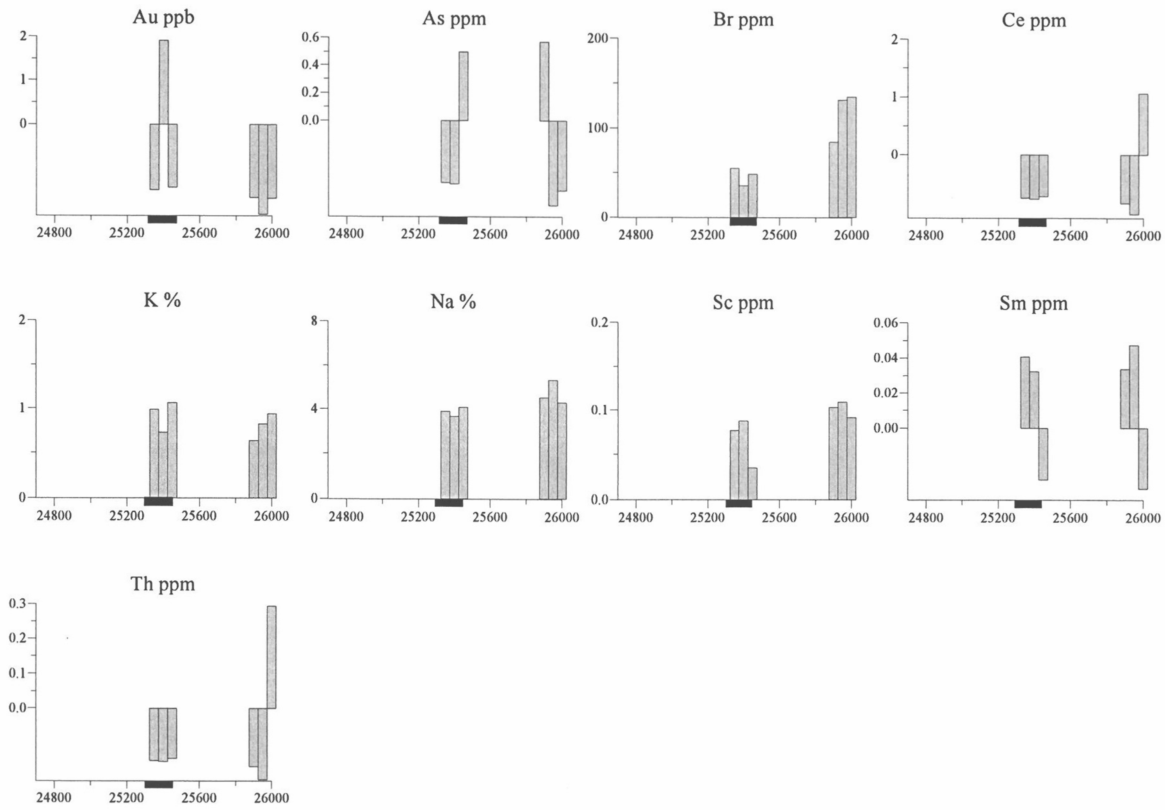

Figure A4: Elemental abundances for vegetation (bluebush) samples from 62200N at Runway Prospect. Black area beneath x axis (easting) indicates position of mineralization. For all samples Ag (1.5), Ba (40), Co (0.8), Cr (1.5), Cs (0.3), Fe (300), Hf (0.2), Ir (0.005), Lu (0.03), Mo (0.7), Rb (9), Sb (0.07), Se (1.5), Ta (0.7), U (0.3), W (0.6) and Yb (0.07) were at or below the detection limits indicated in parentheses (ppm). X axis is Easting (m). Negative data below detection.