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PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - ENIGMA PROSPECT (WOLLUBAR), WESTERN AUSTRALIA

M.J. Lintern and D.J. Gray

CRC LEME OPEN FILE REPORT 90

January 2001

(CSIRO Division of Exploration and Mining Report 98R, 2nd Impression.)

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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 90) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 98R, first issued in 1995, which formed part of the CSIRO/AMIRA Project P409.

Copies of this publication can be obtained from:
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PREFACE

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 biogeochemistry, hydrogeochemistry, soil and regolith geochemistry of the Enigma prospect at Wollubar.

This progress statement summarizes the recent investigations undertaken at the Enigma deposit at Wollubar. There were many reasons for selecting Enigma for further study which include the medium grade Au mineralization and the remoteness of the deposit from potential contributing upstream sources.

This is one of a number of similar studies in the Kalgoorlie-Kambalda region investigating whether there is a surface geochemical expression to gold mineralization concealed within or beneath sediments in palaeodrainages. Other sites that are, or have been, studied are Zuleika Sands (Ora Banda), Mulgarrie, Panglo (southern extension), Baseline, Lady Bountiful Extension, Kanowna QED, Kurnalpi, Argo and Steinway.

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

January 1995.

PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - ENIGMA PROSPECT (WOLLUBAR), WESTERN AUSTRALIA.

M.J. Lintern and D.J. Gray

SUMMARY

Investigations from previous AMIRA Projects have indicated that Au deposits may have geochemical expression throughout the regolith. In Project 409, knowledge gained from these earlier projects, dominantly in areas of erosional and relict landforms, is being extended to determine whether previously developed methods can be applied or adapted to depositional regimes. In the Kalgoorlie area, the work programme has been to investigate potential sample media in the transported regolith above mineralization at a number of dominantly palaeochannel environments. Specifically, the study has investigated the presence of:

(i) Gold in surficial horizons;
(ii) Sub-surface gold in transported overburden;
(iii) Pathfinder elements in transported and relict regolith and bedrock.

This progress statement summarizes the recent investigations undertaken at the Enigma Au deposit located 30 km south-east of Kalgoorlie. The Enigma site was chosen for further study for several reasons including the moderate Au grades in mineralization and the remoteness of the deposit from potential contributing upstream sources.

The results indicate:

1. that total, water-soluble and iodide-soluble gold have no anomalies over mineralization.
2. that gold is associated with calcium in the top metre of the soil profile.
3. that gold in vegetation does not define the location of the mineralization.
4. drilling to the south of the Enigma deposit possibly has not gone deep enough.
5. cobalt, copper, molybdenum, lead, antimony and tungsten may be useful pathfinders for gold mineralization.

More information needs to be gathered from the Enigma area. Specifically, there is a need:

1. to construct regolith sections and plan for the area.
2. to detail important type sections for drilling programs which should be also verified by others; this could be easily achieved by archiving chip trays.
3. to collect further samples of ferruginous material from transported overburden, and material from saprolite and bedrock and analyse for tungsten and possibly cobalt, copper, molybdenum, lead and antimony.

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PROGRESS STATEMENT FOR THE KALGOORLIE STUDY AREA - ENIGMA PROSPECT (WOLLUBAR), WESTERN AUSTRALIA.

M.J. Lintern and D.J. Gray

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 and mineralization concealed by up to 20m of barren sediments and/or leached saprolite. In this project (P409), outcome of the previous projects are being further tested to determine whether similar procedures can be routinely applied in depositional regimes. This particular study is one of a series from the Kalgoorlie area, selected because of its high resource potential and the ubiquitous nature of near-surface carbonate and ferruginous material, that specifically examines sample media from the transported regolith to assess their potential for exploration. A multi-site approach has been adopted in order to examine (i) the effects of regolith types, and (ii) the potential to use similar sample media at different sites.

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

(i) 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. Failure to sample this horizon in an exploration programme will result in ineffective soil surveys;
(ii) ferruginous materials, particularly lateritic residuum.

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

(i) gold in surface horizons;
(ii) gold 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 four most suitable sites, namely Argo, Steinway, Kurnalpi and Wollubar, were selected for more detailed investigations of the geochemistry of regolith materials, vegetation and groundwater (Figure 1). Some investigations of transported environments that were undertaken in previous studies (*e.g.*, at the Panglo and Zuleika Au deposits) will be also be discussed.

This progress statement summarizes the investigations undertaken at the Enigma deposit at Wollubar. There were several reasons for including the Enigma site for further study, including the moderate amount of drilling available for sampling and the remoteness of the location from (potentially contaminating) known Au deposits.

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			
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 completed, due to pit excavation. Poor condition of drill material in top 10 m.
Steinway	In saprolite, 5 m beneath 30 m of transported sediments.	Known surficial anomaly. Extensive drilling available. Distant from known Au min.	Not scheduled to be mined. Weak mineralization.
Kurnalpi	At interface and saprolite, beneath 60 m of transported sediments.	Moderate drilling available. Distant from known Au min.	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.
Sites not chosen			
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.
Kat Gap (Forrestania)	Little information available.	Moderate drilling available. Distant from upslope Au min.	Depth of transported material not determined - may be thin.
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.
Mt Celia	Beneath 5 to 15 m of transported deposits.	Extensive drilling available. Distant from upslope Au min.	Not scheduled to be mined. Not typical of regolith in Kal. area.
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			
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.
Matt Dam	At interface and saprolite, 15m beneath 10m of transported sediments.	Extensively studied in earlier project. Known surficial anomaly.	This part of deposit not scheduled to be mined.
Baseline	Beneath 20 m of transported sediments.	Exposed pit. Known surficial anomaly.	Samples not available.
Panglo	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.

2. Site Description

This site is in a flat, depositional landscape with some development of ephemeral drainage in the west part of the study area. Vegetation is sparse and consists of eucalypt open woodland with eremophila, bluebush and other small shrubs, and a considerable groundcover of grasses; the area has been extensively logged in the past. The study area is adjacent to the Wollubar palaeochannel (Figure 2) - a large channel of presumed Tertiary origin in-filled with sediments of clays and sands (Commander *et al.*, 1992, Kern and Commander, 1993).

The regolith consists of a thin sand-rich top soil containing considerable quantities of ferruginous granules overlying a clay-rich red sub-soil. Carbonate infuses the top one to two metres of the red clays. Red clays with ferruginous granules continue from the soil to about 15m, the last few metres of which are intensely mottled. Pale (cream, yellow and pink) clays dominate the remaining transported overburden from 15m to 55m. Directly over the Wollubar palaeochannel, the presence of grey, reducing clays was noted from about 35m to the base of the channel. Sand grains (rounded to sub-rounded) can be sieved from the clays from 20m to 55m. Weathered bedrock occurs at about 55m.

The Enigma deposit at Wollubar is located about 5 km south-west of the Jubilee Gold mine. Mineralization is associated with sericitic schist (Ian Copeland, Normandy Poseidon Ltd, pers. comm., 1994). Gold mineralization also appears to have spread horizontally in sands immediately above and adjacent to the saprolite at the unconformity between the transported overburden and residual materials.

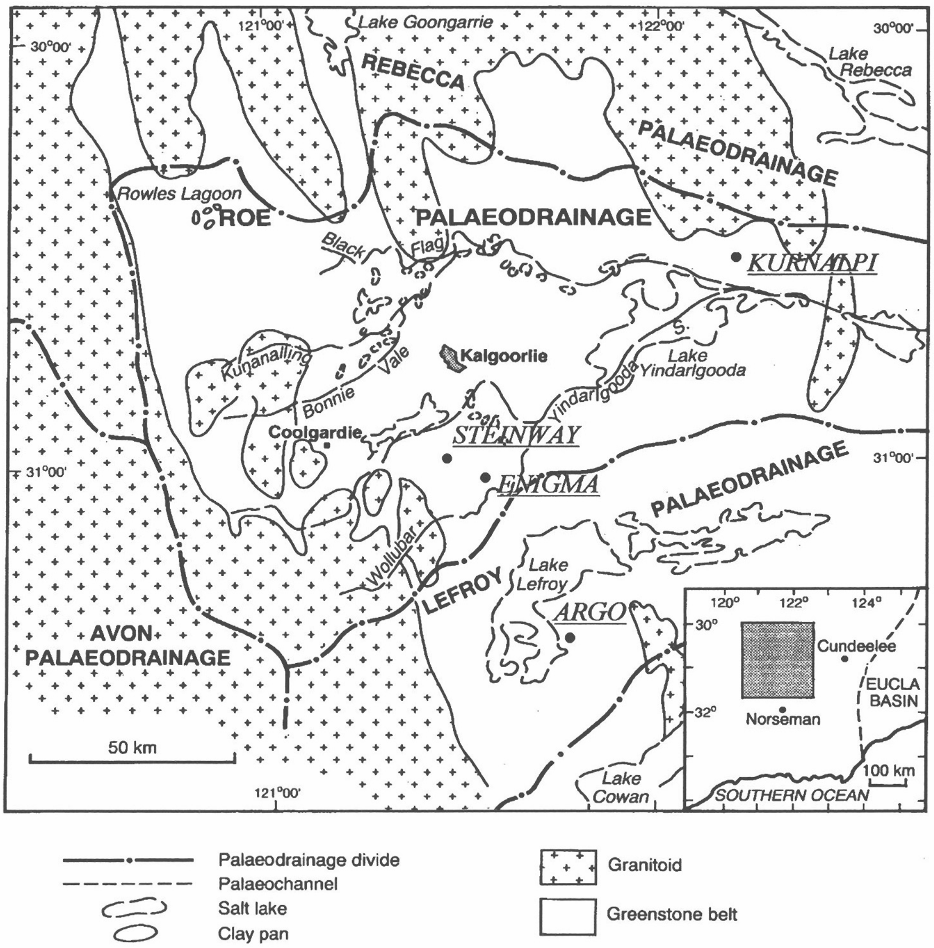


Figure 1: Location map (after Kern and Commander, 1993).

3. Methods

A selection of sample types were collected from the Enigma deposit and surrounding area. These included groundwaters (Gray, 1993), vegetation, soil (0 - 1 m composites), ferruginous granules (lag), ferruginous material separated from the transported material, saprolite and saprock. These samples have been analysed for a variety of elements and a synthesis of the results are presented below. All samples were analysed by CSIRO unless otherwise stated. The rationale for collecting these samples are as follows:

(i) groundwaters: may mobilize Au and be important in the formation of mineralized horizons and other anomalies in the soils and sediments. Elements may be mobilized via capillarity, vapours, gases or other means from the groundwater through the transported overburden to the surface. Redox fronts are known as important sites for the accumulation of Fe, Au and other elements;

(ii) vegetation: implicated in the mobilization of Au in erosional and relict landscapes; vegetation that made up the bulk of the above ground biomass was collected from above, adjacent and distant to mineralization;

(iii) soils: soil is a complex body of mineral and organic constituents, differentiated into horizons of variable thickness. Examination and analysis of different soil horizons provides detailed information on the preferential siting (if any) of elements and minerals. Knowledge of specific soil horizons allows better definition of anomalies that may be otherwise smothered or diluted by soil of lower element concentration *e.g.*, the depth of soil sampling (such as 0 - 0.1 m or 0.1 - 0.2 m) may be critically important. Deeper composites (*i.e.*, 0 - 1 m) can be readily collected by augering; this technique is being extensively used for Au exploration in erosional and relict landforms. The carbonate horizon is an important sample medium for Au and is nearly always present in the top 1 or 2 metres. Various soil samples were used for partial extraction studies to determine whether different reagents extract Au at concentrations and proportions depending on the soil type, horizon, geomorphology or proximity to mineralization. The partial extraction concentrations, rather than total content, may provide a better target anomaly;

(iv) ferruginous separations: Fe oxides are important scavengers of many elements, including Au. They occur as segregations, granules, mottles, pisoliths, buried laterite, lag and coatings throughout the transported regolith;

(v) saprolite, saprock and bedrock: weathered and fresh material from beneath the transported overburden material was sampled and analysed for a suite of elements. Other elements associated with mineralization may present a better target for exploration than Au itself.

3.1 Groundwater

Groundwaters were sampled for a previous study (Gray, 1993) along about 30 km of the Wollubar palaeodrainage system (Figure 2). Waters were analysed for pH, temperature, conductivity and oxidation potential (Eh) at the time of sampling, and for Na, Mg, Ca, K, SO_4, Sr, Ba, Al, Si, P, Ti, Cr, Mn, Fe, Co, Ni, Cu, Pb, Cd, Zn, Cs, Ba, Ga, Y, Mo, Ag, Sn, rare earth elements (REE), W, Hg, Tl, Bi, Th, U, Cl, Br and SO_4 in the laboratory. It was not possible to collect water samples from the Enigma deposit due to hole collapse.

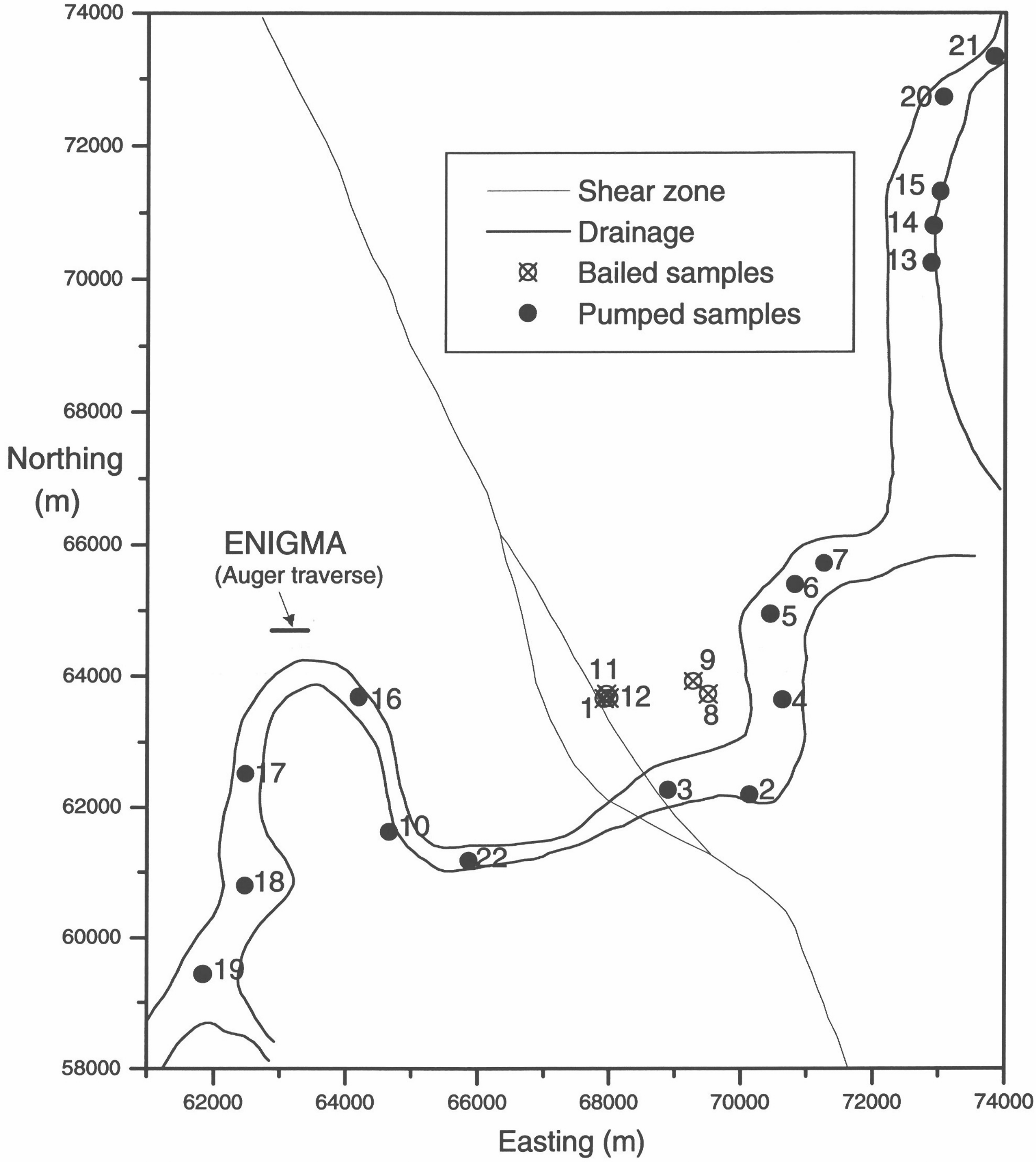


Figure 2: Hydrogeochemical sample points, auger traverse , main shear zone and palaeochannel locations at Wollubar (courtesy Newcrest Mining Ltd.).

3.2 Vegetation

Vegetation samples were collected using secateurs. New growth was sampled where possible and leaves were collected from large eucalypt trees. Mull was collected from around the base of the eucalypt trees. Samples were washed with copious amounts of hot water and then rinsed with deionised water, before being dried in an oven at approximately 70°C. The samples were macerated to a moderately fine powder in a cross-beater mill. Samples were analysed for the INAA element suite (see below).

3.3 Regolith sampling

3.3.1 Sample preparation and analysis

One to two kilos of sample were collected using a vehicle-mounted power auger. These were dried at 70ºC, split and jaw-crushed (as required) before a 100-200 g sub-sample was pulverized in a K1045-steel ring mill to nominal <75µm. The varying analyses used for the different sample types were:

(i) Gold only by INAA;
(ii) Antimony, 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 by Instrumental Neutron Activation Analysis (INAA) at Becquerel Laboratories, Lucas Heights;
(iii) Bismuth, Cu, Fe, Mn, Ni, Pb, Sr, Ti, Zn and Zr by X-ray fluorescence (XRF; pressed powders);
(iv) Calcium and Mg by atomic adsorption spectrophotometry (AAS) after digesting in 5M HCl for 15 minutes and then diluting to 1M HCl;
(v) Salinity of soil slurry (1 part soil to 2 parts deionised water) using a conductivity meter.

3.3.2 Ferruginous granules

Lag samples were collected from the surface using a dust pan and brush, and sieved retaining the 2 mm to 6 mm size fraction. Samples were analysed by INAA for Au only.

3.3.3 Soil traverses

Samples were collected using a vehicle-mounted, power auger and analyzed for the INAA, XRF and AAS element suites. In addition, Normandy Poseidon personnel performed duplicate (64700N) and additional augering (64500N and 64800N). These samples were analysed for Au (AAS), after aqua regia digest.

3.3.4 Material separated from the transported overburden

Samples were collected from selected depths from 6 RC drill hole cuttings (Appendix 5), wet sieved through a (approximately) 0.8 mm screen, hand sorted, and the ferruginous fraction (granules, mottles and pisoliths) collected and analysed for the INAA and XRF element suites. Some samples were analysed for additional elements by XRF (fusion and pressed powders) and details of these are given in Appendix 7.

3.3.5 Material separated from saprolite and saprock.

A selection of samples was collected from 3 RC drill hole cuttings (Appendix 6), jaw-crushed as required (Denver jaw crusher) before pulverizing in a K1045-steel ring mill and analysed for the INAA and XRF element suites. Some samples were analysed for additional elements by XRF (fusion and pressed powders) and details of these are given in Appendix 7.

3.4 Partial extractions.

Three in-house partial extraction solutions (Gray and Lintern, 1993), were used to test the solubility of Au. In all cases, a 25 g portion of un-publicized 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 is measured. The three solutions are:

(i) deionised water: dissolves the most soluble Au.
(ii) iodide: a 0.1M KI solution is adjusted to pH 7.4 with HCl whilst CO_2 is bubbled through. This extraction dissolves more Au than water alone. Another form of this test did not involve pH adjustment; there is little difference in Au recovery between the two extraction variants when carbonate-rich soils are being analysed.
(iii) cyanide: 0.2% KCN solution saturated with CaO dissolves all but the most refractory Au - this can include larger pieces of Au and Au encapsulated within resistant material such as quartz.

The partial extraction tests were performed either on separate portions of the same sample or as a sequential extraction starting with water and finishing with cyanide. Batch effects have previously been noted with deionised water extraction and so all partial extraction tests were performed under identical conditions and at the same time; the reason for the batch effects has not been determined but does NOT occur with iodide or cyanide soluble Au.

4 Results

4.1 Groundwater

Groundwater results have been reported previously (Gray, 1993). Groundwaters were acid, with pH varying from near 6 at the northern part of the study area down to 3 in the western arm, with groundwater near the Enigma deposit having pH values between 3.2 and 3.6 (*i.e.*, highly acid). In general, results for the Wollubar Palaeochannel closely match observations at other sites with acid groundwaters, with the major difference that the Wollubar groundwaters are Fe-rich, and therefore tend to have lower Eh values. The mineral phases that appear to be equilibrating with some or all of the groundwaters, and the elements being controlled are:

(i) gypsum (Ca);
(ii) barite (Ba);
(iii) amorphous silica, for pH < 4 (Si);
(iv) jurbanite ($AlOHSO_4$), for pH < 5 (Al);
(v) amorphous alumina, for pH > 5 (Al);
(vi) ferrihydrite [$Fe(OH)_3$], for pH > 4.5 (Fe);

With the exception of Au, for which speciation analysis works poorly, the minor elements were undersaturated with respect to their least soluble mineral phase, indicating that dissolution has occurred slowly and/or that concentration is being limited by other mechanisms such as sorption on, or co-precipitation with, iron oxides. Most metals (other than the higher charge ions Al, Sc, Cr and U), and particularly the base metals, show no clear relationship with pH, possibly because their abundance was also affected by other hydrogeochemical or lithological factors. The concentrations of REE were very high at Wollubar, both in the palaeodrainage and where acid waters are directly contacting Archaean rocks, being at least 5 times greater than for any other documented surface water or groundwater in the world.

Groundwater samples adjacent to the main Boulder-Lefroy shear (approximately 400 m east of the Enigma study area) showed particularly anomalous characteristics, being enriched in a "sulphide suite" (Ga, Fe, Mo, W, Ag, Hg and Tl), in acid soluble elements (Sc, Y, REE and, relative to the observed pH, Al, Si and U) and also Au and Pb. This may represent acid weathering of mineralized rocks, and indicates that even high flow palaeochannel groundwaters can have solution characteristics relating to underlying mineralization. However, groundwaters in the channel close to the Enigma study area have low dissolved Au concentrations (< 0.01 ppb) and no significant element anomalies.

4.2 Vegetation

There are no significant differences between Au content of vegetation (eucalypt leaves, eremophila, bluebush and mull) overlying mineralization compared with background (Table 2). The concentrations of Au were lower than those found in the depositional regime over mineralization at Zuleika, which had up to 0.6, 7.9 and 5.8 ppb in eucalyptus, bluebush and mull, respectively (Lintern and Butt, 1992). The maximum concentrations for eucalyptus leaves and eremophila over the palaeochannel mineralization at Panglo (Lintern and Scott, 1990) were 0.1 and 1.4 ppb, respectively;

results at Enigma were similar for these sample types. Maximum reported Au values for vegetation from erosional and/or relict areas at Bounty (Lintern, 1989), Zuleika, and Panglo were an order of magnitude greater than those from Enigma.

Table 2: Results of Au analyses (in ppb) of dried vegetation from Wollubar-Enigma.

Sample Type	Mineralization	Adjacent to Mineralization	Background
Eucalypt leaves	<0.5	<0.5	<0.5
Eremophila	<0.5	0.6	1.6
Bluebush	4.3	2.2	3.1
Mull	2.1	2.8	3.0

Bromine in eremophila and W in mull showed slightly greater concentrations over, or close to, mineralization. None of the other elements analysed for showed significantly higher concentrations above mineralization, compared with either areas adjacent to mineralization or background (Appendix 3).

4.3 Ferruginous granules

All ferruginous granules from the surface from 2800E to 3100E (64700N) contained less than 5 ppb Au.

4.4 Soil traverses

The distribution of Au does not appear to be related to the underlying mineralization (Figure 3). Gold concentrations were generally low (mean 12 ppb, maximum 25 ppb), and several were below the detection limit of 5 ppb, including 2 samples directly over mineralization. A duplicate set of 0 - 1 m samples (collected and analysed by Normandy Poseidon Ltd. personnel) also showed similar low Au contents, though one sample with 41 ppb was found directly over mineralization (Appendix 2); this may have been due to contamination since the corresponding result for the sample taken for CSIRO was below detection. Additional results for 64500N and 64800N were similar to those recorded for the other traverses (Appendix 2).

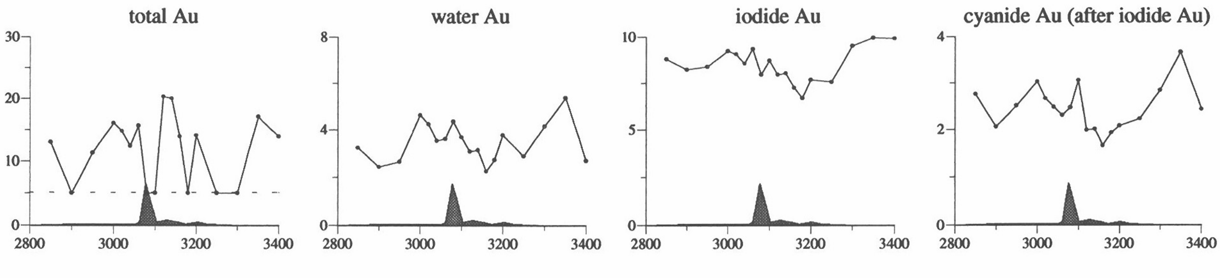


Figure 3: Total, water, iodide and cyanide Au values for 0 - 1 m samples from 64700N at Wollubar-Enigma. Dashed line represents the detection limit. Hatched area locates mineralization. X axis is Easting (m).

Calcium and Mg were evenly distributed for most of the traverse; the greatest Ca concentration was recorded in the two western most samples. Normalizing the Au data with respect to Ca or Mg does not produce any significant trends (Appendix 2).

The partial extraction of Au by water, iodide and cyanide did not produce any significant results (Figure 3). Water- and iodide-extractable Au were proportional to total Au (calculated as iodide and cyanide extractions combined). Marginally greater Au concentrations for the three extractions occur in the east of the traverse where no Au mineralization has been recorded. Normalizing (i) water-extractable Au with respect to iodide or total Au, and (ii) iodide to total Au, did not produce any significant trends (Appendix 2).

4.5 Material separated from transported overburden

Samples were grouped according to their proximity to mineralization. Nine (out of ten) ferruginous sub-samples separated from transported material were below the detection limit for Au; the exception being the sample closest to mineralization, which had a Au value of 8 ppb. Some samples superadjacent and directly above mineralization were more concentrated in As, Co, Cu, Eu, Lu, Mo, Pb, Sb, Sm and W, relative to background (Appendix 3).

4.6 Material separated from saprolite and saprock

Nine samples were grouped into three on the basis of Au content: less than 0.1 ppm, 0.1 to 1 ppm, and greater than 1 ppm. Most samples with high concentrations of Au (> 1 ppm) were higher in K, Ti, Co, Cr, Mo, Ni, Sb, Sc and W with a few samples also higher in Cu, Pb and Zn (Appendix 4).

5 Discussion

The Enigma deposit has no surface geochemical expression in total or partially extractable Au or in other elements. Water would be expected to dissolve the most active Au and thus include the most recently mobilized or introduced component. The absence of a response suggests that any introduced component is minimal in comparison with Au mobilized by normal soil processes. It is possible that the latter has led to a widespread homogenization of Au, a possible consequence being a broad lower order soil anomaly. Such an anomaly would only be apparent on a district scale and not with the short traverses examined here.

Gold in soil at Enigma is largely confined to the calcareous horizon which is generally restricted to the top 2m. Augering thus remains an effective sampling procedure. Although the results suggested here do not indicate mineralization, the procedure should not necessarily be abandoned for a first pass evaluation of depositional regimes because in other areas *e.g.*, Steinway, significant surficial anomalies have been found. The reasons for this have not been determined but, presumably, relate to some specific conditions. Conversely, a negative result should not be taken as conclusive.

Sampling of material from within the transported overburden and from underlying saprolite and bedrock indicates that certain elements may be useful as pathfinders for Au; these include Co, Cu, Mo, Pb, Sb, and W. Further samples should be collected from the deposit to substantiate this conclusion.

Accurate logging of selected drill holes on lines 64700N located the interface between transported and residual zones of the regolith, as defined by the presence or absence of transported sands. The sands consisted of rounded and sub-angular grains and were found to a depth of 55 m. Defining the position of the unconformity between transported material and *in situ* regolith is important. While rich Au grades are confined to a narrow portion of the saprolite, some Au appears to have formed a broad "mushroom" anomaly in an east-west direction along the interface, for at least 200 m, and centred on the rich grades located in deeper saprolite. Therefore, targeting of sample material from this interface by an exploration program is highly recommended. On 64000N, it appears that hole logging has at least partly relied on a section constructed a few years ago which (inaccurately) determined the base of the Wollubar Palaeochannel at 35m below the surface. The true depth of the palaeochannel sediments is at least 55m below surface based on (i) field observations of drill cuttings on 64700N and (ii) the work of Kern and Commander (1993). Unfortunately, over 100 RC holes have been drilled to 50 m or less and, therefore, finish in transported overburden rather than the interface or saprolite beneath this. In depositional regimes especially, it is important that drill hole material is accurately logged, *e.g.*, by wet sieving, in order that the interface can be identified and samples taken accordingly.

6 Recommendations

It is recommended that more information needs to be gathered from the Enigma area. Specifically, there is a need:

1. to construct regolith sections and plan for the area.
2. to detail important type sections for drilling programs which should be also verified by others; this could be easily achieved by archiving chip trays.
3. to collect further samples of ferruginous material from transported overburden, and material from saprolite and bedrock and analyse for W and possibly Co, Cu, Mo, Pb and Sb.

References

Commander, D.P., Kern, A.M. and Smith, R.A., 1992. Hydrogeology of the Tertiary Palaeochannels in the Kalgoorlie Region: Western Australian Geological Survey, Record 1991/10.

Gray, D.J., 1993. Investigation of the Hydrogeochemical Dispersion of Gold and other Elements in the Wollubar Palaeodrainage, Western Australia. (CSIRO/AMIRA P241A: Weathering Processes Group). CSIRO Division of Exploration Geoscience Restricted Report 387R. Vols I and II. 133pp.

Gray, D.J. and Lintern, M.J., 1993. Further aspects of the chemistry of gold in some Western Australian soils. (CSIRO/AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 391R. 50pp.

Kern, A.M. and Commander, D.P., 1993. Cainozoic stratigraphy in the Roe Palaeodrainage of the Kalgoorlie region, Western Australia. Geological Survey of Western Australia, Perth. *In* Professional Papers, Report 34, 85-95.

Lintern, M.J., 1989. Study of the distribution of gold in soils at Mt. Hope, Western Australia. (AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 24R. 36pp.

Lintern, M.J.. and Butt, C.R.M., 1992. The distribution of gold and other elements in soils and vegetation at Zuleika, Western Australia. (AMIRA P241A: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 328R. 90pp.

Lintern, M.J. and Scott, K.M., 1990. The distribution of gold and other elements in soils and vegetation at Panglo, Western Australia. (AMIRA P241: Weathering Processes). CSIRO Division of Exploration Geoscience Restricted Report 129R. 96pp.

Acknowledgements

The following people and companies are thanked for their support and expertise in preparation of this report: Normandy Poseidon Ltd. for (i) providing resources required for the auger survey and (ii) allowing access to the database for details on mineralization, soil anomaly plans and geology; J.F. Crabb for sample preparation; G.D. Longman for preparation of section figures, data base management, sample preparation and selected analyses; M.K. Hart for XRF analyses.

Appendices contents

Appendix 1: Vegetation results.

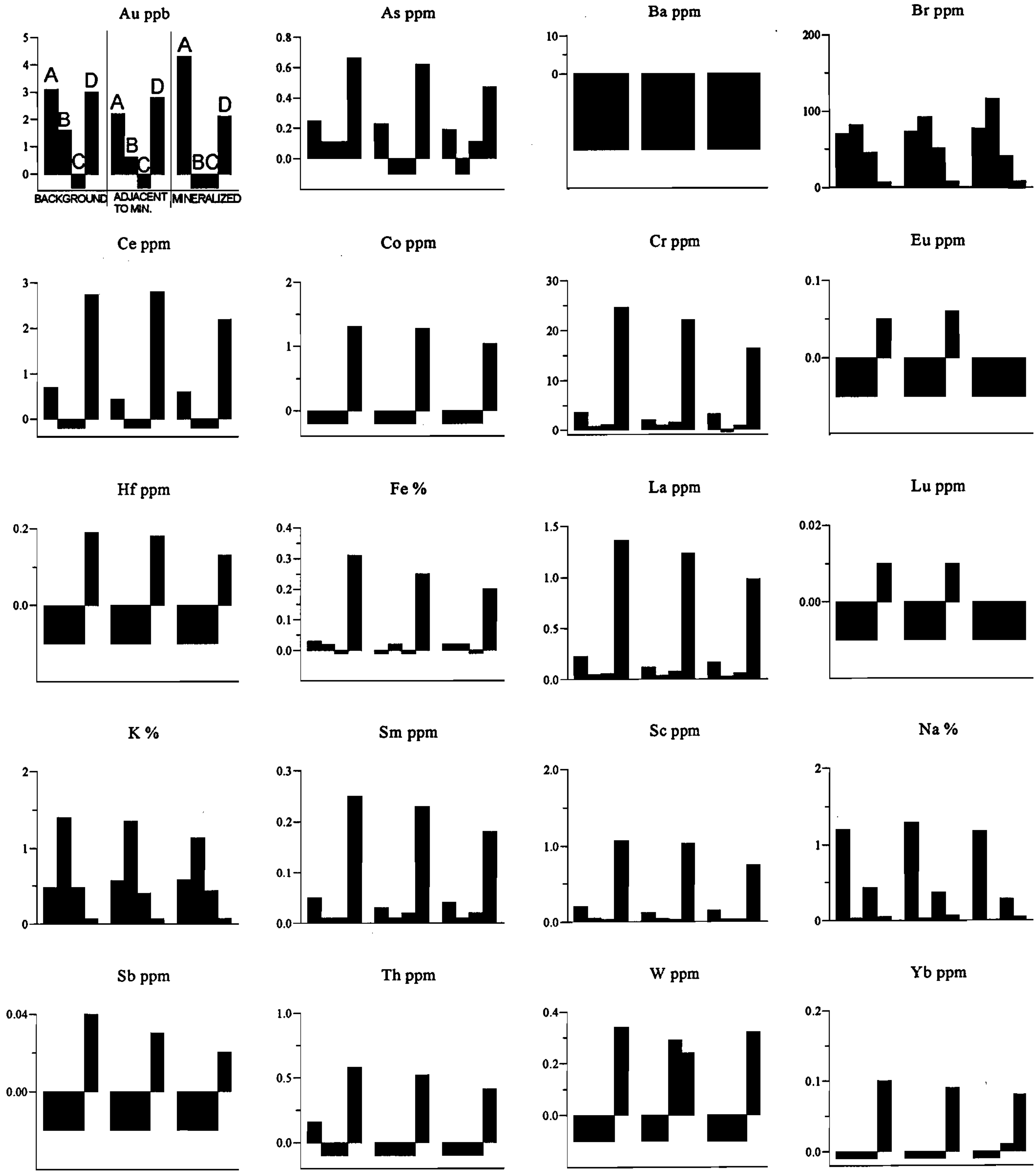


Figure A1: Elemental abundances for vegetation at Wollubar - Enigma.
Samples grouped according to proximity to mineralization.
Negative data below detection.
A) Bluebush; B) Eremophila; C) Eucalyptus; D) Mull.

Appendix 2: 0 - 1 m - graphed.

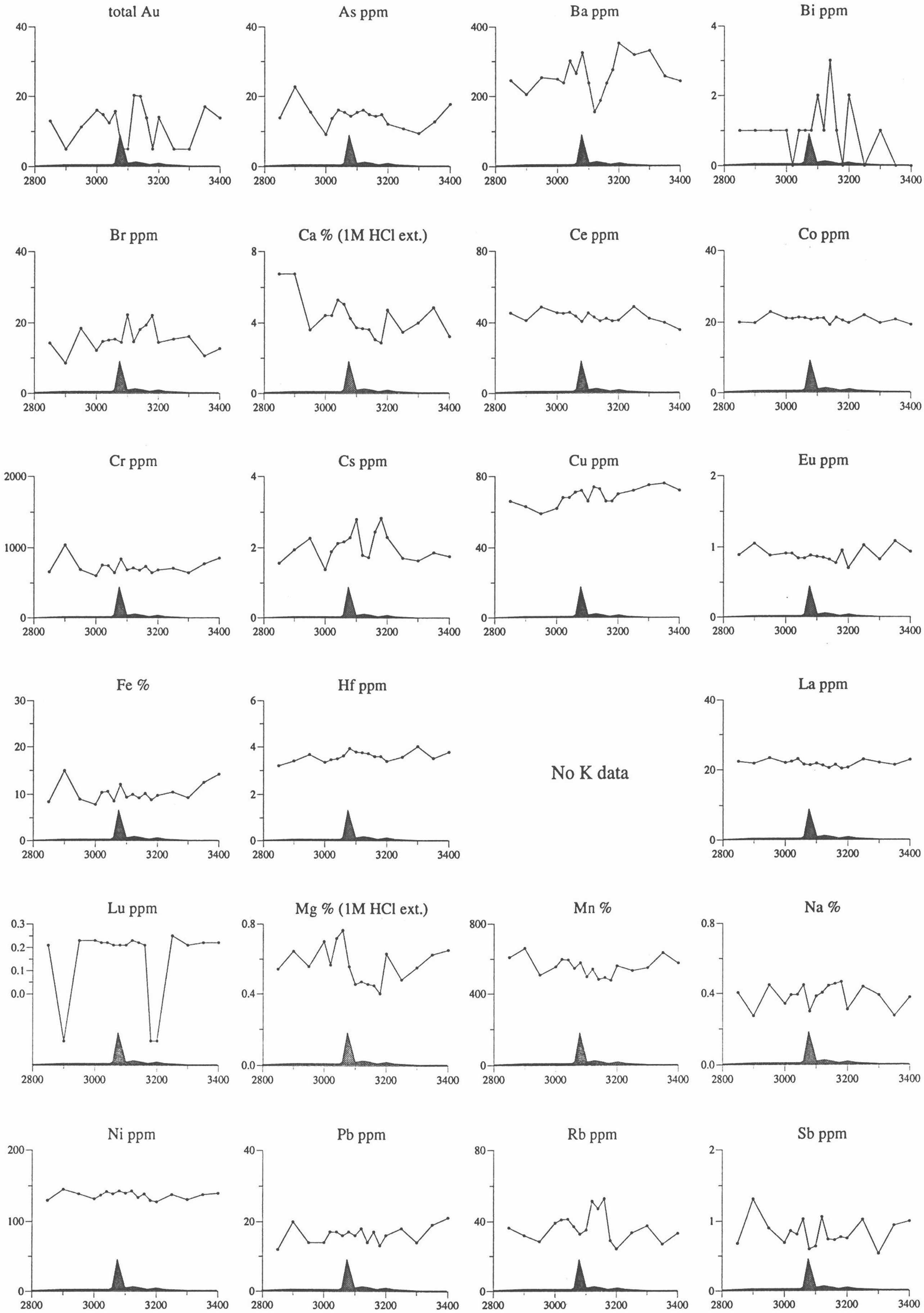


Figure A2.1: Elemental abundancies for 0 - 1m samples from 64700N at Wollubar-Enigma.
Hatched area indicates position of mineralization. X axis is Easting (m). Negative data is below detection.
For all samples Ag (5 ppm), Ir (20 ppb), Mo (5 ppm), Se (5 ppm) and W (2 ppm) were below detection indicated in brackets.

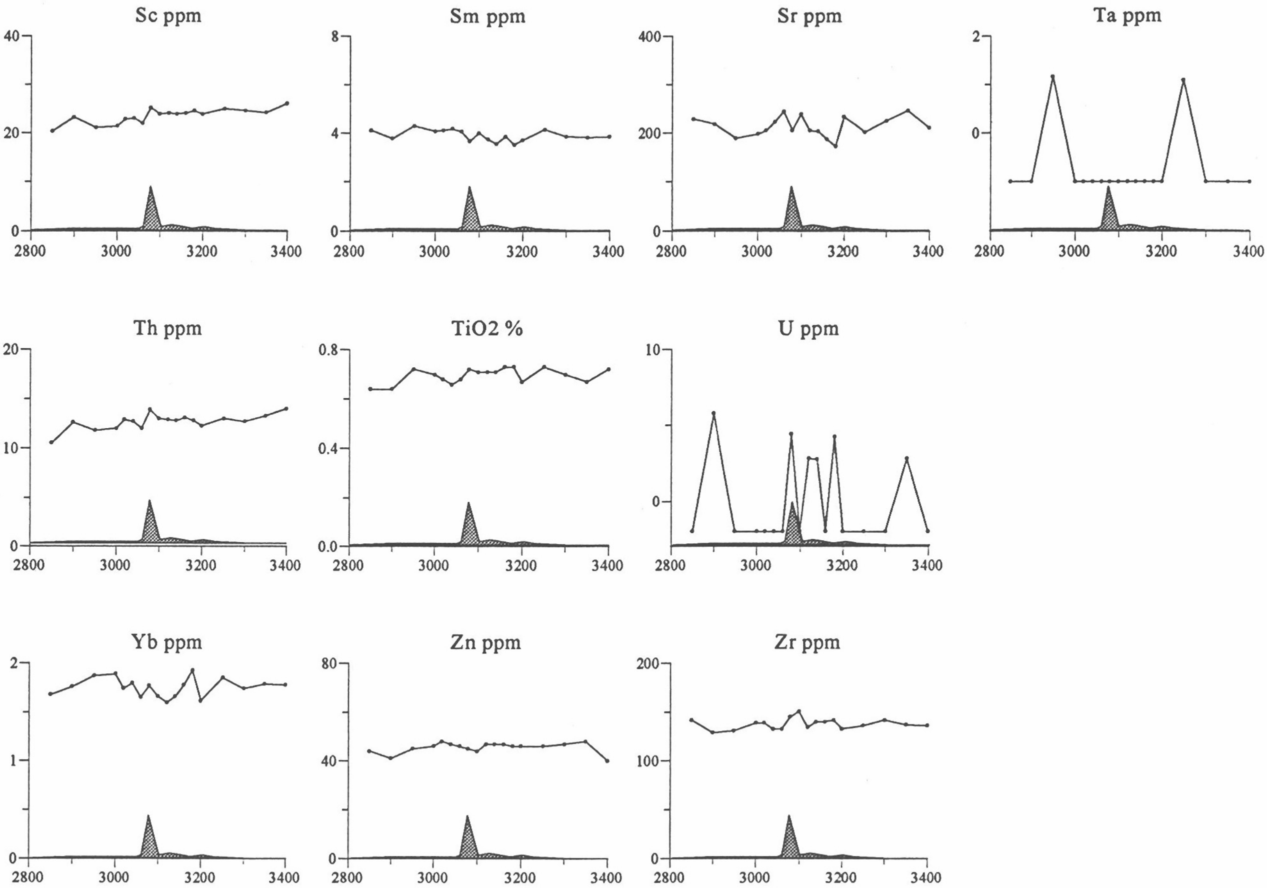


Figure A2.1 (continued).

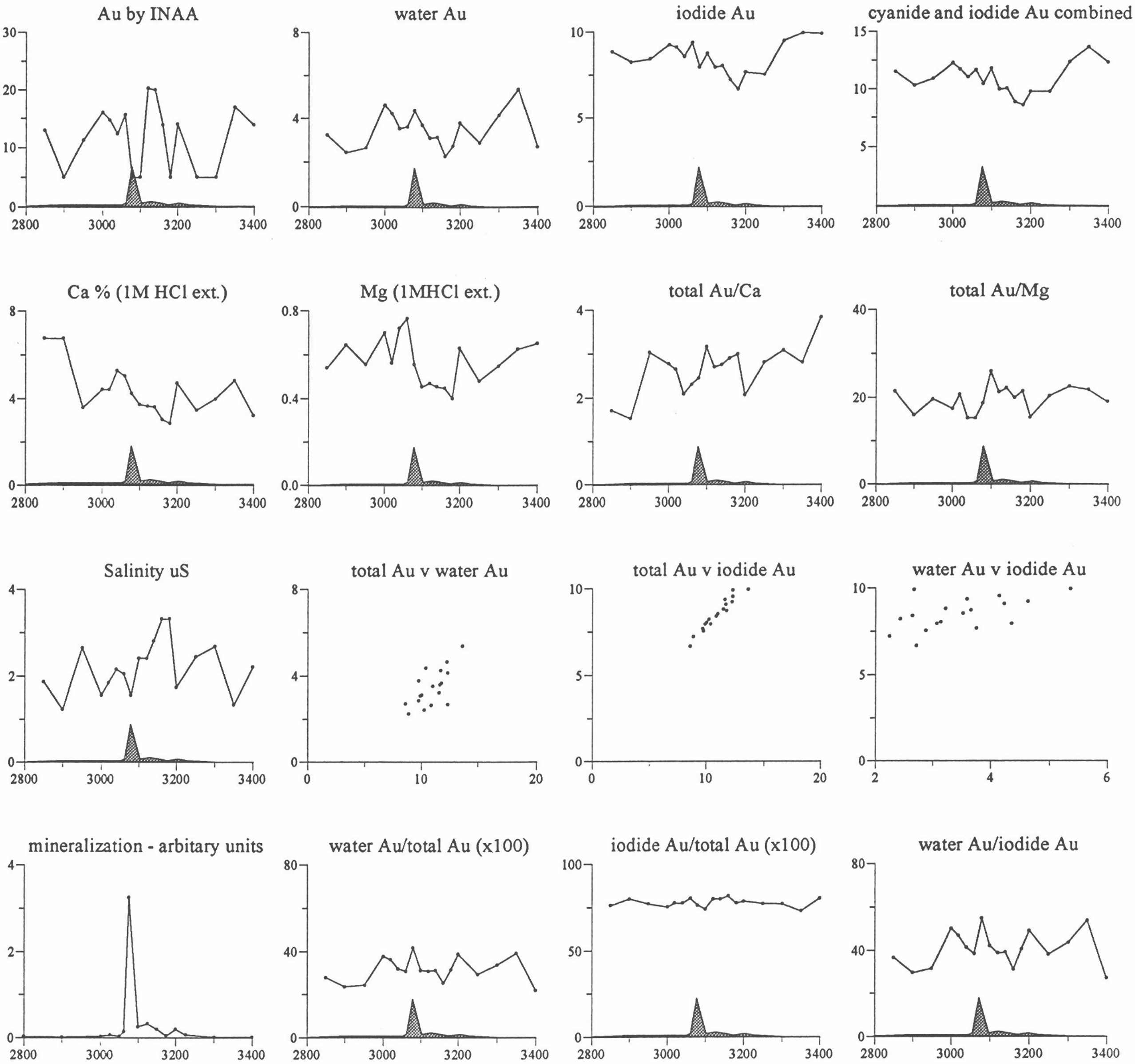
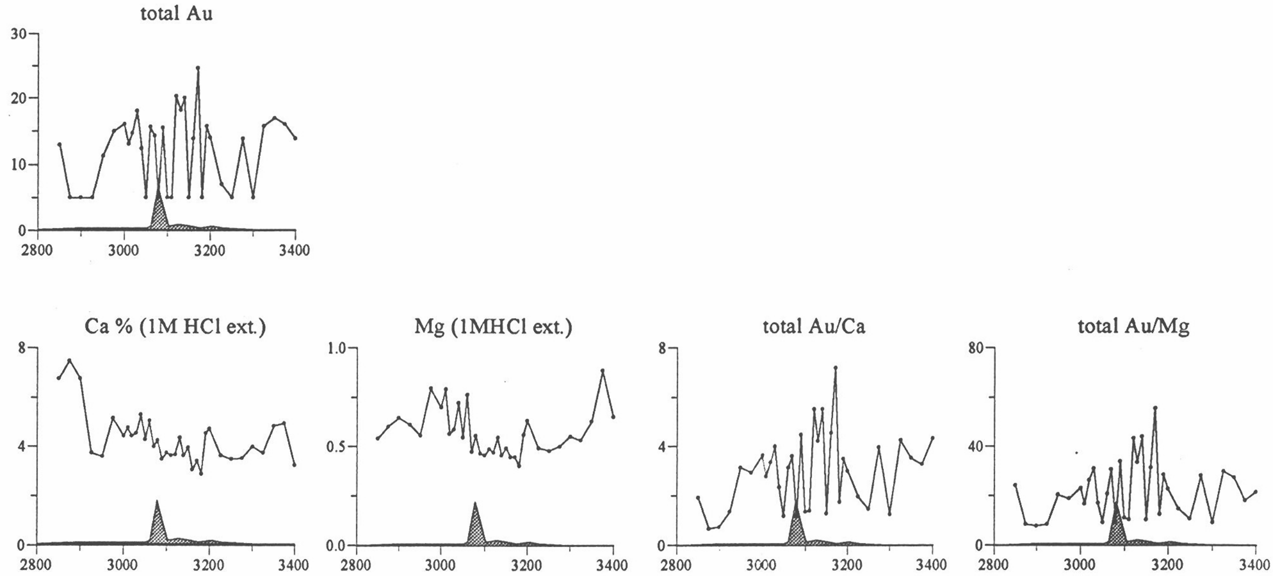
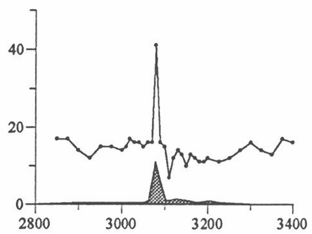


Figure A2.2: Elemental abundancies and scatter plots for 0 - 1 m samples from 64700N at Wollubar-Enigma.
All values in ppb unless otherwise stated.
For scatter plots first element in header is the X axis, otherwise X axis is Easting (m).
Hatched are indicates mineralization.
Ttotal Au in these plots refers to iodide and cyanide Au combined.
"Au by INAA" plot refers to Au in the solid sample.

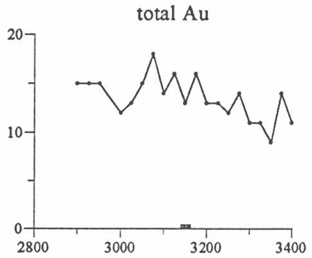
ENIGMA AUGER 0-1M 64700N CSIRO all 0 - 1 m samples INAA



ENIGMA AUGER 0-1M 64700N NORMANDY POSEIDON Aqua regia



ENIGMA AUGER 0-1M 64500N NORMANDY POSEIDON Aqua regia



ENIGMA AUGER 0-1M 64800N NORMANDY POSEIDON Aqua regia

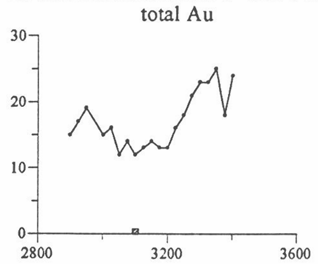


Figure A2.3: Gold, Ca and Mg abundances for 0 - 1 m samples from 3 traverses at Wollubar-Enigma.
Hatched area indicates mineralization.
X axis is Easting (m).

Appendix 3: Ferruginous material separated out from transported overburden - graphed.

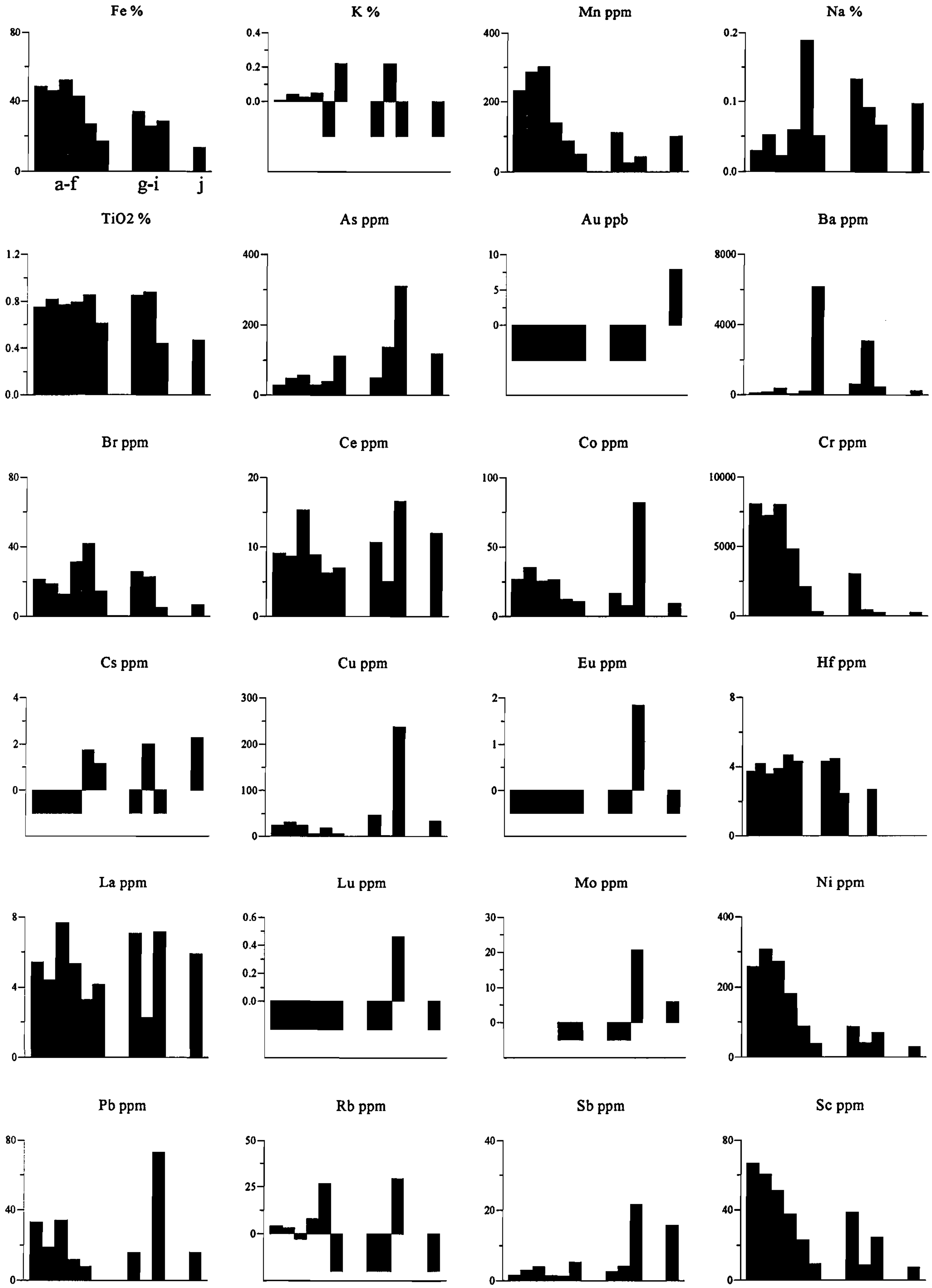


Figure A3: Elemental abundances for ferruginous material hand-picked from bulk sample from the transported overburden at Wollubar-Enigma
Samples a-f: <5 ppb Au and furthest from mineralization.
Samples g-i: <5 ppb Au and superadjacent to mineralization.
Sample j: 8 ppb Au and above mineralization.
Negative data below detection. See Appendix 7 for sample description and location.
Most samples were at or below detection indicated in brackets for Ag (5 ppm), Bi (1 ppm), Ir (20 ppb), Se (5 ppm) and Ta (1 ppm).

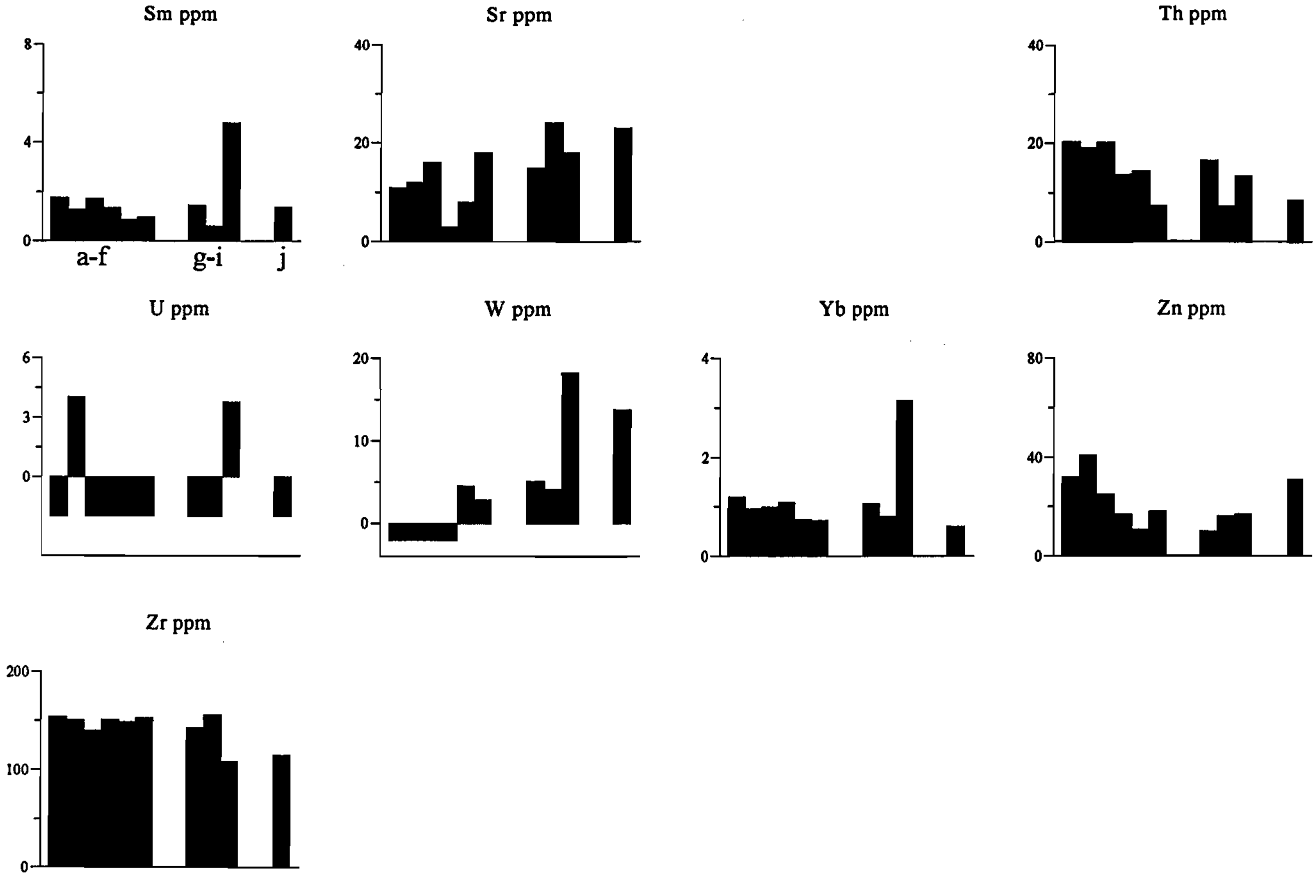


Figure A3 (continued).

Appendix 4: Saprolite and bedrock - graphed.

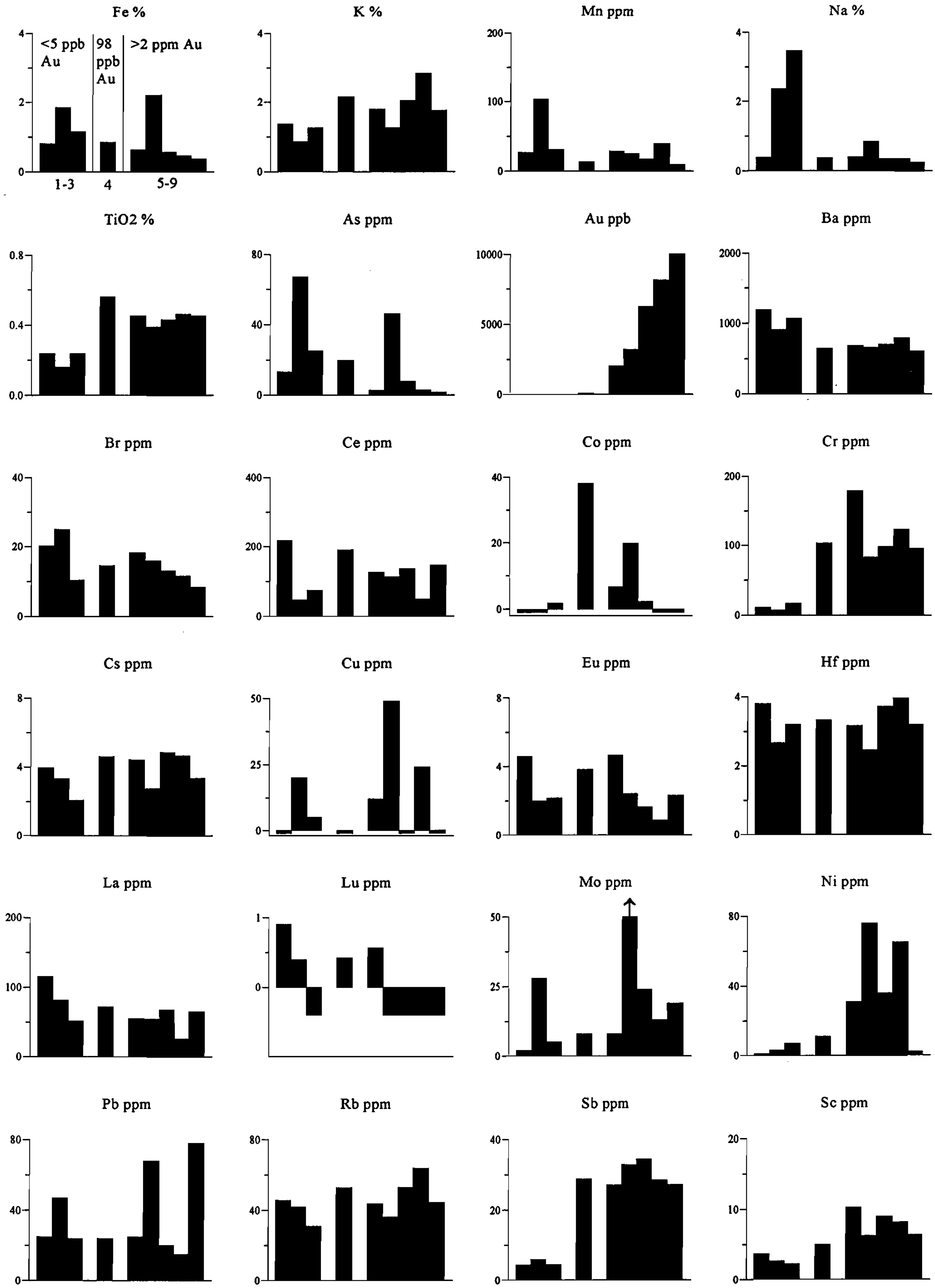


Figure A4: Elemental abundancies for selected saprolite and bedrock samples from Wollubar-Enigma.
See Appendix 7 for sample type and location.
Samples grouped into three according to Au content (<5 ppb, 98 ppb and >2 ppm).
Negative data below detection.
For all samples, Ag (5 ppm), Bi (1 ppm), Ir (20 ppb), Se (5 ppm), Ta (1 ppm) and U (2 ppm) were below detection indicated in brackets.

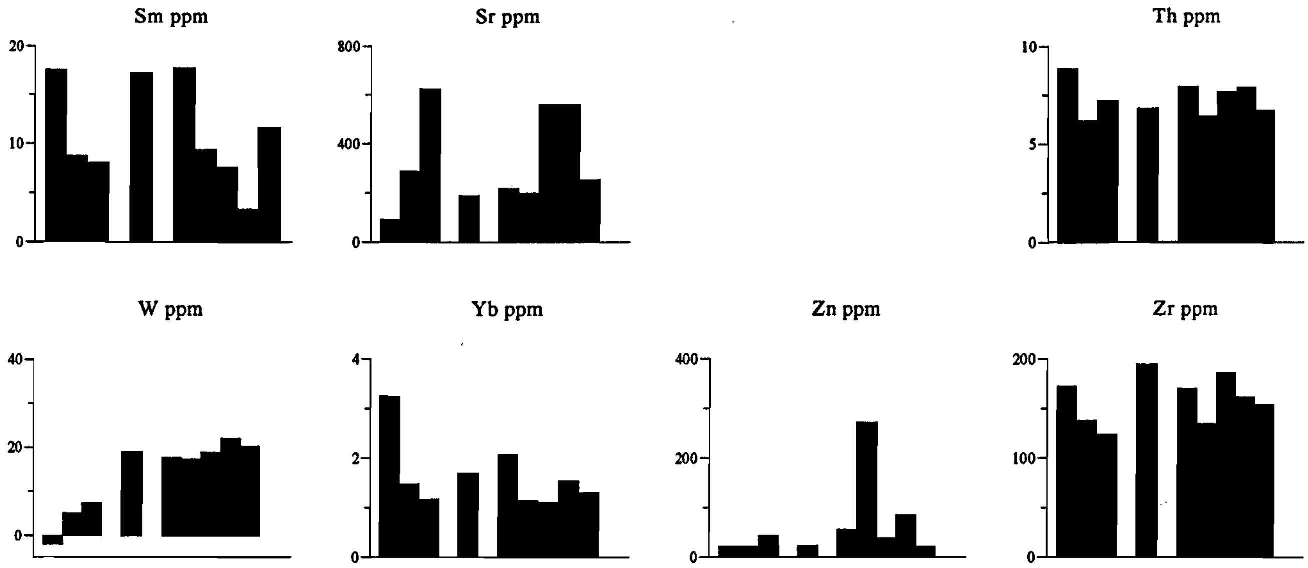


Figure A4 (continued).

Appendix 5: Selected scatter plots.

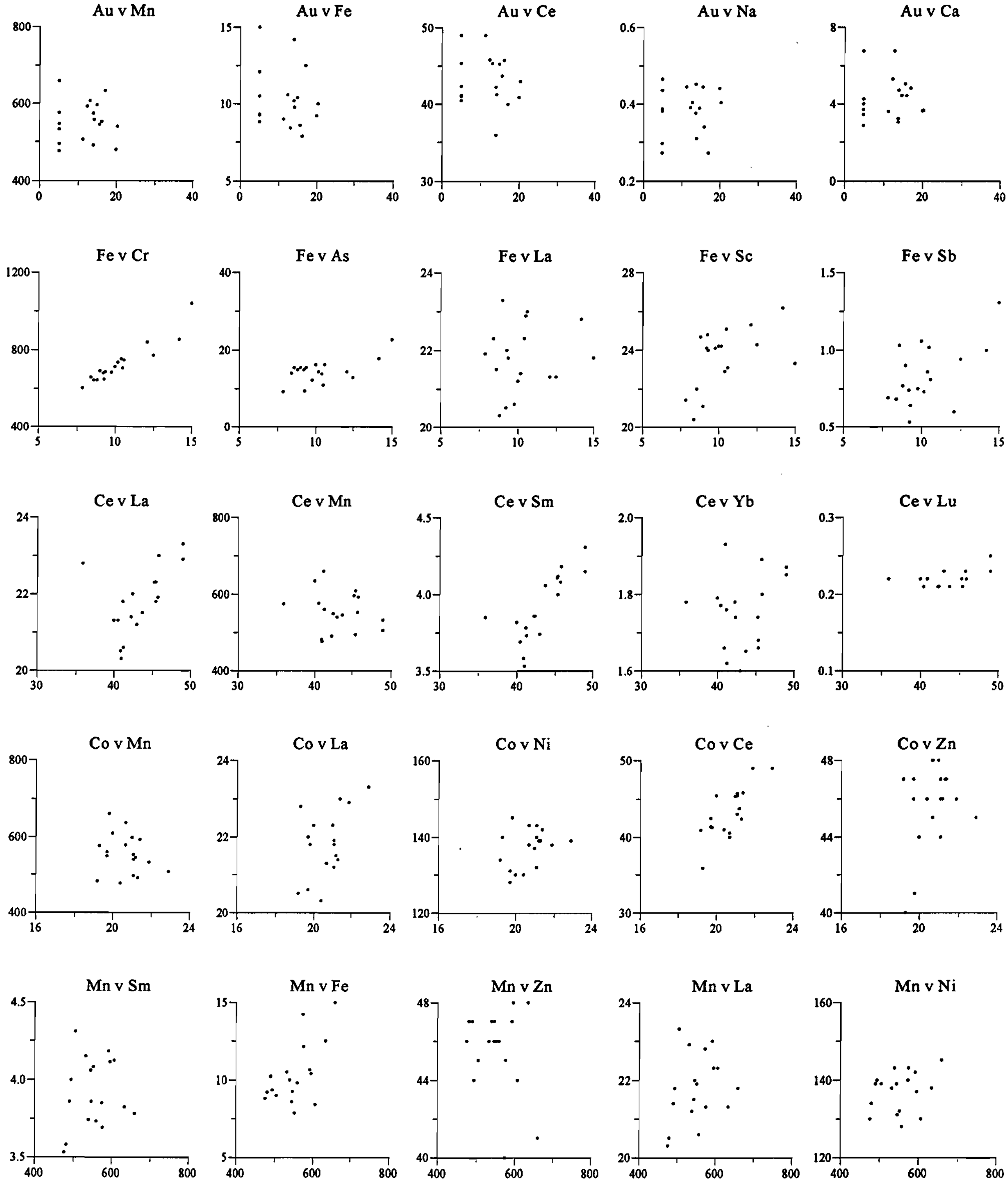


Figure A5.1: Selected scatter plots for 0 - 1 m bulk samples from 64700N at Wollubar-Enigma.
Majors in %, traces in ppm and Au in ppb.
First element in header is the x axis.

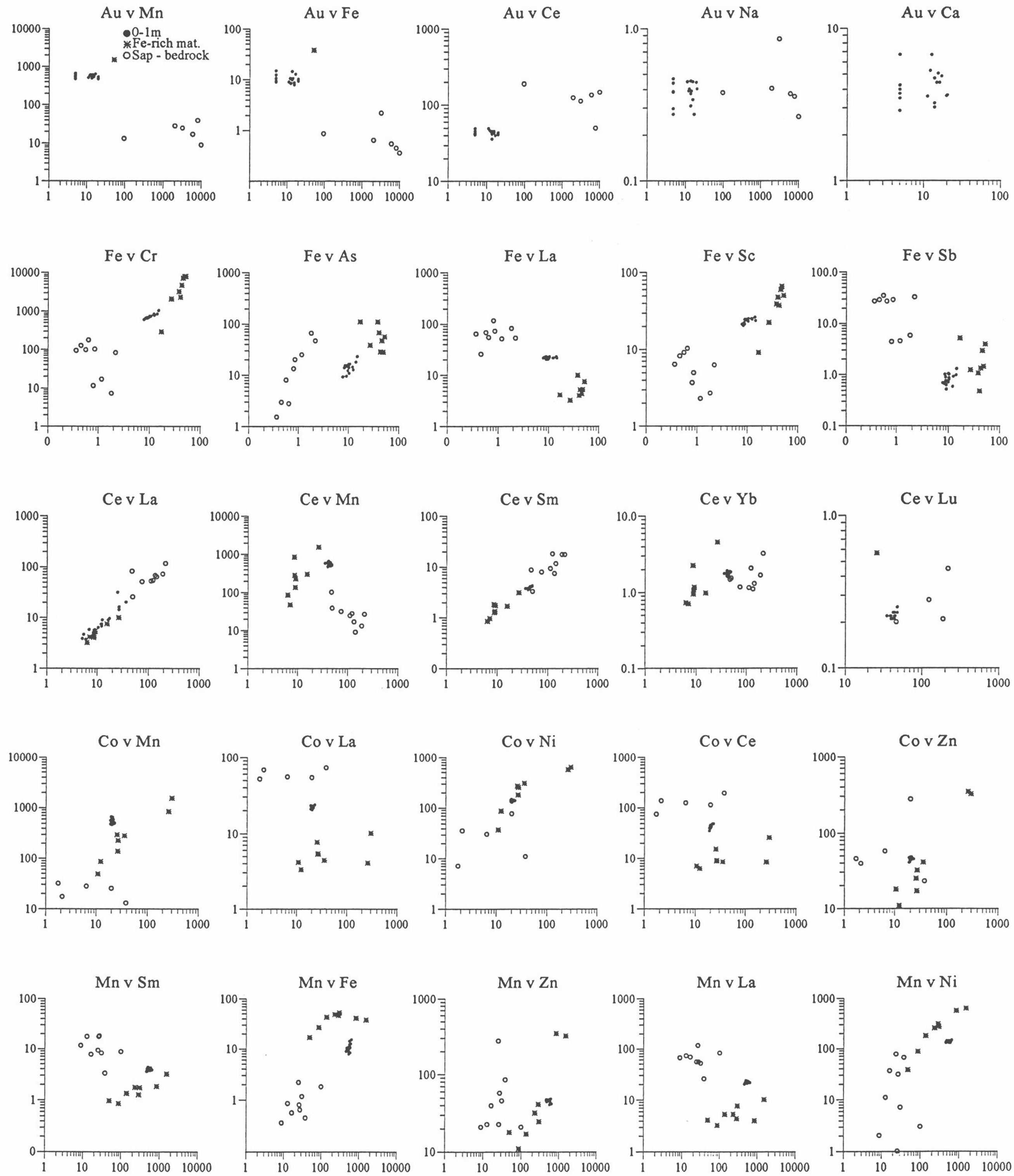


Figure A5.2: Selected scatter plots for 0 - 1 m bulk samples, Fe-rich material separated from the overburden, and saprolite and bedrock material for Wollubar-Enigma.
Major elements in %, trace elements in ppm, Au in ppb.
First element in header is the x axis.

Appendix 6: Section.

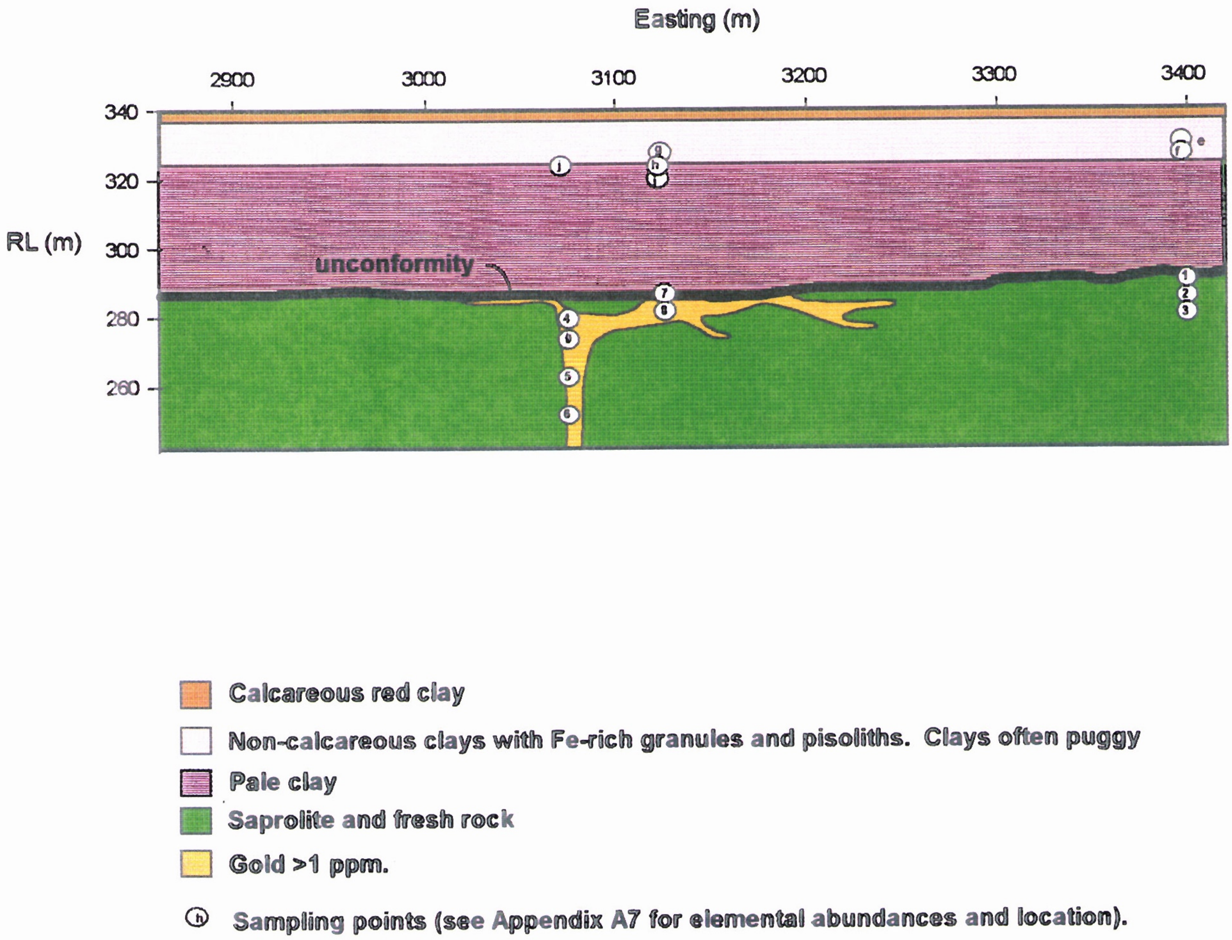


Figure A6: Gold abundance, regolith and sampling points for 64700N at Wollubar-Enigma. After data supplied by Normandy Poseidon Ltd.

Appendix 7: Tabulated results.

Sample	East.	North.	Sb	As	Ba	Bi	Br	Ca	Cs	Ce	Co	Cr	Cu	Eu
2187	2850	64700	0.68	13.9	244	1	14.3	6.75	1.56	45.4	20	658	66	0.89
2189	2900	64700	1.31	22.7	205	1	8.58	6.75	1.94	41.2	19.8	1040	63	1.05
2191	2950	64700	0.9	15.5	253	1	18.4	3.60	2.27	49	22.9	690	59	0.88
2193	3000	64700	0.69	9.22	248	1	12.2	4.43	1.38	45.7	21.1	603	62	0.91
2195	3020	64700	0.86	13.8	237	<1	14.7	4.43	1.89	45.3	21	753	68	0.91
2197	3040	64700	0.81	16.2	301	1	15.1	5.30	2.12	45.8	21.4	746	68	0.84
2199	3060	64700	1.03	15.5	264	1	15.4	5.05	2.17	43.7	21.2	642	71	0.84
2201	3080	64700	0.6	14.4	325	1	14.5	4.25	2.29	40.5	20.7	840	72	0.88
2203	3100	64700	0.64	15.5	237	2	22.3	3.73	2.8	45.4	21.1	687	66	0.86
2205	3120	64700	1.06	16.2	155	1	14.6	3.68	1.79	43	21.1	712	74	0.85
2207	3140	64700	0.74	14.9	188	3	18.1	3.63	1.72	40.9	19.2	679	73	0.82
2209	3160	64700	0.73	14.4	237	1	19.4	3.05	2.45	42.3	21.3	735	66	0.77
2211	3180	64700	0.77	14.9	275	<1	22.1	2.88	2.83	41	20.4	645	66	0.95
2213	3200	64700	0.75	12.2	352	2	14.4	4.73	2.3	41.3	19.7	685	70	0.7
2215	3250	64700	1.02	10.8	319	<1	15.4	3.48	1.71	49	21.9	706	72	1.02
2217	3300	64700	0.53	9.42	331	1	16.1	4.00	1.63	42.4	19.7	647	75	0.82
2219	3350	64700	0.94	12.8	257	<1	10.6	4.85	1.86	40	20.7	772	76	1.08
2221	3400	64700	1	17.8	243	<1	12.7	3.23	1.75	35.9	19.3	855	72	0.93

Sample	total Au	Fe	Hf	La	Pb	Lu	Mg	Mn	Na	Ni	K	Rb	Sm	Sc
2187	13.0	8.4	3.2	22.3	12	0.21	0.54	608	0.40	130	nd	36.2	4.12	20.4
2189	5.0	15	3.4	21.8	20	<0.2	0.65	660	0.27	145	nd	32	3.78	23.3
2191	11.3	8.99	3.67	23.3	14	0.23	0.56	506	0.45	139	nd	28.4	4.31	21.1
2193	16.1	7.85	3.34	21.9	14	0.23	0.70	553	0.34	132	nd	39.2	4.08	21.4
2195	14.8	10.4	3.45	22.3	17	0.22	0.57	597	0.39	137	nd	41	4.11	22.9
2197	12.4	10.6	3.5	23	17	0.22	0.72	593	0.39	142	nd	41.4	4.18	23.1
2199	15.7	8.59	3.62	21.5	16	0.21	0.77	545	0.45	139	nd	37.1	4.06	22
2201	5.0	12.1	3.93	21.3	17	0.21	0.56	577	0.30	143	nd	32.8	3.69	25.3
2203	5.0	9.34	3.78	21.8	16	0.21	0.45	495	0.38	140	nd	35.2	4	24
2205	20.3	10	3.75	21.2	18	0.23	0.47	540	0.40	143	nd	51.6	3.74	24.2
2207	20.0	9.21	3.71	20.5	14	0.22	0.45	481	0.44	134	nd	47.4	3.58	24.1
2209	13.9	10.2	3.6	21.4	17	0.21	0.45	491	0.45	139	nd	53	3.86	24.2
2211	5.0	8.82	3.59	20.3	13	<0.2	0.40	476	0.47	130	nd	29	3.53	24.7
2213	14.1	9.79	3.39	20.6	16	<0.2	0.63	559	0.31	128	nd	24.2	3.73	24.1
2215	5.0	10.5	3.57	22.9	18	0.25	0.48	532	0.44	138	nd	33.5	4.15	25.1
2217	5.0	9.28	4.01	22	14	0.21	0.55	548	0.39	131	nd	37.5	3.86	24.8
2219	17.1	12.5	3.51	21.3	19	0.22	0.63	635	0.27	138	nd	27	3.82	24.3
2221	13.9	14.2	3.77	22.8	21	0.22	0.65	575	0.38	140	nd	33.2	3.85	26.2

Sample	Sr	Ta	Th	TiO2	U	W	Yb	Zn	Zr	Salinity	water Au	iodide Au	cyanide Au	
2187	230	<1	10.5	0.64	<2	<10	1.68	44	142	1.88	3.232	8.8	2.756	
2189	219	<1	12.6	0.64	5.79	<10	1.76	41	129	1.23	2.436	8.24	2.06	
2191	190	1.17	11.8	0.72	<2	<10	1.87	45	131	2.66	2.652	8.4	2.512	
2193	198	<1	12	0.7	<2	<10	1.89	46	139	1.57	4.64	9.24	3.028	
2195	205	<1	12.9	0.68	<2	<10	1.74	48	139	1.86	4.24	9.08	2.656	
2197	223	<1	12.7	0.66	<2	<10	1.8	47	133	2.16	3.528	8.56	2.48	
2199	246	<1	12	0.68	<2	<10	1.65	46	133	2.05	3.604	9.36	2.304	
2201	206	<1	13.9	0.72	4.44	<10	1.77	45	145	1.56	4.36	7.96	2.472	
2203	241	<1	13	0.71	<2	<10	1.66	44	151	2.42	3.676	8.72	3.056	
2205	205	<1	12.9	0.71	2.85	<10	1.6	47	134	2.41	3.08	7.96	1.992	
2207	203	<1	12.8	0.71	2.79	<10	1.66	47	140	2.82	3.14	8.04	2.004	
2209	188	<1	13.1	0.73	<2	<10	1.78	47	140	3.32	2.248	7.24	1.648	
2211	173	<1	12.8	0.73	4.27	<10	1.93	46	142	3.32	2.724	6.68	1.932	
2213	234	<1	12.3	0.67	<2	<10	1.62	46	133	1.75	3.772	7.68	2.08	
2215	202	1.1	13	0.73	<2	<10	1.85	46	136	2.45	2.884	7.56	2.228	
2217	226	<1	12.7	0.7	<2	<10	1.74	47	142	2.68	4.16	9.52	2.84	
2219	248	<1	13.3	0.67	2.85	<10	1.79	48	137	1.34	5.36	9.96	3.668	
2221	211	<1	14	0.72	<2	<10	1.78	40	136	2.21	2.684	9.92	2.436	

Table A7.1: Elemental abundances at Wollubar-Enigma for 0-1m material.
Majors are in %, traces in ppm, Au in ppb.
Ir (20 ppb), Mo(5 ppm), Se(5 ppm) and Ag(5 ppm) are below detection (in brackets) for all samples.
nd not determined.

sample id	Sample	Hole ID	Easting	Northing	Depth(m	Type	Al2O3	CaO	Fe
a	09-0007/8	SSA 031	4800	63900	1.5	Fe granules	10.65	0.02	48.56
b	09-0057/58	SSA 018	3500	63900	1.5	Fe granules	9.34	0.02	46.08
c	09-0043/44	SSA 089	3950	63900	3	Fe granules	8.23	0.03	52.09
d	09-0009/10	SSA 031	4800	63900	4	Fe granules	10.12	0.01	42.71
e	09-1950	SSA 133	3400	64700	8.5	reddy brown mottles	nd	nd	26.90
f	09-1957	SSA 133	3400	64700	9.5	purple mottles	nd	nd	17.00
g	09-1975/6	SSA 194	3125	64700	8-10	mottles red brown	nd	nd	34.00
h	09-1979	SSA 194	3125	64700	12.5	purple mottles	nd	nd	25.70
i	09-1981	SSA 194	3125	64700	14.5	pisoliths	nd	nd	28.70
j	09-2009	SSA 195	3075	64700	13.5	purple mottles	nd	nd	13.50
1	09-1969	SSA 133	3400	64700	49.5	pale clay with quartz sands	nd	nd	0.81
2	09-1970	SSA 133	3400	64700	54.5	orange clay with quartz sands	nd	nd	1.84
3	09-1971	SSA 133	3400	64700	59.5	orange clay with quartz-rich materia	nd	nd	1.16
4	09-2024	SSA 195	3075	64700	60.5	pale clay	nd	nd	0.85
5	09-2032	SSA 195	3075	64700	77.5	pale clay	nd	nd	0.64
6	09-2038	SSA 195	3075	64700	88.5	partially weathered rock	nd	nd	2.20
7	09-1994	SSA 194	3125	64700	53.5	pale clay	nd	nd	0.56
8	09-2000	SSA 194	3125	64700	58.5	pale clay	nd	nd	0.46
9	09-2027	SSA 194	3075	64700	66.5	pale clay	nd	nd	0.37

Table A7.2: Elemental abundances at Wollubar-Enigma for regolith and bedrock samples. Majors are in %, traces in ppm, Au and Ir in ppb.
nd not determined.

id	K	MgO	Mn	Na	P2O5	S	SiO2	TiO2	Ag	As	Au	Ba	Bi	Br	Ce	Cl	Co	Cr	Cs	Cu	Eu	Ga
a	0.01	0.1	232	0.03	0.02	770	10.3	0.75	nd	29	<5	109	nd	22	9	160	27	8080	<1	24	<0.5	42
b	0.04	0.22	287	0.05	0.019	1130	14.3	0.82	nd	48	<5	139	nd	19	9	270	35	7220	<1	31	<0.5	22
c	0.02	0.14	302	0.02	0.019	990	8.4	0.77	nd	57	<5	368	nd	13	15	210	26	8020	<1	24	<0.5	32
d	0.05	0.23	139	0.06	0.019	1100	17.8	0.79	nd	29	<5	65	nd	31	9	200	27	4820	<1	5	<0.5	20
e	<0.2	nd	87	0.19	nd	nd	nd	0.85	<5	39	<5	190	4	42	6	nd	12	2110	1.73	19	<0.5	nd
f	0.22	nd	49	0.05	nd	nd	nd	0.61	<5	112	<5	6170	<1	14	7	nd	11	292	1.15	6	<0.5	nd
g	<0.2	nd	111	0.13	nd	nd	nd	0.85	<5	50	<5	620	<1	26	11	nd	17	3040	<1	47	<0.5	nd
h	0.22	nd	26	0.09	nd	nd	nd	0.88	<5	137	<5	3090	1	23	5	nd	8	429	1.99	1	<0.5	nd
i	<0.2	nd	43	0.07	nd	nd	nd	0.44	<5	311	<5	451	4	5	17	nd	82	255	<1	238	1.84	nd
j	<0.2	nd	100	0.10	nd	nd	nd	0.47	<5	118	7.9	235	<1	7	12	nd	9	263	2.26	34	<0.5	nd
1	1.37	nd	27	0.40	nd	nd	nd	0.24	<5	13	<5	1190	1	20	218	nd	<1	11	4.0	<1	4.6	nd
2	0.86	nd	103	2.36	nd	nd	nd	0.16	<5	67	<5	915	<1	25	47	nd	<1	7	3.3	20	2.0	nd
3	1.26	nd	31	3.47	nd	nd	nd	0.24	<5	25	<5	1070	<1	10	75	nd	2	17	2.1	5	2.2	nd
4	2.15	nd	13	0.38	nd	nd	nd	0.56	<5	20	98	650	1	15	190	nd	38	103	4.6	<1	3.8	nd
5	1.79	nd	28	0.41	nd	nd	nd	0.45	<5	3	2030	689	<1	18	125	nd	7	179	4.4	12	4.7	nd
6	1.27	nd	25	0.85	nd	nd	nd	0.39	<5	46	3220	660	<1	16	113	nd	20	83	2.7	49	2.4	nd
7	2.05	nd	17	0.37	nd	nd	nd	0.43	<5	8	6220	709	<1	13	136	nd	2	98	4.8	<1	1.6	nd
8	2.85	nd	39	0.36	nd	nd	nd	0.46	<5	3	8110	804	1	12	50	nd	<1	124	4.6	24	0.9	nd
9	1.76	nd	9	0.26	nd	nd	nd	0.45	<5	2	21700	611	1	8	146	nd	<1	96	3.3	<1	2.3	nd

id	Hf	Ir	La	Lu	Mo	Ni	Pb	Rb	Sb	Sc	Se	Sm	Sr	Ta	Th	U	V	W	Y	Yb	Zn	Zr
a	3.71	<20	5	<0.2	nd	257	33	4	1	67	<5	2	11	<1	20	<2	973	<2	<1	1.2	32	154
b	4.18	20.9	4	<0.2	nd	307	19	3	3	60	<5	1	12	<1	19	4	917	<2	4	1	41	151
c	3.58	<20	8	<0.2	nd	271	34	<3	4	51	<5	2	16	<1	20	<2	1098	<2	4	1	25	140
d	3.88	<20	5	<0.2	nd	181	12	8	1	37	<5	1	3	<1	14	<2	946	<2	3	1.1	17	151
e	4.67	<20	3	<0.2	<5	87	8	27	1	23	<5	1	8	1.1	14	<2	nd	5	nd	0.7	11	149
f	4.3	<20	4	<0.2	<5	38	<1	<20	5	9	<5	1	18	<1	7	<2	nd	3	nd	0.7	18	153
g	4.3	<20	7	<0.2	<5	86	16	<20	3	39	<5	1	15	<1	17	<2	nd	5	nd	1.1	10	143
h	4.46	<20	2	<0.2	<5	40	<1	<20	4	9	<5	1	24	<1	7	<2	nd	4	nd	0.8	16	156
i	2.44	<20	7	0.46	20.6	69	73	29	22	24	<5	5	18	<1	13	3.8	nd	18	nd	3.2	17	109
j	2.69	<20	6	<0.2	5.8	29	16	<20	16	7	<5	1	23	<1	9	<2	nd	14	nd	0.6	31	115
1	3.8	<20	115	0.5	2	1	25	46	4	4	<5	18	93	<1	9	<2	nd	<2	nd	3.3	23	173
2	2.7	<20	82	0.2	28	3	47	42	6	3	<5	9	289	<1	6	<2	nd	5	nd	1.5	21	138
3	3.2	<20	52	<0.2	5	7	24	31	4	2	<5	8	624	<1	7	<2	nd	7	nd	1.2	45	124
4	3.3	<20	72	0.2	8	11	24	53	29	5	<5	17	191	<1	7	<2	nd	19	nd	1.7	23	195
5	3.2	<20	55	0.3	8	31	25	44	27	10	<5	18	219	<1	8	4.2	nd	18	nd	2.1	57	170
6	2.5	<20	54	<0.2	50	76	68	36	33	6	<5	9	202	<1	6	3.5	nd	17	nd	1.2	272	135
7	3.7	<20	67	<0.2	24	36	20	53	34	9	<5	8	565	<1	8	<2	nd	19	nd	1.1	39	186
8	4.0	<20	26	<0.2	13	65	15	64	29	8	<5	3	563	<1	8	<2	nd	22	nd	1.6	86	162
9	3.2	<20	65	<0.2	19	2	78	45	27	6	<5	12	254	<1	7	<2	nd	20	nd	1.3	21	154

Table A7.2 (continued).

Sample	Easting	Northing	Type	Sb	As	Ba	Br	Ce	Cr	Co	Eu	Au	Hf	Fe	La
2235	3090	64670	mull	0.02	0.47	<20	8.91	2.19	16.3	1.04	<0.05	2.1	0.13	0.2	0.98
2236	3140	64700	mull	0.03	0.62	<20	8.12	2.8	22.1	1.28	0.06	2.8	0.18	0.25	1.23
2237	3450	64700	mull	0.04	0.66	<20	7.58	2.74	24.6	1.31	0.05	3	0.19	0.31	1.36
2238	3090	64670	eucalyptus	<0.02	0.11	<20	41.4	<0.2	0.8	<0.2	<0.05	<0.5	<0.1	<0.01	0.06
2239	3140	64700	eucalyptus	<0.02	<0.1	<20	51.4	<0.2	1.5	<0.2	<0.05	<0.5	<0.1	<0.01	0.08
2240	3450	64700	eucalyptus	<0.02	0.11	<20	45.6	<0.2	1.1	<0.2	<0.05	<0.5	<0.1	<0.01	0.06
2241	3090	64670	eremophila	<0.02	<0.1	<20	117	<0.2	<0.5	<0.2	<0.05	<0.5	<0.1	0.02	0.03
2242	3140	64700	eremophila	<0.02	<0.1	<20	92.5	<0.2	0.9	<0.2	<0.05	0.6	<0.1	0.02	0.04
2243	3450	64700	eremophila	<0.02	0.11	<20	81.9	<0.2	0.7	<0.2	<0.05	1.6	<0.1	0.02	0.05
2244	3090	64670	bluebush	<0.02	0.19	<20	77.2	0.6	3.2	<0.2	<0.05	4.3	<0.1	0.02	0.17
2245	3140	64700	bluebush	<0.02	0.23	<20	72.9	0.44	2	<0.2	<0.05	2.2	<0.1	<0.01	0.12
2246	3450	64700	bluebush	<0.02	0.25	<20	70.1	0.7	3.6	<0.2	<0.05	3.1	<0.1	0.03	0.23

Sample	Easting	Northing	Type	Lu	K	Sm	Sc	Na	Th	W	Yb
2235	3090	64670	mull	<0.01	0.07	0.18	0.75	0.05	0.41	0.32	0.08
2236	3140	64700	mull	0.01	0.07	0.23	1.03	0.07	0.52	0.24	0.09
2237	3450	64700	mull	0.01	0.07	0.25	1.07	0.05	0.58	0.34	0.1
2238	3090	64670	eucalyptus	<0.01	0.43	0.02	0.03	0.28	<0.1	<0.1	0.01
2239	3140	64700	eucalyptus	<0.01	0.4	0.02	0.03	0.37	<0.1	0.29	<0.01
2240	3450	64700	eucalyptus	<0.01	0.48	0.01	0.03	0.43	<0.1	<0.1	<0.01
2241	3090	64670	eremophila	<0.01	1.13	0.01	0.03	0.01	<0.1	<0.1	<0.01
2242	3140	64700	eremophila	<0.01	1.35	0.01	0.04	0.03	<0.1	<0.1	<0.01
2243	3450	64700	eremophila	<0.01	1.4	0.01	0.05	0.03	<0.1	<0.1	<0.01
2244	3090	64670	bluebush	<0.01	0.58	0.04	0.15	1.18	<0.1	<0.1	<0.01
2245	3140	64700	bluebush	<0.01	0.57	0.03	0.12	1.29	<0.1	<0.1	<0.01
2246	3450	64700	bluebush	<0.01	0.48	0.05	0.2	1.2	0.16	<0.1	<0.01

Table A7.3: Elemental abundances for vegetation samples at Wollubar-Enigma. Majors in %, traces in ppm, Au in ppb.

Sample	id	Easting	Northing	Au ppb	Ca %	Mg %		id	Easting	Northing	Au ppb
09-2187	25436	2850	64700	13	6.75	0.54		25401	2850	64700	17
09-2188	25443	2875	64700	<5	7.50	0.60		25402	2875	64700	17
09-2189	25437	2900	64700	<5	6.75	0.65		25403	2900	64700	14
09-2190	25438	2925	64700	<5	3.73	0.61		25404	2925	64700	12
09-2191	25439	2950	64700	11.3	3.60	0.56		25405	2950	64700	15
09-2192	25440	2975	64700	15	5.15	0.80		25406	2975	64700	15
09-2193	25441	3000	64700	16.1	4.43	0.70		25407	3000	64700	14
09-2194	25442	3010	64700	13.1	4.75	0.79		25408	3010	64700	15
09-2195	25444	3020	64700	14.8	4.43	0.57		25409	3020	64700	17
09-2196	25445	3030	64700	18.1	4.53	0.59		25410	3030	64700	16
09-2197	25446	3040	64700	12.4	5.30	0.72		25411	3040	64700	16
09-2198	25447	3050	64700	<5	4.30	0.55		25412	3050	64700	15
09-2199	25448	3060	64700	15.7	5.05	0.77		25413	3060	64700	16
09-2200	25449	3070	64700	14.4	4.00	0.47		25414	3070	64700	16
09-2201	25450	3080	64700	<5	4.25	0.56		25415	3080	64700	41
09-2202	25451	3090	64700	15.5	3.48	0.46		25416	3090	64700	16
09-2203	25452	3100	64700	<5	3.73	0.45		25417	3100	64700	15
09-2204	25453	3110	64700	<5	3.65	0.49		25418	3110	64700	7
09-2205	25454	3120	64700	20.3	3.68	0.47		25419	3120	64700	12
09-2206	25455	3130	64700	18.3	4.35	0.55		25420	3130	64700	14
09-2207	25456	3140	64700	20	3.63	0.45		25421	3140	64700	13
09-2208	25457	3150	64700	<5	3.98	0.49		25422	3150	64700	10
09-2209	25458	3160	64700	13.9	3.05	0.45		25423	3160	64700	13
09-2210	25459	3170	64700	24.7	3.43	0.44		25424	3170	64700	12
09-2211	25460	3180	64700	<5	2.88	0.40		25425	3180	64700	11
09-2212	25461	3190	64700	15.8	4.55	0.56		25426	3190	64700	11
09-2213	25462	3200	64700	14.1	4.73	0.63		25427	3200	64700	12
09-2214	25463	3225	64700	7.1	3.65	0.49		25428	3225	64700	11
09-2215	25464	3250	64700	<5	3.48	0.48		25429	3250	64700	12
09-2216	25465	3275	64700	13.9	3.53	0.50		25430	3275	64700	14
09-2217	25466	3300	64700	<5	4.00	0.55		25431	3300	64700	16
09-2218	25467	3325	64700	15.8	3.73	0.53		25432	3325	64700	14
09-2219	25468	3350	64700	17.1	4.85	0.63		25433	3350	64700	13
09-2220	25469	3375	64700	16.1	4.93	0.89		25434	3375	64700	17
09-2221	25470	3400	64700	13.9	3.23	0.65		25435	3400	64700	16
	id	Easting	Northing	Au ppb				id	Easting	Northing	Au ppb
	25334	2900	64500	15				25355	2900	64800	15
	25335	2925	64500	15				25356	2925	64800	17
	25336	2950	64500	15				25357	2950	64800	19
	25337	3000	64500	12				25358	3000	64800	15
	25338	3025	64500	13				25359	3025	64800	16
	25339	3050	64500	15				25360	3050	64800	12
	25340	3075	64500	18				25361	3075	64800	14
	25341	3100	64500	14				25362	3100	64800	12
	25342	3125	64500	16				25363	3125	64800	13
	25343	3150	64500	13				25364	3150	64800	14
	25344	3175	64500	16				25365	3175	64800	13
	25345	3200	64500	13				25366	3200	64800	13
	25346	3225	64500	13				25367	3225	64800	16
	25347	3250	64500	12				25368	3250	64800	18
	25348	3275	64500	14				25369	3275	64800	21
	25349	3300	64500	11				25370	3300	64800	23
	25350	3325	64500	11				25371	3325	64800	23
	25351	3350	64500	9				25372	3350	64800	25
	25352	3375	64500	14				25373	3375	64800	18
	25353	3400	64500	11				25374	3400	64800	24

Table A7.4: Gold, Ca and Mg abundance at Wollubar-Enigma for all 0 - 1 m samples collected by auger.

Sample	Hole	Easting	Northing	Depth (m)	Au ppb	Ca %
09-001	SSA034	5100	63900	0.5	<5	1.20
09-006	SSA031	4800	63900	0.5	10.6	2.06
09-011	SSA028	4500	63900	0.5	<5	0.81
09-016	SSA027	4400	63900	0.5	<5	0.48
09-021	SSA026	4300	63900	0.5	13.3	4.63
09-026	SSA025	4200	63900	0.5	11.4	2.49
09-031	SSA 24	4100	63900	0.5	9.5	1.05
09-036	SSA 23	4000	63900	0.5	10.6	1.47
09-037	SSA 23	4000	63900	1.5	<5	0.30
09-038	SSA 23	4000	63900	2.5	<5	0.09
09-039	SSA 23	4000	63900	3.5	<5	0.01
09-040	SSA 23	4000	63900	4.5	<5	0.01
09-041	SSA089	3950	63900	0.5	16.8	4.35
09-046	SSA022	3900	63900	0.5	11.0	3.08
09-051	SSA020	3700	63900	0.5	11.5	2.98
09-056	SSA018	3500	63900	0.5	<5	0.54
09-061	SSA016	3300	63900	0.5	10.2	2.70
09-062	SSA016	3300	63900	1.5	<5	0.15
09-063	SSA016	3300	63900	2.5	<5	0.03
09-064	SSA016	3300	63900	3.5	<5	0.01
09-065	SSA016	3300	63900	4.5	<5	0.01

Table A7.5: Gold and Ca abundances for drill hole samples from 63900N