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OPEN FILE REPORT SERIES

THE GEOCHEMICAL DISCRIMINATION OF MINERALISED AND BARREN IRONSTONES FROM THE SELWYN Au-Cu DEPOSIT, N.W. QUEENSLAND

J.E. Wildman

CRC LEME OPEN FILE REPORT 128

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(CSIRO Exploration and Mining Report 341R / CRC LEME Report 35R, 1997.
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CRC LEME is an unincorporated joint venture between CSIRO-Exploration & Mining, and Land & Water, The Australian National University, Curtin University of Technology, University of Adelaide, University of Canberra, Geoscience Australia, Bureau of Rural Sciences, Primary Industries and Resources SA, NSW Department of Mineral Resources-Geological Survey and Minerals Council of Australia.
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CSIRO/CRC LEME/AMIRA PROJECT P417
GEOCHEMICAL EXPLORATION IN REGOLITH-DOMINATED TERRAIN, NORTH QUEENSLAND 1994-1997

In 1994, CSIRO commenced a multi-client research project in regolith geology and geochemistry in North Queensland, supported by 11 mining companies, through the Australian Mineral Industries Research Association Limited (AMIRA). This research project, "Geochemical Exploration in Regolith-Dominated Terrain, North Queensland" had the aim of substantially improving geochemical methods of exploring for base metals and gold deposits under cover or obscured by deep weathering in selected areas within (a) the Mt Isa region and (b) the Charters Towers - North Drummond Basin region.

In July 1995, this project was incorporated into the research programs of CRC LEME, which provided an expanded staffing, not only from CSIRO but also from the Australian Geological Survey Organisation, University of Queensland and the Queensland Department of Minerals and Energy. The project, operated from nodes in Perth, Brisbane, Canberra and Sydney, was led by Dr R.R. Anand. It was commenced on 1st April 1994 and concluded in December 1997. The project involved regional mapping (three areas), district scale mapping (seven areas), local scale mapping (six areas), geochemical dispersion studies (fifteen sites) and geochronological studies (eleven sites). It carried the experience gained from the Yilgarn (see CRC LEME Open File Reports 1-75 and 86-112) across the continent and expanded upon it.

Although the confidentiality period of Project P417 expired in mid 2000, 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 128) is a second impression (second printing) of CSIRO, Division of Exploration and Mining Restricted Report 341R, first issued in 1997, which formed part of the CSIRO/AMIRA Project P417.

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PREFACE

The principal objective of the CSIRO/AMIRA P417 Project is to improve geochemical methods for exploration for base metals and Au in areas obscured by weathering or under cover. The research includes geochemical dispersion studies, regolith mapping, regolith characterisation, dating of regolith and investigation of regolith-landform evolution.

This report studies the geochemistry of weathered magnetic ironstones which are an important host material for Cu-Au and Cu-Pb-Zn deposits in the Eastern Succession of the Mt Isa Inlier. Elsewhere in the Eastern Succession the ironstones are buried under Mesozoic and Tertiary sediments where magnetic anomalies have been the main targets for exploration. Understanding the weathering and dispersion processes for this type of deposit should enable a more effective geochemical approach to be applied to the region.

The work was done in conjunction with studies of geochemical dispersion at the Eloise and Maronan Cu-Au deposits which also occur in magnetic ironstones. These studies are reported separately.

R.R. Anand
Project leader

I.D.M. Robertson
Deputy leader

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SUMMARY

Recent exploration for Au-Cu deposits in the Eastern Succession of the Mt Isa Inlier has concentrated on the type of magnetic ironstones found at Selwyn. Aerial magnetics are used to find the larger occurrences of magnetite but they cannot distinguish between mineralised and barren magnetite bodies. Samples of mineralised and barren ironstones were used to geochemically differentiate the two types of ironstone. Comparisons were also made between the unoxidised sulphide ore and its weathered equivalent found at the surface.

Samples of mineralised and barren ironstones were analysed for 38 elements by XRF and INAA. Photomicrographs and backscattered electron images were used to describe the mineralogy and textures of selected samples. Those elements that distinguish mineralised from barren ironstones have been displayed using several methods of plotting the data.

The mineralised samples are distinguished by Au and W and the barren samples by Ba and Mn. Copper is high in the mineralised samples but there is a large overlap of concentrations with the barren samples.

The SEM investigation shows that Au, W, Sn and Cu can be preserved in hematite derived from the magnetite. This hematite may then be a source of local stream sediment anomalies at surface in the case of Selwyn or at a paleosurface where the ironstones are buried by Mesozoic or recent sediments.

1 INTRODUCTION

The hematitic ironstones that host the Selwyn Au-Cu deposit occur, 150 km south of Cloncurry (Figure 1) as two parallel ridges which rise 70 m above the local land surface. Although parts of the western ironstone hosts Cu-Au mineralisation, the eastern ironstone is barren. Geochemical exploration of the mineralised ironstones is hindered by extreme variation in Cu, Au and trace elements both along strike and also across strike. Anomalous Cu was found by the Bureau of Mineral Resources in 1956 when assessing the ironstones as an Fe resource. Gold was found in the late sixties by Anaconda Australia Inc., but it was not until 1988 that sufficient Au reserves were recognised to start mining (Kary and Harley, 1990). The deposits were delineated by rock chip sampling. The mineralised parts of the western ironstone form subdued topography or are concealed because oxidation of their contained sulphides causes more intense weathering and, until this was recognised, rock chip sampling tended to overlook this less exposed material.

Similar mineralisation has since been discovered at Osborne to the south (Adshead and Keough 1993), and at Eloise (Baker, 1994) and Maronan to the north. Selwyn-style mineralisation was used as an exploration model which assisted in the discovery of Ernest Henry north of Cloncurry (Craske, 1995). These newer deposits are under Tertiary cover and were discovered by drilling magnetic anomalies related to magnetite, which also occurs beneath the oxidised ironstones at Selwyn.

In this project, samples were collected and analysed to characterise the geochemical and mineralogical properties of the ironstones, in order to distinguish the mineralised from the barren ironstones. This is used to discriminate between ironstone types in the Selwyn area and predict the style of weathering and dispersion from this mineralisation.

2 GEOLOGY

The geology of the area is described by Kary and Harley (1990). The deposit lies within the Mary Kathleen Group of the Eastern Succession of the Mt. Isa Inlier. The formations within this group have been deformed to produce a northerly trend and have been intruded by the Gin Creek, Mount Dore and Yellow Waterhole granitic plutons (Figure 2). Regional metamorphism is to upper greenschist or lower amphibolite facies. Both the eastern and western ironstones are located within the Stavely Formation. The mineralised sections of the western ironstones occur at the base of the Stavely Formation near the upper part of a magnetite rich schist, the upper 50 m of which contains chalcopyrite. Mineralisation generally occurs in quartz-magnetite-hematite-chalcopyrite-siderite ironstones, increasing to the eastern side of each deposit and on the eastern side of each ironstone.

The ironstones are thought to have originated in a shallow evaporative basin whose sediments have suffered several intense structural and hydrothermal episodes which recrystallised the BIF and, at a later stage, provided mineralising saline fluids which mobilised the Cu and Au. Evidence for the shallow basinal environment is provided by evaporite pseudomorphs and shallow water facies composed of sandstones and black shales with high Ba and Mn contents (Davidson *et al.,* 1988). Comparisons have been made between the Selwyn and Tennant Creek mineralised ironstones which have similar structural and mineralogical characteristics (Wall and Valenta, 1990).

On the surface, the ironstones at Selwyn occur as low hills extending for sixty kilometres. They contain economic Cu-Au orebodies where they thicken, through structural deformation, or where parallel ironstone veins coalesce. Parallel, ferruginous veining, with a similar appearance one kilometre to the east is barren. The eastern ironstones are more hematitic but the magnetite content of the western ironstones is variable and may have been controlled by the mineralising process.

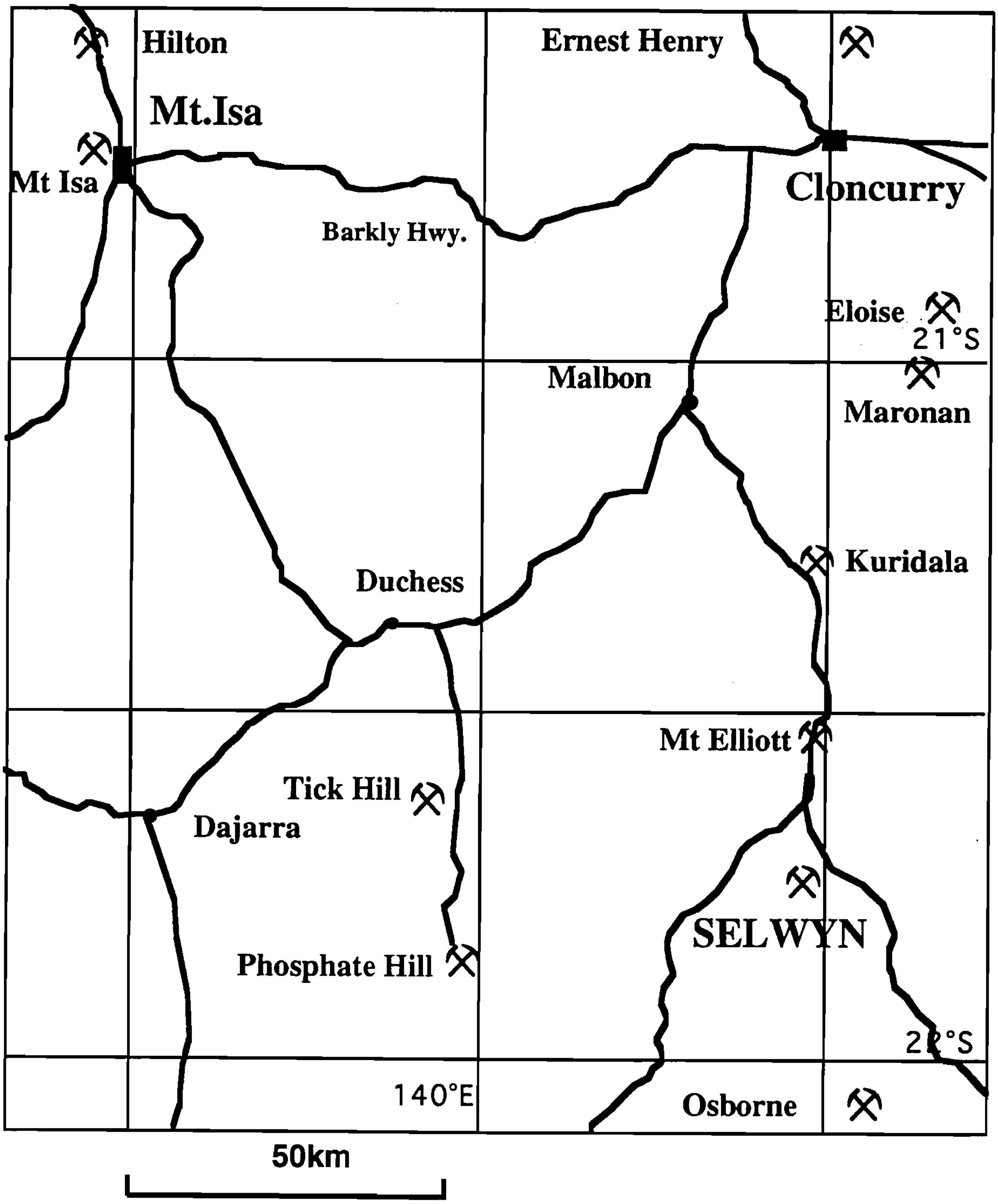

Figure 1. Location of the Selwyn mine in North-west Queensland.

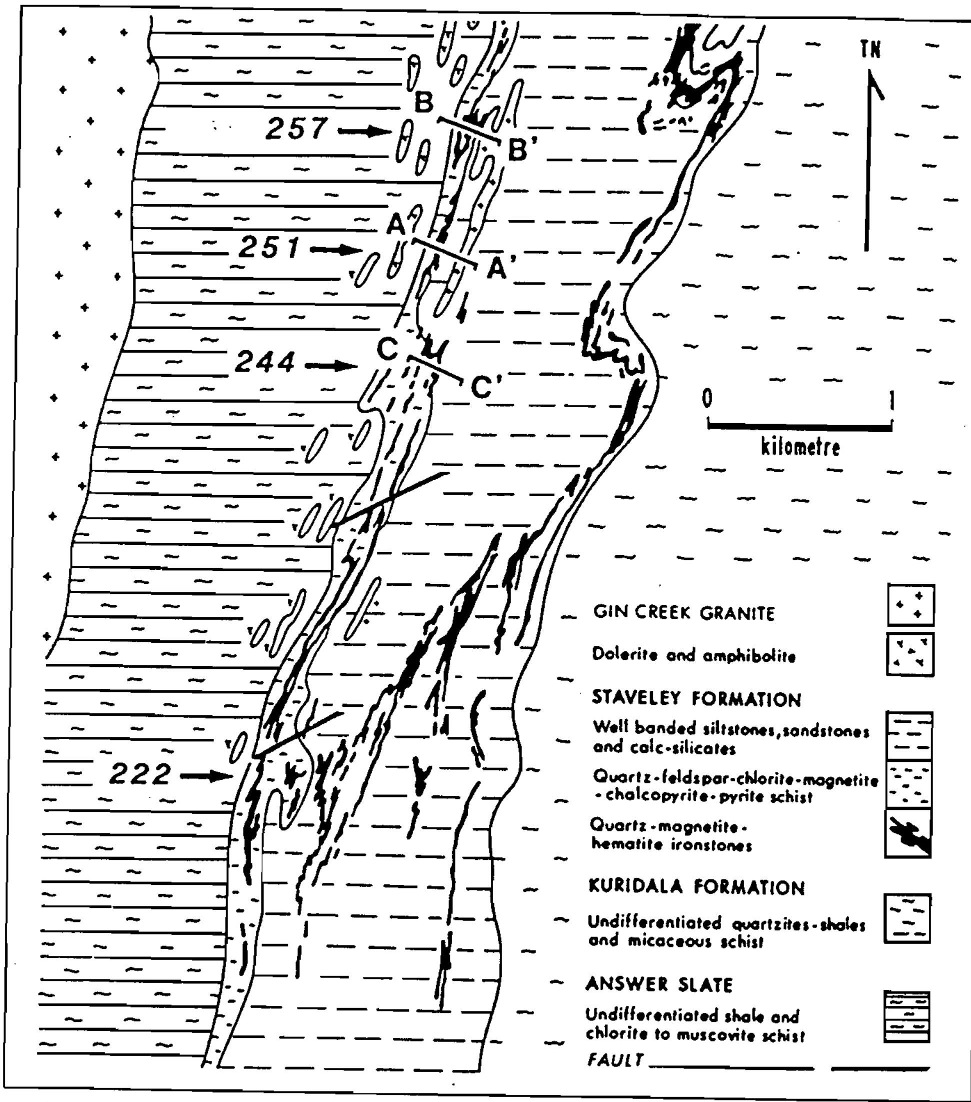

Figure 2. Local geology of the Selwyn area.(From Kary and Harley, 1990)

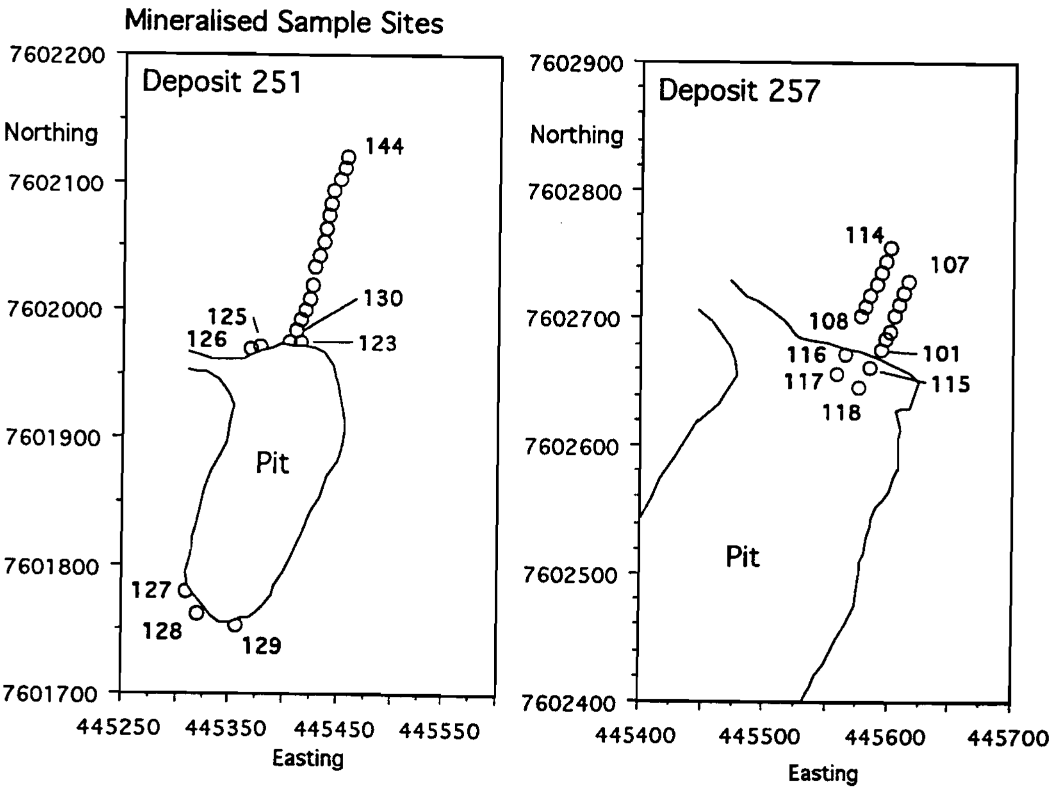

Figure 3. Map of the location of mineralised ironstone samples .

Table 1 Selwyn Ironstones Mineralogy (XRD)

sampno	TYPE	HEMATITE	GOETHITE	MAGNETITE	QUARTZ	Mn-OXIDES	MICA	CHALCOPYRITE
SE103	MIN257	XXXX	X		XXXX			
SE108	MIN257	XXXX			XXXX		X	
SE112	MIN257	XX			XXXX			
SE 115	MIN257	XXXX			XXXX			
SE116	MIN257	XXXX		X	XXX			
SE117	MIN257	XXX	X		XXXX			
SE118	MIN257	XX	X	X	XXXX			
SE120**	ORE251			XXX	XXXX			XXX
SE130	MIN251	XXXX			XXXX			
SE136	MIN251	XXX	XX					
SE141	MIN251	XX	XXXX					
SE143	MIN251	X	XXX		XXXX			
SE149	BARREN	XXXX			XXXX			
SE150	BARREN	XXXX			XXXX			
SE153	BARREN	XXXX	X		XXXX			
SE156	BARREN	XXX			XXXX	XXX	XXX	
SE158	BARREN	XXXX			XXX		X	
SE159	BARREN	X			XX	XXXXXX*	XX	

* SEM composition suggests Hollandite

**SEM, deposit 251 ore showed gold telluride, bismuth telluride, molybdenite, cassiterite, scheelite,chalcopyrite, pyrite, magnetite and quartz.

Table 2 Descriptive Statistics

	Barren N = 19				Deposit 251 N= 23				Deposit 257 N = 19			
	Mean	Min	Max	G Mean	Mean	Min	Max	G Mean	Mean	Min	Max	G Mean
SiO2 (%)	23.5	6.5	42.1	21.7	11.3	1.2	44.5	6.4	26.6	3.7	53.9	21.4
Al2O3 (%)	1.6	0.1	8.1	0.8	1.0	0.2	2.5	0.8	1.1	0.1	4.0	0.7
Fe2O3 (%)	72.5	44.9	89.8	71.6	85.5	52.7	97.7	84.4	71.1	42.7	93.3	69.3
MgO (%)	0.09	0.02	0.44	0.062	0.042	0.02	0.1	0.039	0.057	0.02	0.12	0.05
CaO (%)	0.01	0.01	0.04	0.012	0.011	0.01	0.02	0.011	0.015	0.01	0.06	0.013
Na2O (%)	0.03	0.01	0.11	0.017	0.016	0.01	0.06	0.014	0.129	0.01	1.37	0.03
K2O (%)	0.34	0.002	2.749	0.071	0.016	0.001	0.132	0.006	0.078	0.001	0.377	0.022
TiO2 (%)	0.19	0.048	0.352	0.168	0.106	0.001	0.314	0.072	0.114	0.008	0.284	0.081
P2O5 (%)	0.09	0.006	0.268	0.06	0.183	0.01	1.069	0.076	0.042	0.002	0.107	0.032
MnO (%)	0.69	0.009	5.315	0.094	0.013	0.007	0.024	0.012	0.031	0.006	0.224	0.016
Total	99.1	95.9	100.7	99.1	98.1	89.8	101.1	98.1	99.2	97.2	100.6	99.2
Ag (ppm)	2	2	2	2	2	2	10	2	2	2	2	2
As (ppm)	6	2	9	6	6	0	25	4	2	0	5	1
Au (ppb)	2	2	2	2	450	2	4320	23	405	2	2320	57
Ba (ppm)	1428	30	6861	510	44	10	254	24	65	10	175	38
Br (ppm)	1	1	2	1	1	1	2	1	1	1	1	1
Ce (ppm)	42	2	132	28	68	6	394	31	20	1	97	10
Cl (ppm)	49	7	280	27	50	7	190	32	47	7	110	37
Co (ppm)	39	0	228	13	10	0	87	2	12	3	54	9
Cr (ppm)	21	7	51	18	12	2	34	9	13	2	44	9
Cs (ppm)	1	0	2	1	1	0	2	1	1	0	2	0
Cu (ppm)	45	3	212	26	445	3	2446	120	173	3	577	97
Eu (ppm)	1	0	1	0	1	0	2	0	1	0	3	0
Ga (ppm)	6	1	23	4	5	1	17	3	8	1	17	6
Hf (ppm)	1	0	3	1	1	0	2	1	1	0	3	1
Ir (ppb)	7	7	7	7	7	7	7	7	7	7	7	7
La (ppm)	24	2	79	17	21	3	67	15	10	1	47	5
Lu (ppm)	0	0	0	0	0	0	2	0	1	0	8	0
Mo (ppm)	2	2	7	2	6	2	50	3	6	2	66	3
Nb (ppm)	4	1	16	3	4	1	9	3	5	1	19	3
Ni (ppm)	16	3	31	13	18	3	32	16	13	3	42	10
Pb (ppm)	8	2	20	5	8	2	19	7	11	2	21	8
Rb (ppm)	13	2	82	6	3	2	9	3	2	2	2	2
S (ppm)	267	40	2490	140	145	20	600	101	413	10	2580	158
Sb (ppm)	21	1	71	11	49	1	116	25	5	1	19	3
Sc (ppm)	4	1	10	3	8	2	42	6	5	1	10	4
Se (ppm)	2	2	2	2	2	2	2	2	2	2	2	2
Sm (ppm)	3	0	7	2	4	1	14	3	3	0	9	2
Sr (ppm)	28	2	138	17	7	2	27	4	25	2	135	9
Ta (ppm)	0	0	1	0	0	0	1	0	0	0	1	0
Th (ppm)	4	0	11	3	2	0	5	2	3	0	7	2
U (ppm)	2	1	5	1	4	1	37	2	3	1	9	2
V (ppm)	62	24	183	54	46	23	85	42	48	19	122	43
W (ppm)	7	1	22	4	407	14	2880	204	84	15	217	63
Y (ppm)	8	2	37	4	19	2	163	5	56	2	726	12
Yb (ppm)	1	0	4	1	2	0	14	1	5	0	62	1
Zn (ppm)	13	7	54	9	15	7	126	9	7	7	7	7
Zr (ppm)	47	8	108	39	25	2	64	18	30	2	117	18

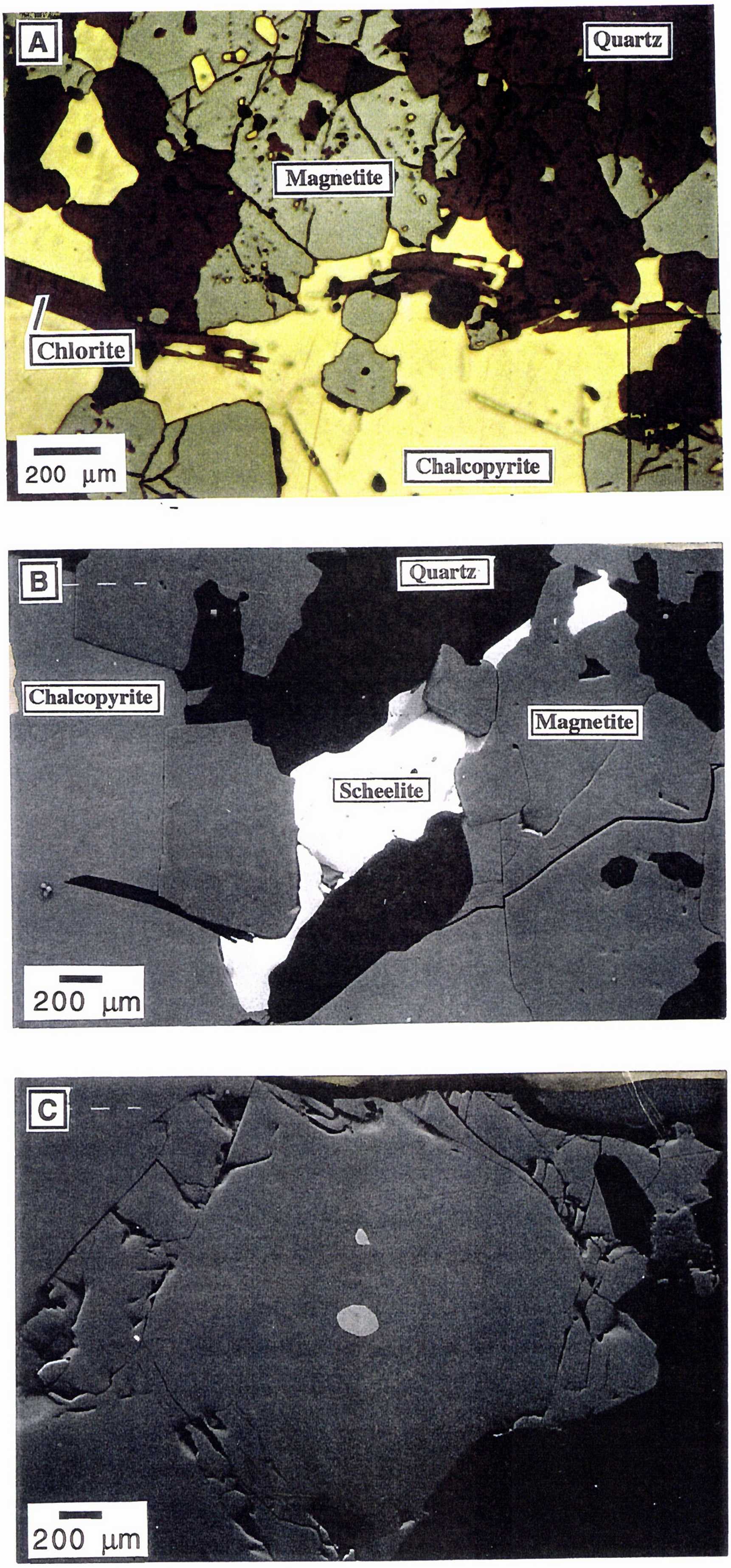

Figure 4A Photograph of ore sample SE120 with quartz, chalcopyrite and magnetite assemblage.
4B Backscattered electron image of ore sample SE120 with major mineralogy.
4C Backscattered electron image of a Ta-W mineral in chalcopyrite in sample SE120.

3 SAMPLING AND ANALYSES

Surface samples were collected from two mineralised locations within the western ironstones, and several unmineralised locations representative of the eastern ironstones. Two unweathered ore samples from Deposit 251 were also collected. Forty-one weathered, mineralised samples were collected along strike at approximately ten metre intervals at Deposits 251 and 257 (Figure 3). The mineralogy of selected samples was determined by XRD (Table 1). The minor mineralogy was further investigated by optical microscope, scanning electron microscope and electron microprobe. The samples were crushed to <75µm and analysed by XRF (SiO_2, Al_2O_3, Fe_2O_3, MgO, CaO, Na_2O, K_2O, TiO_2, Ba, Cr, Cu, Ge, Ga, Mn, Nb, V, Zn and Zr) and INAA (As, Au, Ce, Cl, Cs, Eu, Hf, Ir, La, Lu, Mo, Rb, Sc, Se, Sm, Ta, Th, U, Y and Yb). The analyses are listed in Appendix 1. The data from mineralised and barren ironstones are plotted and compared below.

4 RESULTS

4.1 Deposit 251

An unweathered sample of ore from Deposit 251 was studied to compare primary mineralogy with the weathered surface samples. Photomicrographs of the ore matrix in sample SE120 show mainly coarse grained quartz, chalcopyrite and magnetite (Figure 4A). The magnetite and quartz occur as angular 1-3 mm grains and chalcopyrite fills the interstices. Chalcopyrite also occurs as small, angular crystals and small blebs within magnetite. The larger chalcopyrite grains within the magnetite commonly contain small exsolved crystals of pyrite.

SEM investigation provided more information on mineralogy and textures. Figure 4B is a backscattered electron micrograph of sample SE120. The minerals shown are, scheelite ($CaWO_4$), chalcopyrite, magnetite and quartz. Figure 4C shows an un-named W-Ta mineral in chalcopyrite. Within the ore sample there is also calaverite ($AuTe_2$), tetradymite (Bi_2Te_2S), molybdenite (MoS_2) and cassiterite (SnO_2). The calaverite and cassiterite were found within the quartz. These ore-associated minerals within resistant phases may survive to the surface to contribute to an anomaly.

In the oxidised surface samples magnetite has oxidised progressively to martite (Figure 5A) retaining its magnetite morphology. Copper-rich goethite is formed by oxidation of chalcopyrite in the ore. Sample SE143 is a highly anomalous surface sample (1.4 ppm Au, 925 ppm Cu and 830 ppm W) which was chosen to analyse the pattern of dispersion in oxidised surface samples using the electron microprobe. Copper is the only ore element which occurs in sufficient concentrations in secondary minerals for measurement by electron microprobe. Gold, W and Sn occur in resistate primary minerals but are below detection limits in secondary minerals. Gold was found by SEM in sample SE143 in both hematite (Figure 5B) and quartz, and cassiterite occurs in quartz. Minor scheelite (Figure 5C) and chalcopyrite (Figure 6A) survive in this surface sample.

The backscattered electron image from the electron microprobe shown in Figure 6 contains the minerals involved in Cu dispersion at the surface. Figure 6A shows an isolated grain of chalcopyrite that has not been oxidised (1). The hematite (2) has protected it from oxidation but intergranular chalcopyrite has been oxidised to goethite (3).

The Cu content of these minerals is illustrated by the element map (Figure 6B). The white circle is an unoxidised chalcopyrite grain, surrounded by hematite with low Cu. The patchy, light grey area is Cu-rich goethite. The variation in Fe between the hematite and goethite is shown in Figure 6C.

Scans across the sample in 10 μm steps are shown in Figure 7. The blocky goethite, after chalcopyrite contains 5500-6000 ppm Cu (Figure 7a). The goethite with solution textures contained 3,000 to 3500 ppm Cu and the hematite after magnetite contained less than detection (<200 ppm Cu) (Figure 7b). The concentration of Cu in the oxidised samples is therefore dependent on the proportion of goethite relative to quartz and hematite in the sample.

Other minerals, found by the electron microprobe, in surface samples were xenotime(YPO_4), barite ($BaSO_4$), monazite ($LaCePO_4$) and cassiterite (SnO_2). Many of these grains occur at the edges of voids in accretions of goethite.

4.2 Deposit 257

This deposit is more quartz rich than Deposit 251 and has two mineralised veins which have slightly different mineralogy. The minor mineralised vein contains more wall rock silicates, Mn oxides and associated elements. Sub-surface samples, collected from the edge of Deposit 257 (SE117, SE118), contain magnetite which is partially oxidised to martite and goethite. This deposit is poor in Cu and W and no relics of chalcopyrite or scheelite were found. Oxidised surface samples contain blocky hematite after magnetite and also lath shaped hematite probably after of chlorite found in other samples. Most of these samples have a low porosity, show few solution channels or accretions since they have not suffered volume changes on weathering and the dominant minerals are crystalline and resistant to solution processes.

4.3 Barren

The barren ironstones have a similar matrix to those that are mineralised. They consist of quartz, magnetite and hematite, but contain more chlorite, mica and Mn minerals. The hematite, after magnetite, shows more oxidation and fragmentation and has been disrupted by indurations of silica. Sample SE159 (Figure 8) is Mn rich (25.6% MnO) and contains Cu (507 ppm), Co (786 ppm) and Ni (123 ppm). The micas in this sample have partially weathered and the potassium is now incorporated into hollandite, ((Ba, K)Mn.Mn7O16).

5 GEOCHEMISTRY

5.1 Introduction

The major elements (as Fe_2O_3 and SiO_2)compose 98.9% of the barren ironstones and 96.9% of the mineralised ironstones (sum of median concentrations). The Al_2O_3 is minor in both sample types; 0.7% is the median in barren samples and 0.9% in mineralised. The surface ironstones are mineralogically dominated by hematite and quartz which constitute over 96% of both sample types. The Al is similar in both mineralised and barren types and there is little difference in oxide concentrations except for K and Mn which add up to less than one percent. The variations in composition are produced by minerals which constitute less than two percent of the sample and occur randomly as inclusions in quartz or magnetite.

The sulphides in the orebody produce a reactive zone in the otherwise inert ironstones. The oxidation of sulphides in this environment, where there are few minerals to buffer the acid produced, results in the dissolution of Fe and Cu which are leached towards the water table and precipitate as goethite and malachite. Below the water table the Cu freed from the oxidation of chalcopyrite precipitates as native Cu in reducing conditions. The major influence on barren ironstone trace element content is the incidence of Mn oxides.

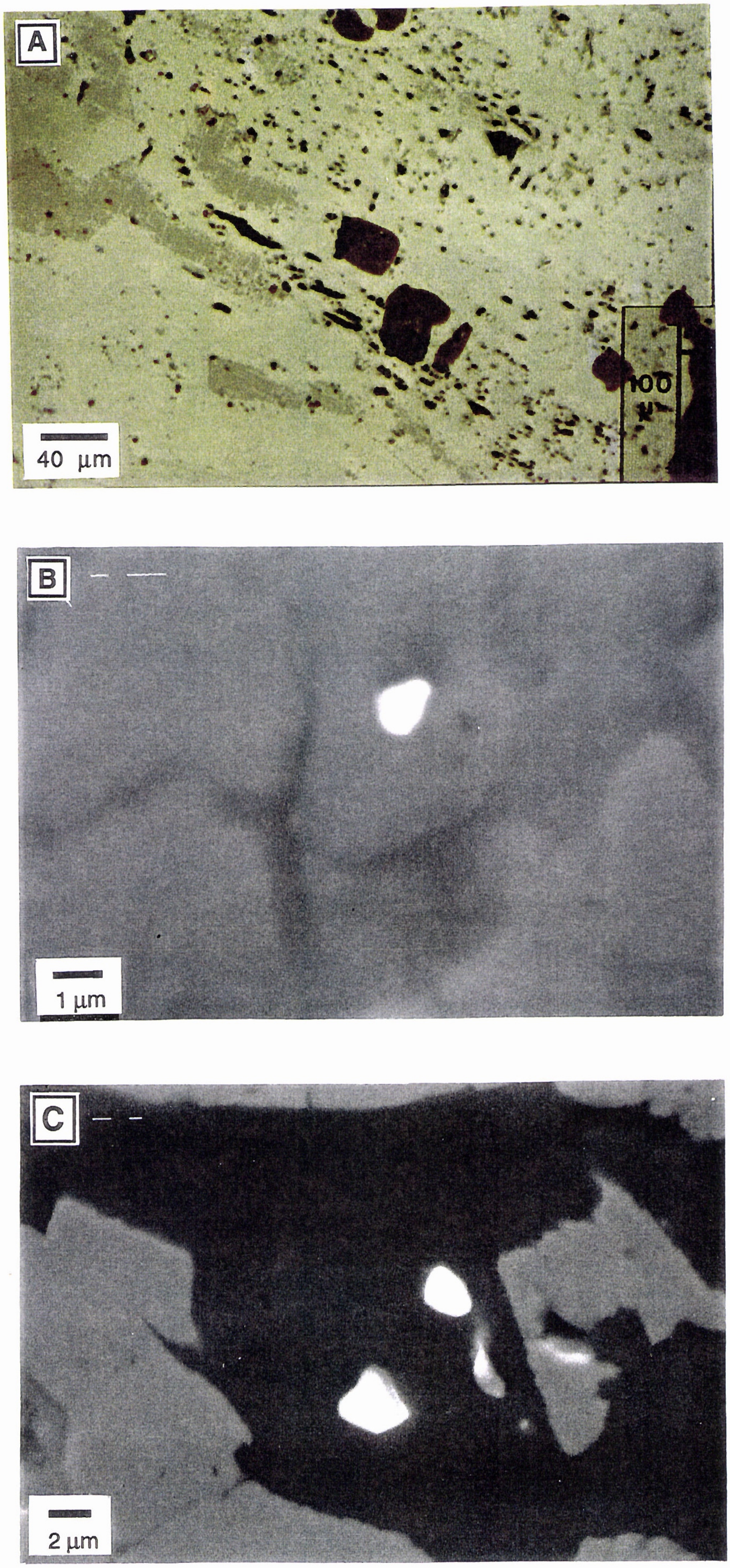

Figure 5A Oxidised surface sample with remnants of magnetite (dull grey) in martite (light grey).
5B Oxidised sample SE143, SEM backscattered electron image of Au in hematite.
5B SE143, scheelite in quartz.

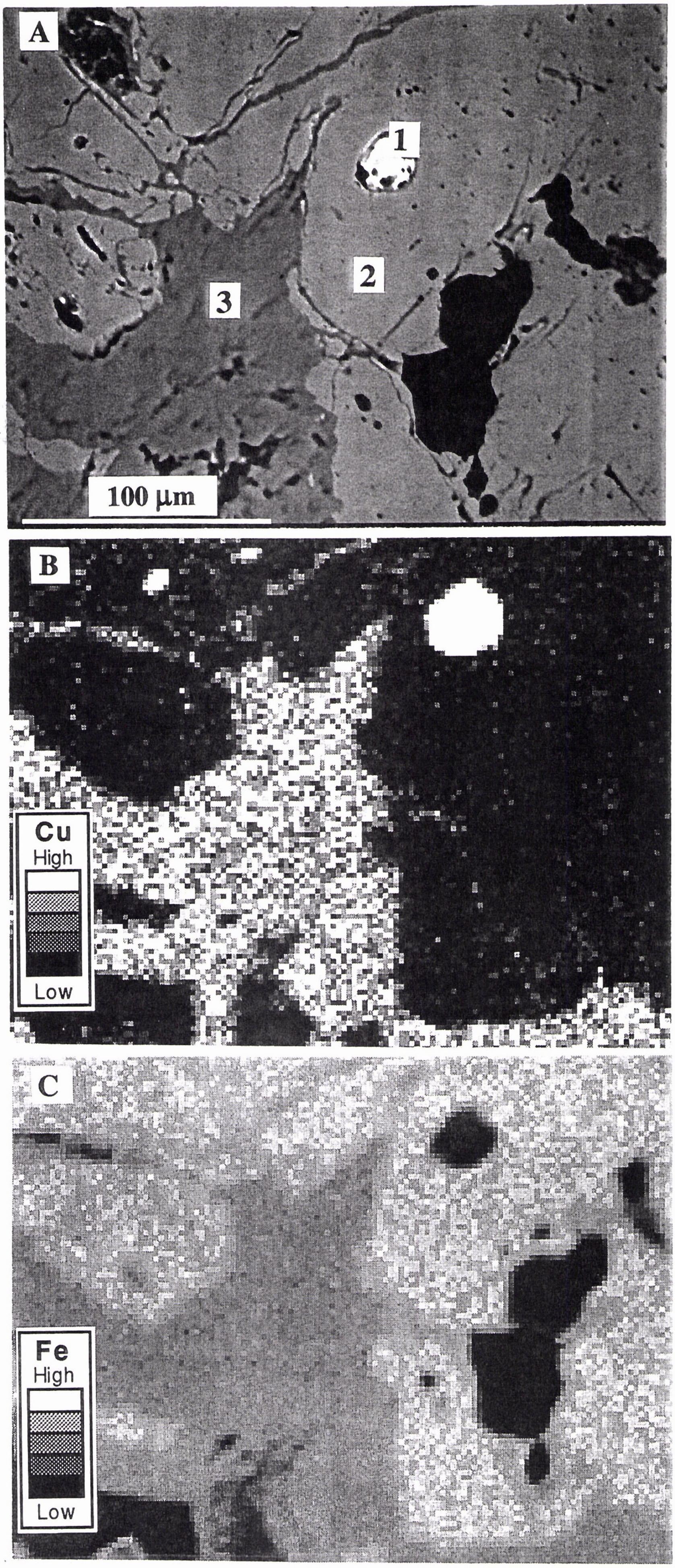

Figure 6A Backscattered electron image of sample SE143 with chalcopyrite grain (1), hematite after magnetite (2), and goethite after chalcopyrite (3). 6B X-ray map of the same grains showing Cu distribution. 6C X-ray map showing Fe distribution.

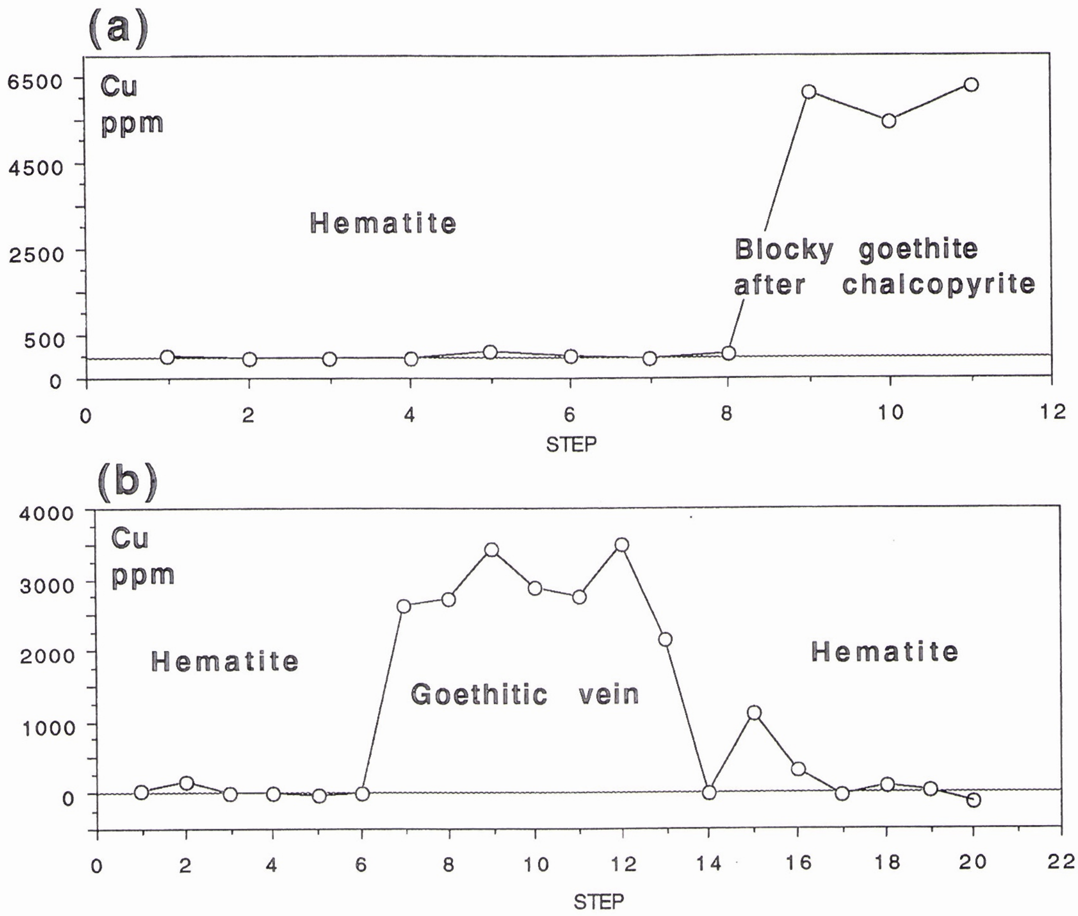

Figure 7. Probe traverse (10μm steps) across hematite and goethite of sample SE 143.

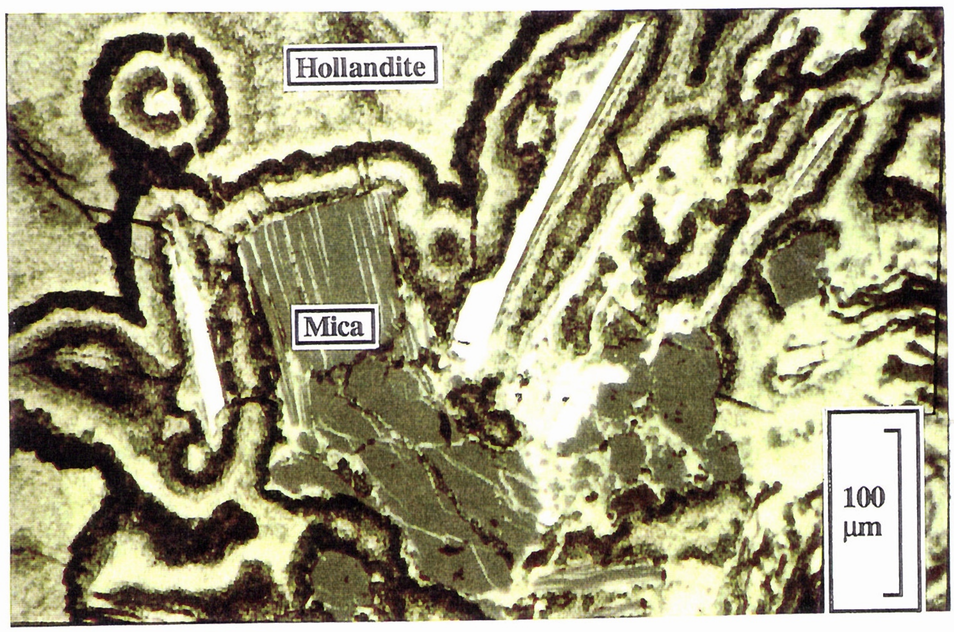

Figure 8 Manganese oxides replacing mica in oxidised barren sample SE159.

5.2 Descriptive statistics

Table 2 lists summary statistics for samples from the two deposits and from barren sites for the 47 elements analysed. Sample SE159 was removed from the barren sample set as it is a single extreme outlier of Mn veining.

Some elements are more variable between deposits than between mineralised and barren samples (eg. Fe, Ca and Ce). Mineralised ironstones are characterised by more Cu, W, and Au but the barren ironstones are richer in Mn, K, Ba, As, Cr and Co. Deposit 251 is richer in Fe, Cu, W, Sb, Zn, As and Au than Deposit 257 and poorer in Si, Mn, K, Ba, Sr, Y. This variation may be affected by the distribution of sampling over the two ironstones as they are very variable spatially.

5.2.1 Box plots

Figure 9 summarises the data comparing mineralised and barren ironstones for the elements showing the most discrimination between the two types. The elements showing the least overlap of ranges and therefore the best discrimination are W, Au, Mn and Ba.. The barren samples have a smaller range of Si. Variability between the mineralised ironstone units is shown in Figure 10. The two parallel mineralised ironstone units at Deposit 257 are labelled as 257E and 257W. The Au box plots show the most overall variability, with negatively skewed data and high 95th percentiles that have been clipped from the diagram. Deposit 251 has the greatest variability and the highest Au concentrations. Copper and W are distinctly greater in Deposit 251 as are As and Sb. Strontium and Co are negatively correlated with As and Sb.

5.2.2 Log/log plots

Figure 11 compares the data for seventeen elements from barren and mineralised ironstones. Geometric means (blue spots) to the right of the red line (median values of barren samples) are greater in the mineralised than the barren samples. The green lines indicate orders of magnitude deviation from the barren geometric mean. Tungsten and Au are the strongest indicators of mineralisation as they have geometric means more than one order of magnitude greater than barren samples. Copper is strongly enriched in the mineralised samples but has a range that overlaps many barren samples. Barium is the strongest indicator of barren ironstones as it has a geometric mean ten times greater than the mean of mineralised ironstones. Manganese is more abundant in barren samples but, since it is very mobile and related more to secondary processes, it is of less use as a discriminator.

5.2.3 Scatter plots

Log plots comparing the scatter of elements relevant to discriminating barren from mineralised samples show that Ba and W separate the two types (Figure 12). Manganese and W separate the two types but Mn is too mobile and variable to be a reliable indicator. Barium and Cu have large overlaps and do not separate the sample types adequately.

5.2.4 Correlations

In Figure 13 the range of correlation coefficients between the three mineralised populations indicates the variability of the ironstones. Skewed data for Au and W distort the correlation coefficients, but normalising is not effective with only nine samples. A few outliers control the correlation coefficients and a much larger sample set is needed to accurately describe the population of each mineralised vein. The SiO_2-Au plot shows a significant correlation for each population. The SiO_2-Fe_2O_3 plot shows the extent that the quartz and hematite which constitute 96% of the sample controls the chemistry. The two samples from Deposit 251 to the left of the trend contain goethite and therefore more water than samples that contain only hematite.

6 DISCUSSION

Except for copper, trace elements in the oxidised Selwyn ironstones occur in microscopic inclusions in hematite and quartz. Trace element (Au, W, Sn, As, Sb) concentrations do not correlate with the proportions of magnetite, hematite or quartz in the sample except for an inconsistent correlation of Au with quartz . Ninety six percent of the sample is quartz and hematite which results in a closure of the data with respect to Fe and Si. This disguises the association of Cu with Fe when chalcopyrite weathers to Cu-rich goethite, because the goethite represents a small proportion of the Fe in the sample. The goethite rich samples however, have low major element totals because of the goethite's lattice water, resulting in a correlation between low totals and Cu.

The variation in Cu and W, between deposits 251 and 257, shown in Figure 13, is not dependent on Fe or Si concentrations. The correlation between elements in the mineralised samples is poor although there are obvious coincident peaks in the transect plots in Figure 14. Plot 14C shows several examples of Cu-W-Au coincidences but this correlation is not consistent and cannot be seen in Plot 14H from the Deposit 257 transect.

Where saline mineralising fluids can vary in composition, temperature and (probably) source during accumulation in localised sections of the ironstones, several populations of geochemical signatures may occur across and along the ironstone bedding. An example of this are the two parallel ironstone veins sampled adjacent to Deposit 257 that are only 25 m apart and can be discriminated on the basis of Sr, Sb and As (Figure 10). Variations in Sb, As and Zn abundances between Deposit 251 and Deposit 257, that are less than one kilometre apart which are shown in Figure 14 E and J. On a district scale, the Osborne deposit, another ironstone Cu-Au deposit 45 km to the south, is Ag rich and W poor. The Swan Cu-Au Prospect, near Mt Elliott, is also located on a magnetic ironstone and has more Cu, As, Co and Zn than the mineralised Selwyn ironstones but it is lacks quartz which is a dominant at Selwyn (Scott, 1985).

The barren ironstone samples have different element correlations that relate to Mn accumulation of Cu, Zn, Co and Ba. This set of elements have negative correlations with Fe indicating that hematite-rich samples are poor in Mn. The barren samples appear to have been influenced by oxidising groundwaters rich in Mn. The Selwyn ironstones differ from the Tennant Creek mineralisation (Stoltz *et al,* 1994) in that they are poor in Bi, Mo, Pb and Zn.

The Selwyn ironstones provide a surface model for a style of mineralisation that recurs under Mesozoic and Tertiary sediments in the Eastern Succession of the Mt Isa Inlier. Exploration for these deposits is currently following up magnetic anomalies in Fe-rich sediments bordering intrusive granites but at Selwyn magnetics do not discriminate between mineralised and barren ironstones. Geochemistry is considered impractical in areas of Mesozoic and Tertiary cover although anomalous gossanous material was found at surface close to the Ernest Henry discovery (Craske, 1995). Copper might be expected to produce a large halo around buried deposits containing chalcopyrite, which may extend upwards into the cover to precipitate as sulphates and carbonates. Gold and W may be fixed in quartz and hematite physically dispersed on the palaeosurface of the Proterozoic. Following up surface or shallow Cu anomalies with sampling of the weathered Proterozoic surface may provide another method to assist the geophysical approach and help prioritise anomalies.

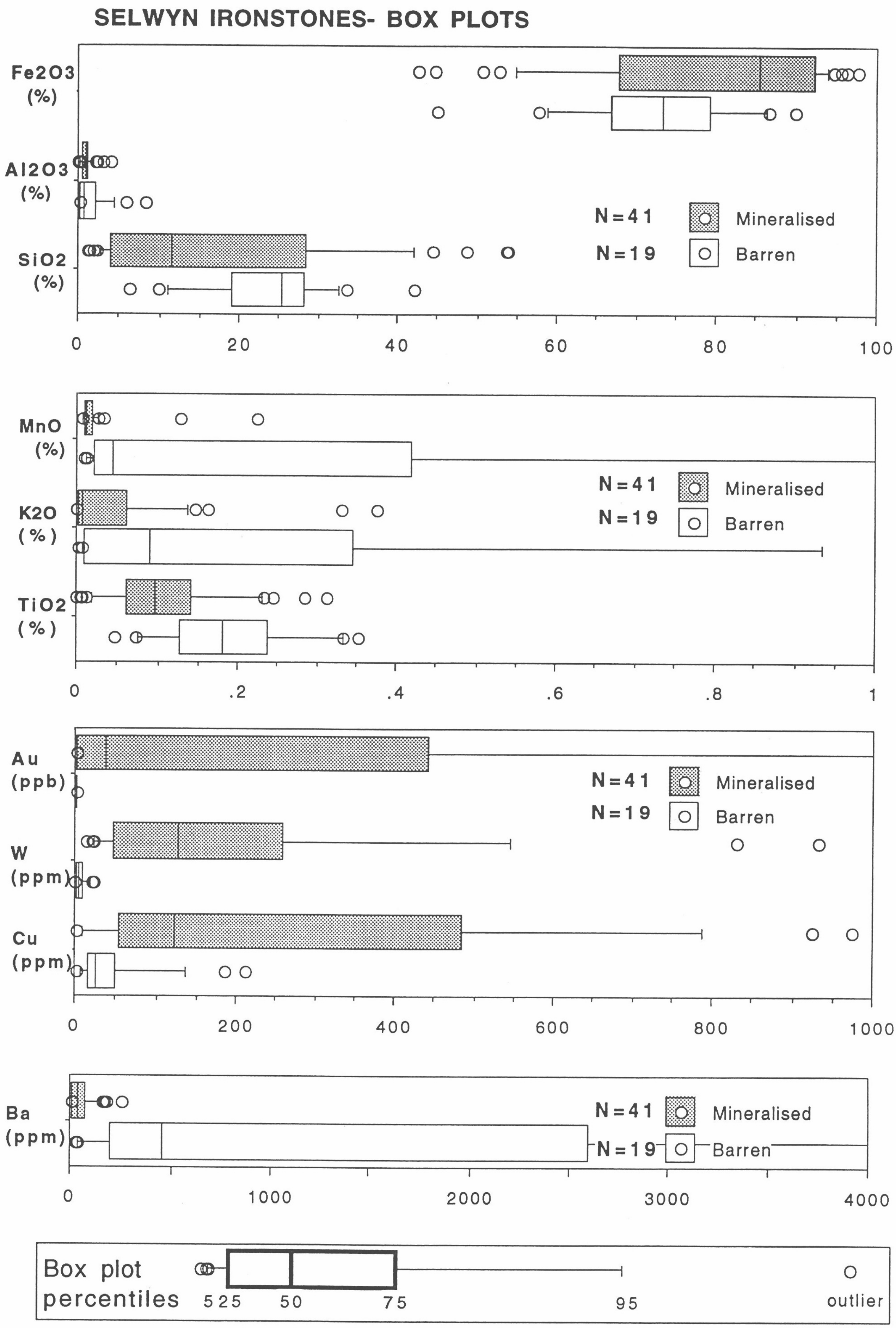

Figure 9 Box plots for mineralised and barren samples for those elements that show discrimination between the two types.

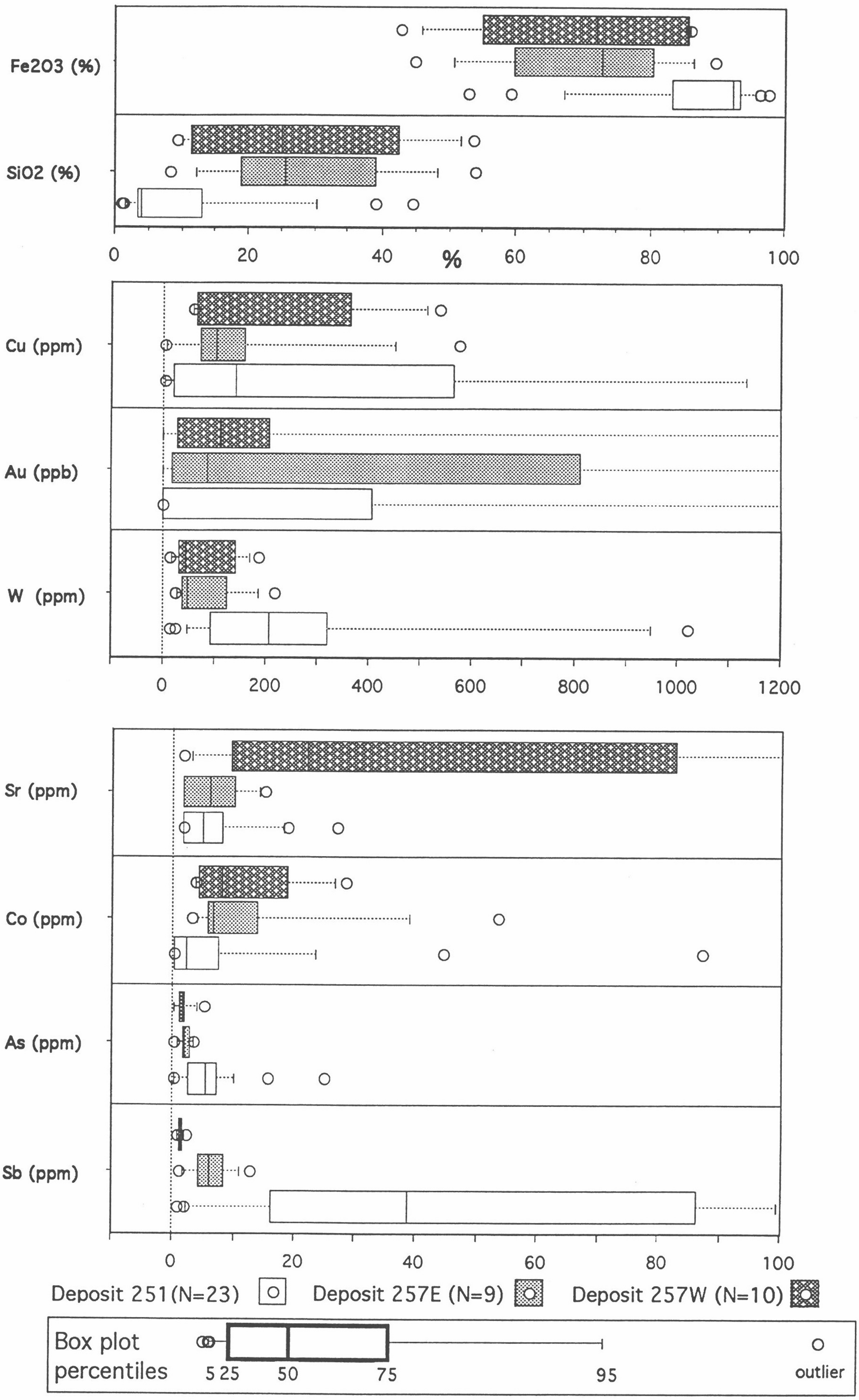

Figure 10 Box plots for mineralised ironstone data showing the variation between deposits.

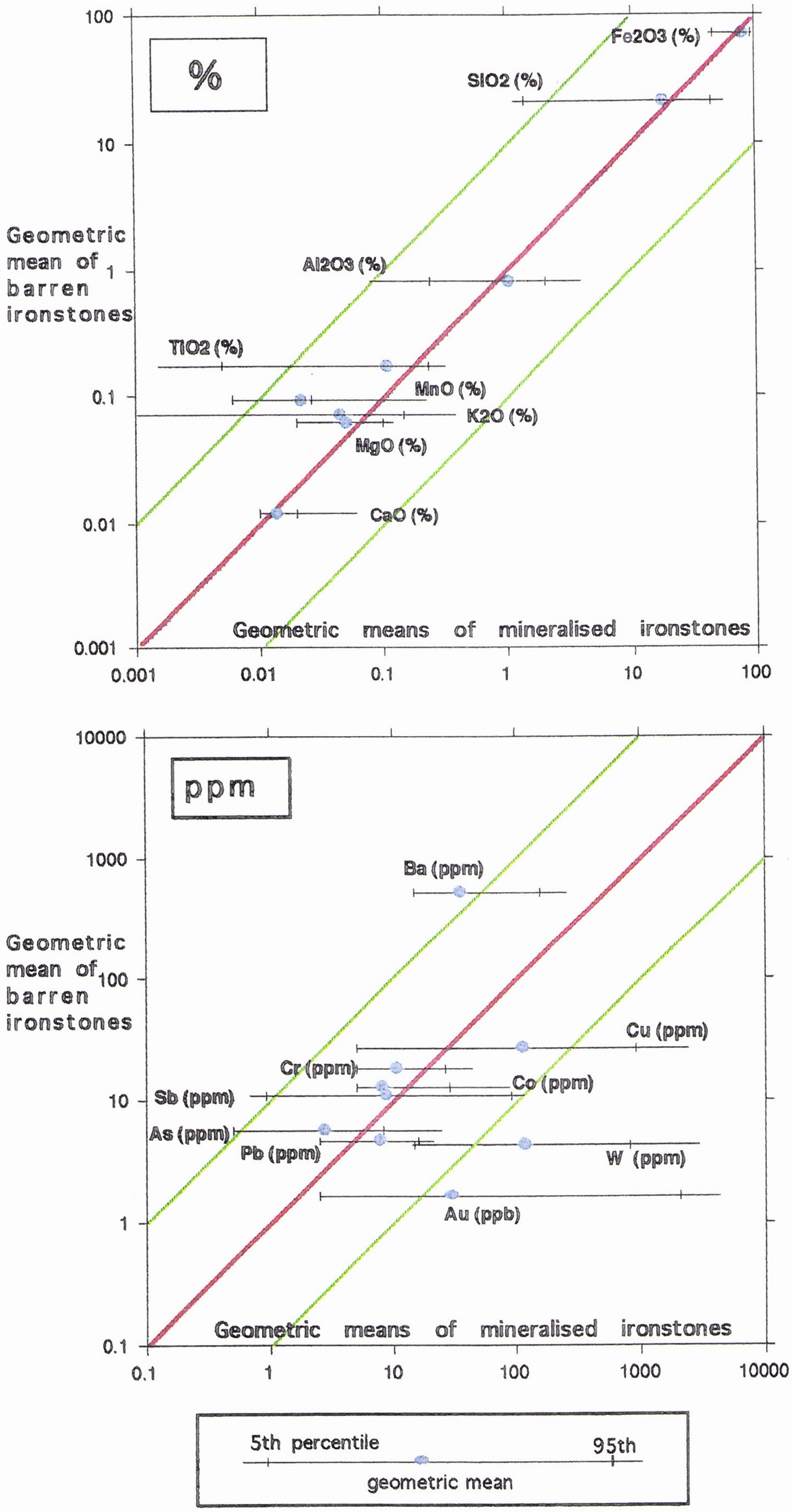

Figure 11 Log-log plots comparing the geometric means and ranges of seventeen elements for the barren and mineralised ironstones, (Au in ppb).

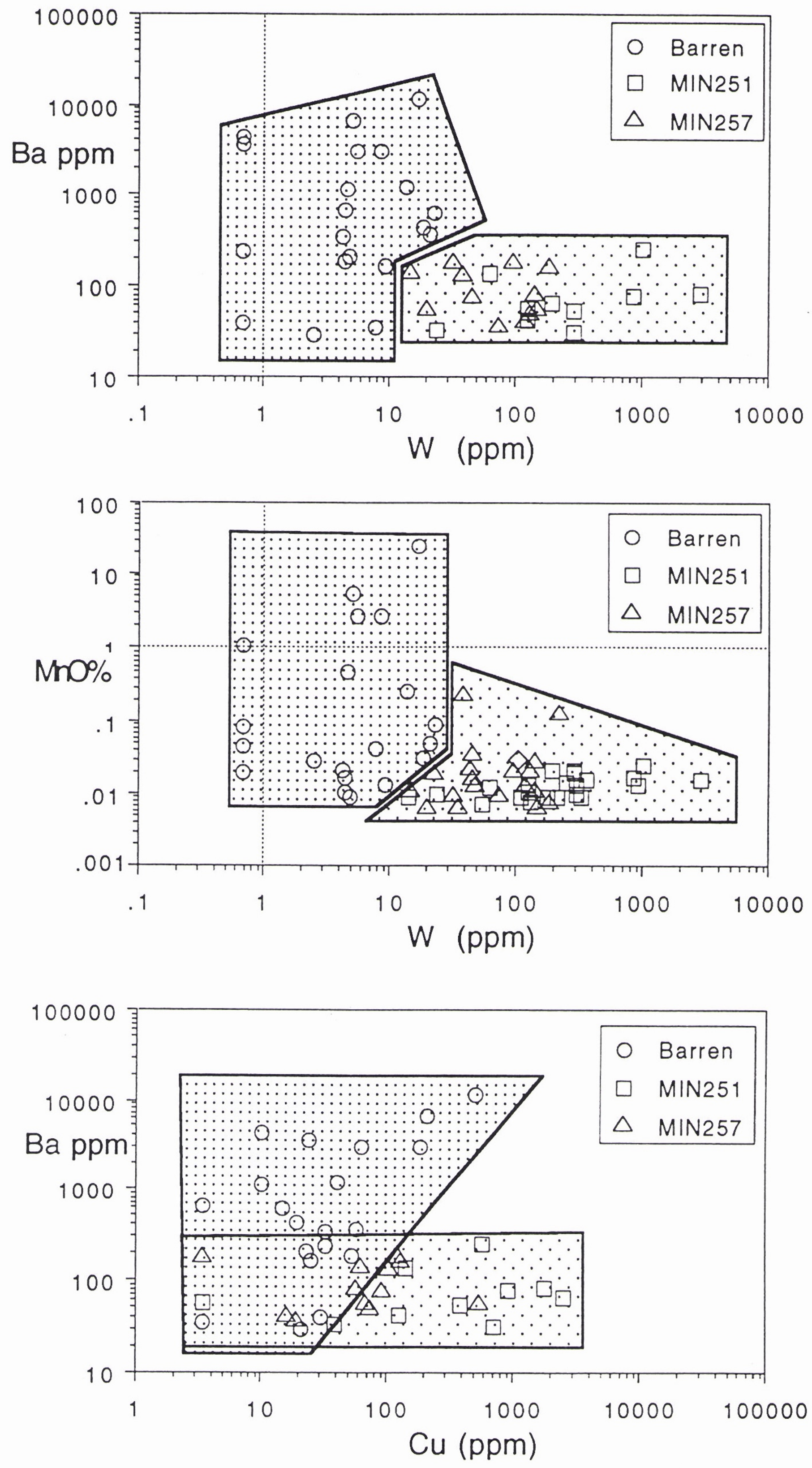

Figure 12. Scatter plots for discriminating barren and mineralised ironstones

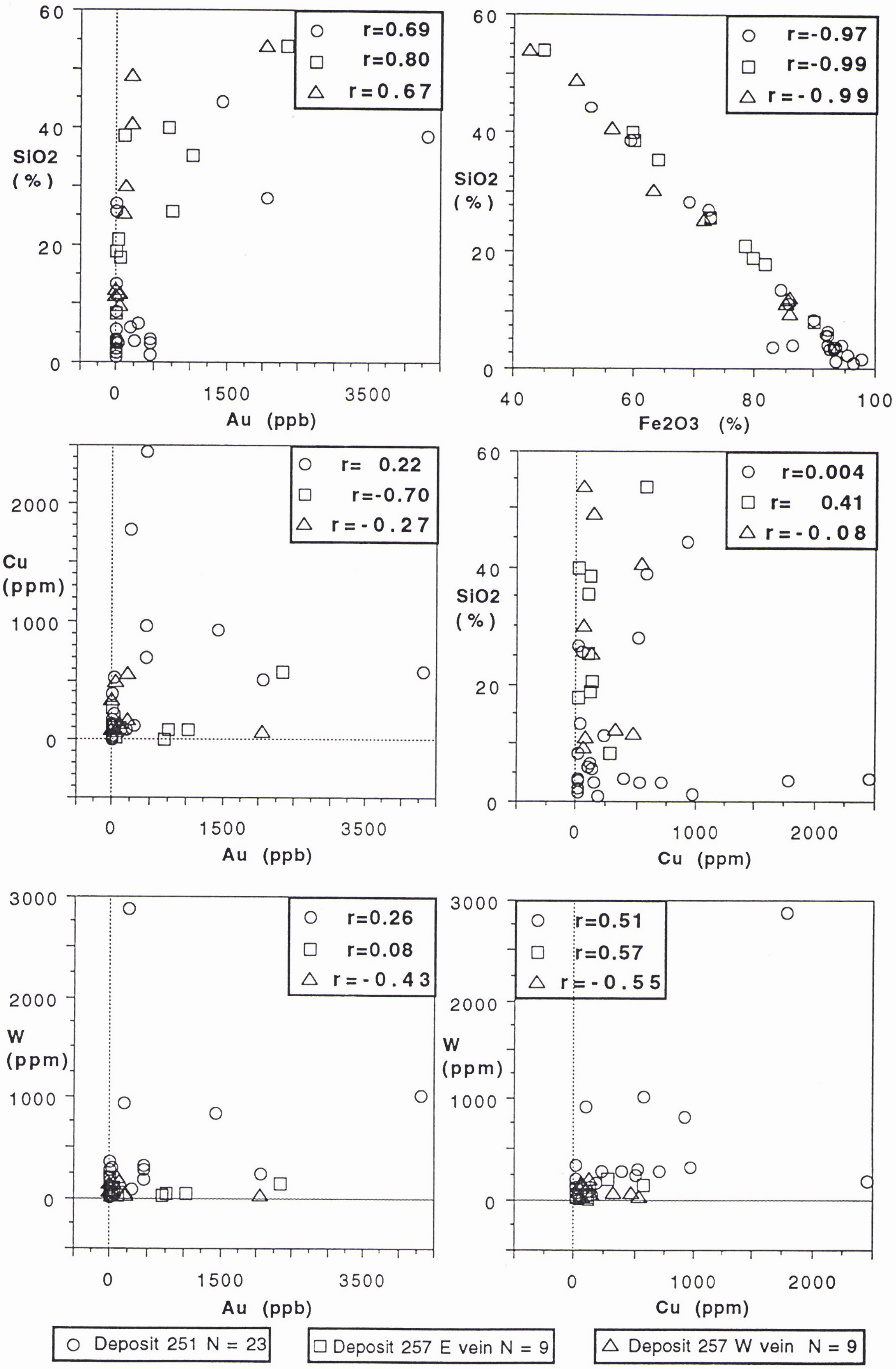

Figure 13 Plots indicating the variabilityof inter-element correlations between deposits.

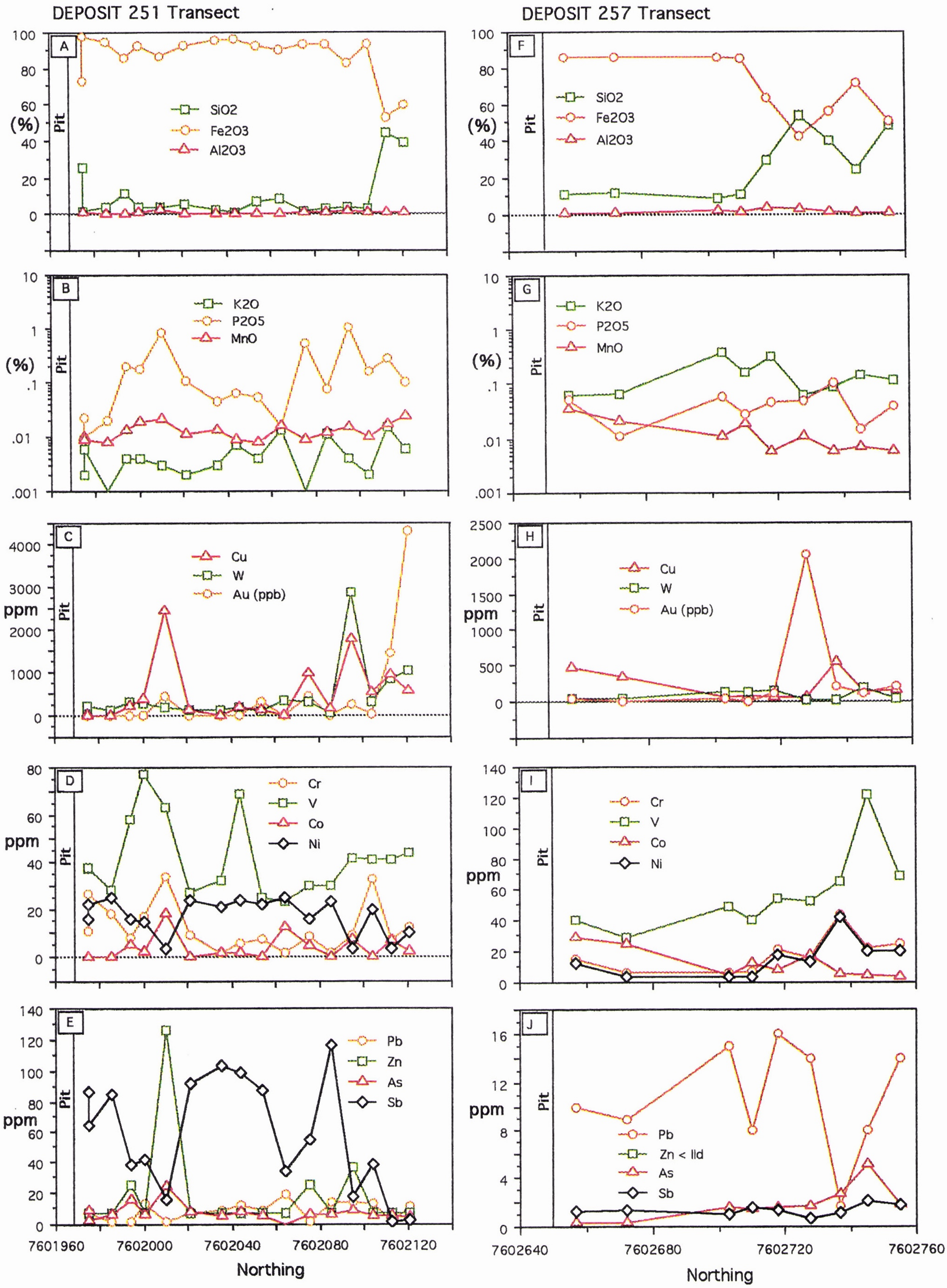

Figure 14 Multielement data for sampling at ten metre intervals adjacent to deposits 251 and 257.

7 CONCLUSIONS

1. The distribution of Au in the ironstones is related to the hydrothermal origin of the deposits with minor effects from oxidation.

2. Gold is concentrated in quartz-rich samples.

3. Copper was originally in chalcopyrite and, on oxidation of the sulphides, concentrates in goethite.

4. Tungsten is the best indicator of mineralised ironstones.

5. Barium (> 250 ppm) is the best indicator of barren ironstones.

6. Barren ironstones are manganese enriched.

7. Gold, W and Sn are contained in resistate minerals which will preserve the anomaly at surface and in detrital materials shed into adjacent streams.

8. Correlations of W, As and Sb with Au are poor in the total dataset because each ironstone ens represents a separate population and insufficient samples were taken within each ironstone lens to be a significant sample.

9. Orientation studies should take into account the stratigraphy and continuity of the ironstone layers, since each ironstone layer has a different geochemistry which may also vary across the layer.

9 ACKNOWLEDGMENTS

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11 APPENDIX 1

Selwyn ironstone data

Appendix 1 SELWYN IRONSTONE DATA

sampno	Samptyp	Northing	Easting	SiO2(%)	Al2O3(%)	Fe2O3(%)	MgO(%)	CaO(%)	Na2O(%)	K2O(%)	TiO2(%)	P2O5(%)	MnO(%)
SE145	Barren	7603214	446821	27.2	0.2	72.7	0.02	0.01	0.01	0.007	0.165	0.019	0.013
SE146	Barren	7603224	446821	16.3	0.2	82.9	0.02	0.01	0.01	0.015	0.077	0.014	0.050
SE147	Barren	7603234	446821	26.1	0.3	73.6	0.04	0.01	0.01	0.031	0.194	0.030	0.009
SE148	Barren	7603244	446821	26.9	0.5	72.4	0.03	0.01	0.01	0.006	0.197	0.061	0.011
SE149	Barren	7601210	446284	18.8	1.5	78.0	0.08	0.01	0.01	0.188	0.145	0.089	0.017
SE150	Barren	7601235	446284	27.5	2.1	67.6	0.10	0.04	0.02	0.156	0.184	0.107	0.084
SE151	Barren	7601265	446275	19.6	0.7	79.1	0.04	0.01	0.03	0.021	0.154	0.032	0.031
SE152	Barren	7601275	446268	31.2	2.4	60.5	0.13	0.01	0.01	0.634	0.181	0.178	2.699
SE153	Barren	7601272	446258	21.8	1.9	73.5	0.11	0.01	0.01	0.359	0.245	0.116	0.472
SE154	Barren	7601281	446250	25.4	5.9	62.8	0.24	0.01	0.07	1.133	0.334	0.183	1.128
SE155	Barren	7601297	446245	6.5	1.2	85.9	0.06	0.01	0.01	0.357	0.121	0.268	2.682
SE156	Barren	7601285	446278	33.7	8.1	44.9	0.44	0.01	0.11	2.749	0.352	0.149	5.315
SE157	Barren	7601278	446282	28.5	2.1	66.7	0.12	0.04	0.01	0.265	0.332	0.086	0.255
SE158	Barren	7601277	446284	20.8	2.2	75.6	0.10	0.01	0.02	0.312	0.161	0.050	0.090
SE159	Barren	7601545	447188	36.8	7.0	16.6	0.99	0.15	0.03	3.990	0.327	0.297	25.656
SE160	Barren	7601780	446894	42.1	0.4	57.6	0.05	0.01	0.02	0.060	0.295	0.075	0.044
SE161	Barren	7601780	446894	31.2	0.5	67.8	0.05	0.03	0.01	0.090	0.220	0.118	0.021
SE162	Barren	7602080	446894	20.7	0.1	79.4	0.02	0.01	0.05	0.002	0.118	0.024	0.043
SE163	Barren	7602080	446894	13.1	0.3	86.6	0.04	0.01	0.01	0.007	0.048	0.006	0.028
SE164	Barren	7602080	446894	9.9	0.2	89.8	0.03	0.01	0.04	0.007	0.073	0.043	0.020
SE101	257min	7602675	445593	40.1	0.6	59.5	0.02	0.01	0.04	0.003	0.229	0.030	0.009
SE102	257min	7602685	445597	17.9	0.2	81.8	0.03	0.01	0.01	0.006	0.078	0.015	0.012
SE103	257min	7602690	445600	20.8	0.5	78.4	0.02	0.01	0.01	0.007	0.024	0.028	0.019
SE104	257min	7602702	445604	35.6	0.4	63.8	0.03	0.01	0.01	0.003	0.012	0.046	0.012
SE105	257min	7602711	445608	25.5	0.5	72.6	0.04	0.01	0.01	0.004	0.051	0.057	0.016
SE106	257min	7602720	445612	19.0	0.5	79.8	0.04	0.02	0.01	0.001	0.147	0.036	0.018
SE107	257min	7602729	445615	8.3	0.3	89.8	0.04	0.02	0.01	0.005	0.059	0.059	0.126
SE108	257min	7602703	445578	9.3	2.0	86.0	0.06	0.01	0.1	0.377	0.068	0.057	0.011
SE109	257min	7602710	445581	11.0	1.7	85.4	0.06	0.01	0.1	0.162	0.128	0.027	0.019
SE110	257min	7602718	445585	29.8	4.0	63.1	0.05	0.01	1.37	0.332	0.215	0.045	0.006
SE111	257min	7602728	445590	53.6	3.1	42.7	0.12	0.03	0.11	0.060	0.087	0.048	0.011
SE112	257min	7602737	445593	40.5	1.9	56.3	0.11	0.01	0.51	0.087	0.164	0.104	0.006
SE113	257min	7602745	445597	25.0	1.2	71.8	0.10	0.06	0.07	0.146	0.284	0.015	0.007
SE114	257min	7602755	445600	48.7	1.0	50.5	0.03	0.02	0.01	0.113	0.245	0.040	0.006
SE115	257min	7602661	445585	38.7	0.9	59.9	0.06	0.01	0.01	0.024	0.143	0.019	0.224
SE116	257min	7602673	445572	12.1	0.7	86.0	0.07	0.01	0.01	0.066	0.075	0.011	0.021
SE117	257min	7602657	445567	11.5	0.8	85.6	0.10	0.01	0.05	0.060	0.098	0.053	0.034
SE118	257min	7602645	445575	53.9	0.7	44.8	0.06	0.01	0.01	0.016	0.008	0.107	0.026
SE122	257min	7603328	445647	3.7	0.1	93.3	0.05	0.01	0.01	0.002	0.050	0.002	0.009
SE123	251min	7601975	445415	25.7	1.3	72.7	0.05	0.01	0.01	0.002	0.130	0.022	0.010
SE124	251min	7601975	445404	1.8	1.2	97.7	0.04	0.01	0.06	0.006	0.234	0.010	0.009
SE125	251min	7601973	445377	6.1	0.5	91.8	0.04	0.01	0.01	0.038	0.027	0.028	0.013
SE126	251min	7601970	445368	3.2	1.7	92.4	0.07	0.01	0.01	0.132	0.062	0.188	0.021
SE127	251min	7601780	445310	28.0	1.1	69.1	0.04	0.01	0.01	0.086	0.116	0.039	0.014
SE128	251min	7601762	445320	13.6	1.1	84.2	0.03	0.01	0.03	0.009	0.105	0.012	0.007
SE129	251min	7601753	445355	26.9	0.9	72.3	0.05	0.01	0.02	0.003	0.127	0.016	0.009
SE130	251min	7601985	445410	4.1	0.4	94.5	0.03	0.01	0.01	0.001	0.141	0.020	0.008
SE131	251min	7601994	445415	11.4	0.4	85.8	0.10	0.02	0.01	0.004	0.075	0.195	0.013
SE132	251min	7602000	445418	4.0	1.0	92.2	0.05	0.01	0.01	0.004	0.200	0.178	0.019
SE133	251min	7602010	445422	4.0	2.5	86.4	0.03	0.01	0.01	0.003	0.139	0.830	0.021
SE134	251min	7602021	445424	5.7	0.2	92.3	0.02	0.01	0.01	0.002	0.096	0.104	0.011
SE135	251min	7602035	445427	2.3	0.5	95.5	0.04	0.01	0.03	0.003	0.073	0.044	0.013
SE136	251min	7602044	445431	1.2	0.3	96.3	0.02	0.01	0.01	0.007	0.065	0.063	0.009
SE137	251min	7602054	445435	6.7	0.4	92.3	0.03	0.01	0.01	0.004	0.087	0.052	0.008
SE138	251min	7602064	445438	8.6	0.4	90.0	0.05	0.01	0.03	0.013	0.045	0.015	0.016
SE139	251min	7602075	445439	1.4	1.4	93.4	0.04	0.01	0.01	0.001	0.111	0.534	0.009
SE140	251min	7602085	445441	3.5	1.2	93.1	0.04	0.01	0.02	0.011	0.098	0.073	0.012
SE141	251min	7602095	445445	3.7	1.9	82.9	0.05	0.02	0.02	0.004	0.089	1.069	0.015
SE142	251min	7602104	445540	3.4	0.8	93.2	0.03	0.01	0.01	0.002	0.314	0.158	0.010
SE143	251min	7602113	445454	44.5	0.9	52.7	0.05	0.02	0.01	0.015	0.005	0.279	0.017
SE144	251min	7602121	445457	38.9	1.0	59.1	0.03	0.01	0.01	0.006	0.001	0.101	0.024
SE119	251ore	251,level-1005		30.1	0.2	68.8	0.20	0.01	0.02	0.004	0.005	0.002	0.028
SE120	251ore	251,level-930		28.8	0.6	62.6	0.50	0.07	0.05	0.057	0.001	0.006	0.011

Appendix 1 SELWYN IRONSTONE DATA

sampno	Ag(ppm)	As(ppm)	Au(ppb)	Ba(ppm)	Br(ppm)	Ce(ppm)	Cl(ppm)	Co(ppm)	Cr(ppm)	Cs(ppm)	Cu(ppm)	Eu(ppm)
SE145	<5	6	<5	163	<2	27	50	7	18	<1	25	<0.5
SE146	<5	8	<5	373	<2	10	<20	26	12	<1	56	<0.5
SE147	<5	6	<5	207	<2	42	<20	3	20	<1	23	<0.5
SE148	<5	6	<5	191	<2	86	<20	1	21	1	53	<0.5
SE149	<5	4	<5	660	<2	35	100	<1	51	1	<10	0.7
SE150	<5	5	<5	4529	<2	108	30	7	18	<1	10	0.6
SE151	<5	8	<5	450	<2	41	130	<1	13	<1	19	0.7
SE152	<5	6	<5	3050	<2	28	280	193	17	2	187	0.7
SE153	<5	9	<5	1190	<2	18	30	28	20	<1	10	<0.5
SE154	<5	7	<5	3808	<2	132	60	44	29	1	24	1.4
SE155	<5	7	<5	3081	<2	29	30	67	14	1	62	0.9
SE156	<5	5	<5	6861	<2	63	60	228	32	1	212	1.3
SE157	<5	9	<5	1249	2	50	40	17	18	<1	41	1.4
SE158	<5	7	<5	636	<2	44	40	8	15	<1	15	1.1
SE159	<5	15	<5	11883	<2	61	230	786	55	5	507	1.1
SE160	<5	6	<5	237	<2	42	<20	10	29	<1	33	<0.5
SE161	<5	5	<5	341	<2	28	30	21	39	<1	33	<0.5
SE162	<5	4	<5	37	<2	7	20	21	11	<1	<10	<0.5
SE163	<5	2	<5	30	<2	2	<20	33	8	<1	21	<0.5
SE164	<5	4	<5	41	<2	6	<20	23	7	2	30	<0.5
SE101	<5	2	684	175	<2	15	50	3	21	<1	<10	0.7
SE102	<5	3	32	40	<2	14	<20	5	7	<1	16	<0.5
SE103	<5	2	23	171	<2	39	70	6	<5	<1	122	1.3
SE104	<5	2	1010	<30	<2	11	70	7	9	2	96	0.6
SE105	<5	2	743	76	<2	44	60	6	9	1	92	0.9
SE106	<5	3	<5	<30	<2	14	70	10	14	<1	113	<0.5
SE107	<5	3	<5	<30	<2	30	<20	54	8	<1	267	<0.5
SE108	<5	2	50	80	<2	5	40	4	6	<1	58	<0.5
SE109	<5	1	<5	49	<2	3	40	13	7	<1	73	<0.5
SE110	<5	2	115	55	<2	5	50	8	21	<1	67	<0.5
SE111	<5	2	2060	140	<2	11	60	17	16	<1	63	<0.5
SE112	<5	3	206	54	<2	21	40	5	44	1	539	2.7
SE113	<5	5	111	156	<2	7	40	4	22	<1	128	<0.5
SE114	<5	2	207	<30	<2	12	40	4	24	<1	149	<0.5
SE115	<5	<1	86	126	<2	97	20	17	15	2	105	1.6
SE116	<5	<1	<5	<30	<2	3	70	24	6	<1	331	<0.5
SE117	<5	<1	38	<30	<2	<2	40	29	15	<1	475	<0.5
SE118	<5	3	2320	<30	<2	48	<20	13	<5	<1	577	0.7
SE122	<5	<1	<5	35	<2	<2	110	3	<5	<1	19	<0.5
SE123	<5	8	<5	33	<2	40	50	<1	11	<1	38	<0.5
SE124	<5	3	<5	<30	<2	144	80	<1	27	2	12	1.0
SE125	<5	<1	170	<30	<2	14	<20	45	7	<1	88	<0.5
SE126	<5	2	444	31	<2	46	90	87	12	<1	698	0.7
SE127	<5	2	2050	<30	<2	6	40	15	16	<1	512	<0.5
SE128	<5	2	<5	<30	<2	6	40	<1	11	<1	20	<0.5
SE129	<5	6	<5	<30	<2	48	40	1	7	2	<10	<0.5
SE130	<5	6	<5	<30	<2	12	50	<1	18	1	<10	<0.5
SE131	<5	16	12	<30	<2	30	60	5	8	<1	223	<0.5
SE132	<5	6	<5	55	<2	217	40	2	17	<1	385	1.5
SE133	10	25	443	68	<2	394	<20	18	34	<1	2446	2.1
SE134	<5	8	<5	43	<2	23	50	<1	9	<1	125	0.5
SE135	<5	5	<5	59	<2	303	50	2	<5	<1	<10	1.5
SE136	<5	8	<5	<30	<2	50	<20	2	6	<1	174	0.6
SE137	<5	6	301	<30	2	19	<20	<1	7	<1	117	<0.5
SE138	<5	<1	<5	<30	<2	7	40	13	<5	<1	13	<0.5
SE139	<5	6	451	<30	<2	22	<20	5	8	1	974	<0.5
SE140	<5	6	<5	139	<2	13	<20	<1	<5	<1	143	<0.5
SE141	<5	9	247	87	<2	7	120	8	9	2	1781	<0.5
SE142	<5	6	16	<30	<2	26	6..67	<1	33	<1	525	<0.5
SE143	<5	5	1430	81	<2	30	190	7	7	1	925	1.0
SE144	<5	5	4320	254	<2	40	80	2	12	1	577	1.6
SE119	<5	<1	1740	<30	<2	6	50	13	<5	<1	13453	<0.5
SE120	<5	<1	10600	<30	<2	2	<20	12	<5	<1	51452	0.5

Appendix 1 SELWYN IRONSTONE DATA

sampno	Ga(ppm)	Hf(ppm)	Ir(ppb)	La(ppm)	Lu(ppm)	Mo(ppm)	Nb(ppm)	Ni(ppm)	Pb(ppm)	Rb(ppm)	S(ppm)	Sb(ppm)
SE145	3	1.0	<20	19.8	<.2	<5	<4	21	10	5	60	48.1
SE146	4	0.6	<20	5.62	<.2	<5	4	<10	<5	<5	150	14.1
SE147	5	1.5	<20	24.7	<.2	<5	<4	20	<5	<5	80	69.3
SE148	<3	1.4	<20	48	<.2	<5	<4	20	<5	<5	90	70.8
SE149	<3	0.9	<20	13.3	<.2	<5	<4	13	15	12	180	15.4
SE150	<3	1.2	<20	79.3	<.2	<5	<4	18	11	<5	2490	6.3
SE151	4	0.6	<20	24.7	<.2	<5	5	31	13	<5	120	54.3
SE152	4	1.0	<20	15.4	<.2	<5	7	<10	<5	23	130	6.7
SE153	7	1.2	<20	10.7	<.2	<5	16	17	16	7	190	24.1
SE154	14	1.9	<20	41	<.2	<5	<4	17	9	50	140	9.2
SE155	<3	<0.5	<20	13.3	<.2	7	<4	23	9	17	100	7.4
SE156	14	2.9	<20	30	0.5	<5	8	11	<5	82	510	5.7
SE157	5	1.4	<20	29	0.4	<5	7	16	<5	5	300	14.8
SE158	5	0.9	<20	22.4	0.3	<5	6	18	<5	6	70	20.3
SE159	11	1.9	<20	28	0.3	15	5	123	26	282	310	2.9
SE160	4	2.6	<20	36.4	<.2	<5	<4	12	20	7	100	9.1
SE161	15	2.6	<20	22	<.2	<5	5	15	6	<5	150	1.0
SE162	<3	<0.5	<20	6.39	<.2	<5	<4	23	<5	6	40	12.9
SE163	23	<0.5	<20	2.16	<.2	<5	<4	12	20	7	100	1.1
SE164	10	<0.5	<20	5.92	<.2	<5	<4	<10	<5	<5	80	0.9
SE101	10	3.1	<20	9.09	0.5	<5	7	22	13	<5	80	8.7
SE102	7	1.0	<20	9.28	<.2	<5	<4	13	<5	<5	40	8.4
SE103	7	<0.5	<20	24.5	0.3	<5	<4	<10	12	<5	160	2.5
SE104	8	<0.5	<20	5.76	0.8	<5	<4	11	<5	<5	70	5.0
SE105	14	0.5	<20	26.1	0.3	<5	<4	<10	21	<5	60	6.0
SE106	3	0.7	<20	9.54	<.2	<5	4	16	11	<5	10	6.6
SE107	<3	0.6	<20	17.5	<.2	<5	<4	<10	15	<5	220	5.5
SE108	17	<0.5	<20	2.71	<.2	<5	<4	<10	15	<5	2580	1.0
SE109	16	0.9	<20	1.58	<.2	<5	11	<10	8	<5	220	1.6
SE110	13	1.8	<20	2.36	<.2	<5	4	17	16	<5	1760	1.4
SE111	9	0.8	<20	5.87	<.2	<5	<4	13	14	<5	750	<0.2
SE112	10	1.2	<20	1.49	8.4	<5	19	42	<5	<5	460	1.1
SE113	12	1.0	<20	3.87	<.2	<5	12	20	8	<5	540	2.1
SE114	6	2.0	<20	6.46	0.5	<5	13	20	14	<5	80	1.7
SE115	<3	1.0	<20	47.4	0.3	<5	7	24	<5	<5	60	12.8
SE116	5	<0.5	<20	1.76	<.2	19	<4	<10	9	<5	40	1.3
SE117	<3	0.5	<20	0.65	0.6	66	9	12	10	<5	270	1.2
SE118	9	0.5	<20	21.8	0.4	10	<4	<10	21	<5	30	1.2
SE122	<3	<0.5	<20	0.77	<.2	<5	<4	18	6	<5	410	18.7
SE123	5	0.8	<20	22.6	<.2	<5	<4	16	8	<5	80	86.8
SE124	3	1.7	<20	19.4	<.2	<5	9	22	7	9	70	64.4
SE125	10	1.4	<20	8.38	0.8	<5	6	32	8	6	60	2.2
SE126	17	<0.5	<20	27	0.6	15	6	16	10	5	260	0.9
SE127	14	0.9	<20	3.27	<.2	<5	5	15	8	9	70	2.3
SE128	5	1.1	<20	4.51	<.2	8	<4	26	10	<5	80	59.5
SE129	4	0.9	<20	67	<.2	<5	<4	21	6	<5	30	30.7
SE130	5	1.3	<20	8.31	<.2	<5	<4	25	<5	<5	20	84.9
SE131	<3	0.9	<20	15.8	<.2	<5	5	16	<5	<5	190	38.6
SE132	<3	2.0	<20	41.2	<.2	10	<4	15	13	<5	110	41.6
SE133	4	1.5	<20	66.2	0.2	50	6	<10	<5	<5	600	15.6
SE134	<3	0.6	<20	12.8	<.2	9	8	24	7	<5	50	92.0
SE135	<3	<0.5	<20	52.2	<.2	<5	<4	21	9	<5	60	103.0
SE136	<3	1.1	<20	16.1	<.2	<5	<4	24	12	<5	110	98.7
SE137	<3	<0.5	<20	9.58	<.2	<5	8	22	9	<5	40	87.3
SE138	10	0.8	<20	4.09	<.2	<5	<4	25	19	<5	70	34.5
SE139	<3	1.1	<20	13.4	<.2	6	7	16	<5	8	400	54.9
SE140	<3	1.0	<20	6.45	<.2	<5	<4	23	14	<5	130	116.0
SE141	<3	2.5	<20	7.14	<.2	<5	<4	<10	14	6	370	17.9
SE142	3	2.1	<20	10.7	<.2	<5	<4	20	13	7	90	38.1
SE143	13	1.2	<20	17.7	0.8	<5	<4	<10	<5	<5	180	2.0
SE144	14	1.6	<20	25.6	2.0	<5	<4	10	11	<5	110	2.5
SE119	10	<0.5	<20	3.39	0.2	10	<4	21	10	<5	4170	1.3
SE120	6	1.0	<20	0.83	1.3	<5	<4	13	7	5	45140	<0.2

Appendix 1 SELWYN IRONSTONE DATA

sampno	Sc(ppm)	Se(ppm)	Sm(ppm)	Sr(ppm)	Ta(ppm)	Th(ppm)	U (ppm)	V(ppm)	W (ppm)	Y(ppm)	Yb(ppm)	Zn(ppm)	Zr(ppm)
SE145	1.3	<5	1.6	6	1	2.5	<2	33	9	<5	<0.5	<20	46
SE146	1.4	<5	0.7	7	<1	1.6	<2	28	21	<5	<0.5	<20	21
SE147	1.7	<5	1.8	19	<1	2.3	<2	33	5	<5	0.7	<20	54
SE148	1.9	<5	3.4	38	<1	3.3	<2	24	4	<5	0.5	<20	43
SE149	5.4	<5	3.1	13	<1	4.7	2	50	4	5	0.8	<20	38
SE150	7.8	<5	2.8	138	<1	4.7	<2	53	<2	<5	0.5	<20	40
SE151	1.9	<5	3.0	7	<1	3.6	3	36	19	<5	<0.5	<20	29
SE152	4.1	<5	3.5	40	<1	4.2	4	46	5	10	1.3	37	41
SE153	3.9	<5	1.6	13	<1	4.9	<2	61	5	6	0.9	<20	48
SE154	7.8	<5	6.6	46	<1	9.7	3	76	<2	16	1.8	<20	67
SE155	2.8	<5	3.4	24	<1	2.4	5	74	8	<5	1.1	35	24
SE156	9.9	<5	4.9	38	<1	10.5	5	100	5	30	3.5	54	108
SE157	5.3	<5	5.9	24	<1	3.3	5	102	14	37	3.4	21	52
SE158	3.6	<5	4.8	7	<1	4.2	<2	54	22	21	2.4	<20	48
SE159	8.3	<5	3.7	908	1	7.6	14	780	17	18	2.3	135	103
SE160	2.1	<5	1.6	30	1	4.5	<2	45	<2	<5	<0.5	<20	98
SE161	3.3	<5	1.8	58	<1	2.3	<2	183	4	<5	<0.5	<20	90
SE162	0.9	<5	0.6	11	<1	0.8	<2	29	8	5	0.5	<20	25
SE163	1.7	<5	0.2	<5	<1	<0.5	2	93	3	<5	<0.5	<20	11
SE164	1.6	<5	0.4	8	<1	<0.5	<2	55	<2	<5	<0.5	<20	8
SE101	4.2	<5	2.5	9	1	6.1	3	40	33	36	3.8	<20	117
SE102	2.7	<5	1.8	<5	<1	2.0	<2	19	118	15	1.7	<20	22
SE103	2.4	<5	5.8	13	1	<0.5	<2	32	94	28	2.6	<20	<2
SE104	2.1	<5	1.9	6	<1	<0.5	4	35	47	64	6.4	<20	<2
SE105	3.0	<5	4.5	5	<1	1.5	3	29	45	19	2.1	<20	30
SE106	1.7	<5	1.7	<5	<1	1.4	<2	80	23	8	0.6	<20	20
SE107	1.4	<5	2.5	8	<1	1.3	2	57	217	7	<0.5	<20	8
SE108	8.9	<5	1.1	109	<1	5.1	<2	49	139	<5	<0.5	<20	18
SE109	8.6	<5	0.5	13	<1	1.7	<2	40	131	<5	<0.5	<20	17
SE110	9.7	<5	1.1	74	<1	6.9	3	54	145	<5	0.7	<20	58
SE111	5.5	<5	1.5	135	<1	1.7	3	52	15	7	0.6	<20	27
SE112	10.2	<5	5.8	22	1	5.8	9	65	20	726	61.5	<20	43
SE113	7.1	<5	1.0	34	1	3.7	<2	122	186	7	0.9	<20	44
SE114	4.8	<5	1.8	<5	<1	3.5	5	69	35	29	3.7	<20	63
SE115	5.9	<5	9.0	15	<1	4.1	<2	39	38	27	2.3	<20	46
SE116	6.3	<5	0.4	5	<1	0.5	4	29	44	<5	<0.5	<20	15
SE117	3.1	<5	0.7	11	<1	0.6	5	40	46	41	4.6	<20	20
SE118	1.9	<5	4.0	<5	<1	<0.5	7	32	144	37	3.4	<20	<2
SE122	1.4	<5	0.3	<5	<1	1.5	<2	21	74	<5	0.5	<20	16
SE123	5.4	<5	3.3	8	<1	2.0	<2	37	24	6	0.6	<20	18
SE124	5.5	<5	4.7	<5	1	4.5	<2	38	206	10	1.1	<20	59
SE125	9.5	<5	1.5	<5	<1	0.7	2	46	932	50	5.3	<20	7
SE126	10.5	<5	3.9	27	<1	3.6	10	84	283	56	5.1	<20	5
SE127	6.2	<5	1.1	6	<1	4.1	<2	85	251	<5	0.7	<20	20
SE128	3.3	<5	0.6	<5	<1	2.1	<2	25	55	<5	<0.5	<20	29
SE129	2.5	<5	2.5	10	<1	1.8	<2	76	14	<5	<0.5	<20	27
SE130	3.0	<5	1.1	9	<1	1.2	2	28	128	<5	<0.5	<20	40
SE131	6.4	<5	2.5	<5	<1	1.6	2	58	298	<5	<0.5	25	22
SE132	7.9	<5	8.1	8	<1	5.0	10	77	285	4	1.2	<20	52
SE133	42.0	<5	14.0	5	1	2.8	37	63	192	16	2.2	126	38
SE134	2.6	<5	2.2	8	<1	2.3	<2	27	126	6	<0.5	<20	17
SE135	3.8	<5	10.4	<5	<1	2.3	<2	32	124	<5	0.8	<20	17
SE136	3.3	<5	3.0	19	<1	2.3	<2	69	174	5	0.7	<20	29
SE137	2.8	<5	1.8	<5	<1	1.4	<2	25	85	<5	<0.5	<20	14
SE138	2.5	<5	1.0	6	<1	1.6	<2	23	356	<5	<0.5	<20	7
SE139	11.5	<5	2.0	<5	<1	3.2	5	30	328	<5	<0.5	25	34
SE140	2.4	<5	0.9	18	<1	2.4	<2	30	63	<5	<0.5	<20	25
SE141	20.9	<5	1.9	<5	<1	2.7	<2	42	2880	<5	0.7	37	20
SE142	9.5	<5	1.9	<5	<1	3.5	5	41	301	9	1.1	<20	64
SE143	9.2	<5	4.6	<5	<1	<0.5	4	41	831	68	5.8	<20	<2
SE144	9.3	<5	8.0	7	<1	<0.5	3	44	1020	163	14.4	<20	<2
SE119	2.9	<5	1.4	<5	<1	<0.5	3	26	105	24	2.3	<20	<2
SE120	7.4	<5	1.7	5	<1	0.6	<2	33	1260	101	8.9	31	<2