Section

DEPARTMENT OF MINES

SOUTH AUSTRALIA

GEOLOGICAL SURVEY

METALLIC RESOURCES DIVISION

A GEOCHEMICAL APPRAISAL OF THE BUNYEROO FORMATION COPLEY 1:250 000 SHEET

by

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G.S. No. 5884
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ABSTRACT

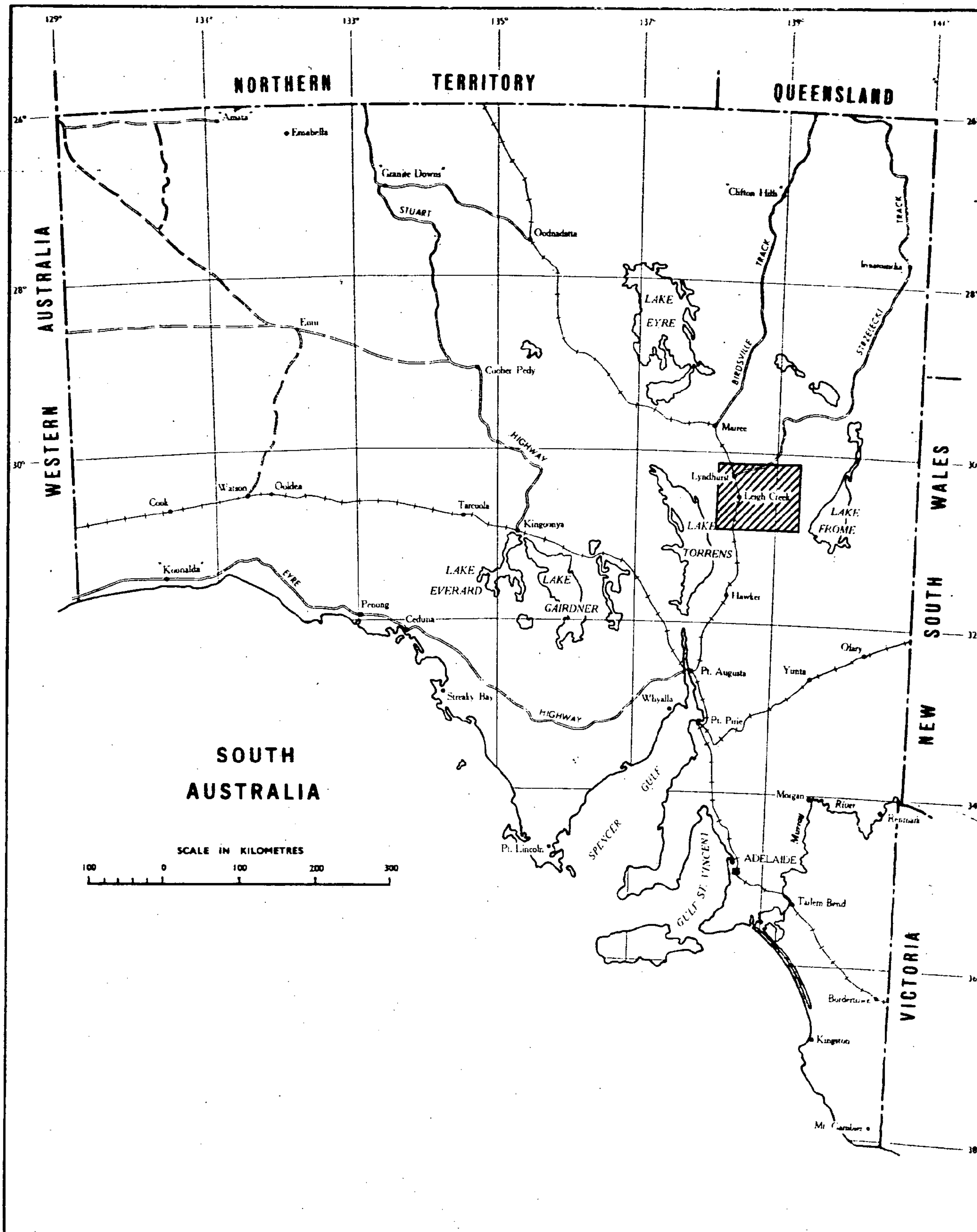
The late Upper Proterozoic Bunyeroo Formation was soil sampled along 16 traverses a bout 45 km apart. About 1 200 samples were analysed for Cu, Pb, Zn, Co, Ni, V, Mn and Mo. Geochemical profiles show a close association between Cu and Pb anomalies and green shale and dolomite beds in three stratigraphic positions. A closer traverse spacing of 15 km is considered more suitable to delineate areas of interest. Further work, with sampling controlled by geology, is recommended.

INTRODUCTION

A soil sampling programme was initiated in September 1976 on the COPLEY 1:250 000 sheet, to study the geochemistry of the Bunyeroo Formation on a regional scale, to locate areas for further exploration work. The Bunyeroo Formation, containing widespread Cu-Pb and Pb-Zn mineralization, represents a favourable sedimentary environment for syngenetic sulphide deposition. About 1 200 samples were taken on 16 traverses across the formation (Fig. 1) and analysed for Cu, Pb, Zn, Co, Ni, V, Mn and Mo. One traverse was analysed for Au, Ag, and Cd, but as all results were at or below the detection limit, analysis for these elements was discontinued. Geochemical and geological profiled, background means and factor analysis were the main methods used to delineate regional trends in the geochemistry of the formation.

GEOLOGY

The Bunyeroo Formation, belonging to the late Pre-cambrian Wilpena Group, was deposited in a period of cyclic sed-



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imentation subsequent to the Marioan Glaciation. It is conformably underlain by the ABC Range Quartzite in the southern areas of the COPLEY 1:250 000 sheet, and by siltstones of the Brachina Formation and Ulupa Siltstone further north. The Wonoka Formation, consisting predominantly of dolomites and dolomitic siltstones, which become more sandy towards the top, conformably overlies the Bunyeroo Formation.

The formation is characteristic of a shelf environment, and consists predominantly of dark red and purple shales, but with occasional carbonate and green shale interbeds and minor carbonaceous shale and phosphatic chert. Lateral changes in the lithology and thickness of the strata are common, and these generally reflect depositional variations in the oxygen content of the water, rate of deposition and fluctuations in sea level.

Geology profiles 1B to 8B (Fig. 2 & 3) in the Wearing Gorge area show that the formation there consists essentially of a lower sequence of shales and an upper sequence of regular interbeds of dolomite in purple shale and including the Wearing Dolomite Member. The boundary with the Wonoka Formation is usually placed where green shales and carbonates become much more common.

Eight traverse lines, 9B to 16B (Figs.4&5), on the rest of COPLEY show that the upper sequence of regularly interbedded dolomites and shales is thinner along lines 9B, 14B and 16B and is absent from lines 12B and 15B to the north west. On lines 9B, 14B and 16B a large proportion of the shales in the lower sequence are grey, and weather to a brown or greenish colour: lines 12B and 15B consist of thinly bedded purple shales with very rare thin green shale interbeds.

Although green shale interbeds may occur anywhere within the formation they are generally thicker and more abundant in the southern areas of COPLEY and in three stratigraphic positions. These are:

(1) a sequence of grey, green and yellow shales, sometimes containing dolomite interbeds, in the lower part of the formation;

(2) purple and green shales with more thickly bedded dolomites, just beneath a distinctive sequence of regularly interbedded shales and dolomites including the Wearing Dolomite Member;

(3) near the top of the formation, where green shales, characterizing the depositional environment of the Wonoka Formation, become more common.

S.A. Barytes Ltd. (1971) distinguished four stratigraphic units in the Bunyeroo Formation in the Alioota Bore area. Commencing from the base of the formation, these are:

(1) purple shale - a finely bedded purple greyish shale. Copper mineralization is confined to sporadic interbeds of green shale;

(2) banded dolomitic siltstone - olive-grey siltstones, containing bands and interbeds of silty dolomite and green shale. Mineralization occurs mainly in this unit, as malachite and limonite stains in green shales and specks of chalcopyrite along bedding planes in the silty dolomites;

(3) interbedded dolomite, siltstone and shale. Specks of chalcopyrite were found in dolomites carrying limonite after pyrite;

(4) a green shale with slaty cleavage, barren of mineralization.

The sequence containing the Wearing Dolomite Member is in the same stratigraphic position as the banded dolomitic siltstone (2) above.

MINERALIZATION

Figure 1 shows the distribution of mines and known occurrences of mineralization in the Bunyeroo Formation. The most important stratigraphic position for copper mineralization is the second unit defined above.

Persistent traces of copper mineralization are found in thinly bedded green shales and dolomites interbedded with the purple shales or in adjacent shales and structural traps. The Wearing Dolomite Member contains weak stratiform copper mineralization as blebs of chalcopyrite within the dolomite and in networks of calcite veins.

The greatest concentration of mineralization occurs in the vicinity of Beltana and is considered to be all secondary. At the Harvey Return, Black Feather and Enterprise Mines, copper mineralization is associated with vertical faults and at the Walter and Six Mile Claim mines, the copper occurs in a green shale bed. Exoil N.L. (1971) drilling near here, in the vicinity of Puttapa, intersected mineralized carbonaceous green shale beds containing fine grained, disseminated, syngenetic pyrite, galena and sphalerite.

The Mocatoona and Lady Millicent Copper Mines occur in a local lens of bleached black shale containing pyrite of presumed sedimentary origin. Secondary redistribution and enrichment of copper has occurred and all workings are of secondary ore. Rock chip samples taken by Mt. Isa Mines Ltd. in this area show a clear variation in Cu contant with respect to geochemical environment of deposition (Table 1).

TABLE 1

Rock Type	Depositional Environment	No. of Samples	Cu Me (ppm)
Upper Red Shale	Oxidising Environment	22	34
Upper Green Shale	Intermediate Environment	13	108
Pyritic Black Shale	Reducing Euxinic Facies	100	266
Lower Green Shale	Intermediate Environment	18	146
Lower Red Shale	Oxidizing Environment	17	69

The company believes that the mineralization was introduced by a volcanic exhalative mechanism through a nearby penecontemporaneous fault.

At the White Virgin mine near Constitution Hill erratically mineralized quartz and calcite veins occur, which contain galena; also, near the top of the formation, lead mineralization is present in a well-bedded carbonaceous rock.

Thomson (1965) rock-chip sampled a 36-metre section at the base of the Wonoka formation in the Wearing Gorge area and noted a strong correlation between high Cu values and green shale and dolomite interbeds.

GEOMORPHOLOGY

The Bunyeroo Formation generally underlies flat, gently undulating country, with occasional low rounded hills, allowing relatively easy access for sampling. It is bounded by ridges and rugged hilly country of the ABC Range Quartzite or Brachina Formation on one side and rolling hills of the Wonoka Formation on the other.

Soil developed over shales in the Bunyeroo Formation is generally thin, consisting of silts and small chips of shale. Thin quartzite gravels, probably derived from the Pound or ABC Range Quartzites, are common.

Vegetation is sparse, with the main growth being small trees, bushes and native grasses. Larger eucalypts grow along stream beds.

GEOCHEMISTRY

Sampling and Analysis

About 1 200 soil samples were taken on 16 traverses across the formation (Fig.1) and the sample interval was 10 or 20 metres depending on the dip of the bedding. Areas of transported soils and gravels were avoided by displacing traverse lines. Bedding dips and an estimate of slope of the land were used to recalculate sample intervals to true stratigraphic thickness. On each line, composite samples were analysed to represent the geochemistry of the stratigraphic intervals. The analysed samples for lines 1B, 2B to 8B and 9B to 16B consisted of 2, 10, and 4 smaller samples respectively, The lower part of the formation on traverse 9B was not sampled.

The samples were sent to AMDEL, where they were dried and sieved to obtain enough -180 micron size fraction for analysis. This size fraction is retained at the Mines Department. Each sample was analysed by atomic absorption spectrometry (A.A.S.) for Cu (detection limit 2 ppm), Pb (5) and Zn (1), and by quantitative emission spectroscopy (E.S.) for Co (5), Ni (5), V (10), Mn (10) and Mo (3); soil traverse 1B was also analysed for Au (0.05) using A.A.S. and Ag (0.1), Cd (3), Cu (1), Pb (1) and Zn (20) using E.S. Analysis for Au, Ag and Cd was discontinued because values were at or below detection limit. All analytical data are recorded in a Department of Mines computer file.

The unsieved samples were tested for anomalous levels of radioactivity with a scintillometer at the Mines Department Depot, but were all at background.

Orientation Survey - Wearing Gorge Area

Orientation work was carried out in the Wearing Gorge area (Fig.1) along 8 lines across the strike over a strike length of 30 km. (Traverses 1B to 8B).

Positions of traverse lines are shown on Figure 1 and geochemical and geological profiles on Figures 2 to 5. The main purpose of the work was:

(a) to find the variability of geochemical results upon resampling a traverse;

(b) to consider the variability of geochemistry along strike and establish the best traverse interval for the regional survey.

Regional threshold to anomalous values were obtained from cumulative frequency plots on log probability paper to define log normal populations, according to the method of Tennant and White (1959). This gave threshold values of 40 ppm for Cu, 30 ppm for Pb and 95 ppm for Zn. It also gave an anomalously low population of Zn values with a threshold of 45 ppm. Means for Cu, Pb and Zn were computed on each line for all values, for all background values below the defined threshold) and for background values in purple shale.

Lines 1B and 2 are almost coincident and were sampled four weeks apart. Each sample analysed was a composite of two smaller samples on line 1B and ten smaller samples on line 2B. A comparison between the two geochemical profiles shows that the Cu, Pb and Zn profiles are very similar. Significant differences between the two profiles are:

(1) a large single point Cu-Pb anomaly on line 1B, presumably associated with a thin dolomite interbed, occurs as a moderate Cu anomaly on line 2B, possibly due to the difference in the sampling method;

(2) Pb background values are consistently higher on line 1B, resulting in a difference of 4 ppm in the Pb background means of the two lines.

Lines 3B, 7B and 8B (Figure 1), show that a change in the geochemistry from line to line may be related to rock type, with values occurring over green shales. An exception to this is the generally depleted Cu, Pb and Zn background values on line 8B and parts of line 7B.

It is concluded from these results that a line spacing of about 15 km is suitable for a regional geochemical appraisal of the formation. Sampling of the remainder of the formation on COPLEY at this spacing would require about 25 soil traverses.

Means for Cu background values are too variable to delineate regional trends due to significant local variations in rock type. However, Cu background values in purple shales give more consistent means and may delineate regional changes in background values. Pb and Zn background values do not vary as much with rock type and may be used for comparison along strike.

TABLE 2

STATISTICAL RESULTS IN THE WEARING GORGE AREA

1. Traverse mean

2. Mean of background values (i.e. values below the defined threshold; see page 5)

3. Mean of background values in purple shales

Line	Type of Mean	Cu No. of Samples	Cu Mean	Cu Standard Deviation	Pb No. of Samples	Pb Mean	Pb Standard Deviation	Zn No. of Samples	Zn Mean	Zn Stand Deviat
1B	1	84	27	39	84	20	14	84	72	9
	2	72	16	8	82	17	5	83	72	9
	3	12	18	4	12	15	3	12	64	7
2B	1	88	24	20	88	15	9	88	71	12
	2	75	16	9	84	13	5	87	71	12
	3	Insufficient Samples								
3B	1	93	26	15	93	13	8	93	70	10
	2	83	22	8	91	12	6	92	70	10
	3	Insufficient Samples								
4B	1	112	23	14	112	20	48	112	71	8
	2	107	21	10	66	13	5	112	71	8
	3	12	19	7	Insufficient Samples					
[illegible]B	1	100	30	53	100	14	15	100	66	9
	2	87	22	11	98	13	15	98	64	6
	3	23	17	4	25	12	3	25	66	5
[illegible]B	1	78	20	23	78	14	4	78	66	6
	2	74	17	9	78	14	4	78	66	6
	3	24	19	5	28	16	2	25	63	5
7B	1	72	22	16	72	13	5	72	55	14
	2	67	18	7	71	13	5	72	55	14
	3	Insufficient Samples								
8B	1	78	18	17	78	9	3	78	39	13
	2	72	12	9	78	9	3	78	39	13
	3	Insufficient Samples								

Regional Survey

In addition to the detailed survey, 8 traverse lines (9B to 16B) were evenly spaced over the remainder of COPLEY (Fig.1) as a preliminary survey at a line spacing of about 45 km. Although this interval was too wide to ensure an accurate picture of regional changes in geochemistry, the data were appraised to see if the results indicated the possibility of completing the project more efficiently.

Cu, Pb and Zn

(a) Background Values

Means and standard deviations for background values in major shale units are shown on Table 3; no mean was calculated for dolomite, as there is no sample interval entirely over this rock type. Background values are generally lower where dolomites are present as thin interbeds in purple shales. Colour changes from purple to green in the shales significantly affect Cu background values. Cu values are very variable in the green shales, but purple shale background values only vary from line to line.

TABLE 3

Statistical Data for Shale Units in the Bunyeroo Formation

	Number of Samples	Cu		Pb		Zn	
		Mean	SD	Mean	SD	Mean	SD
Purple Shale	330	21	7	17	6	67	14
Green shale	56	32	14	19	7	66	12
World Average Shales		23		12		62	

Means and standard deviations for each line are shown on Table 4 and Figure 6. Traverse lines are too widely spaced (about 45 km of strike) to give a true indication of regional trends. However, means for background Cu values and background values in purple shales on the lines that have been sampled suggest a division between northern lines (9B, 13B, 14B, 15B and 16B) with higher background and southern lines with lower background (Fig.6). Zn background values are noticeably lower on the southwestern traverses (lines 11B, 12B and 13B); Pb background values are less variable on a regional scale, but are generally lower in the Wearing Gorge area.

(b) Anomalies

Generally, Cu anomalies appear to be associated with green or green-weathering grey shales. Many of these are single point anomalies over very thin green shale interbeds, which are scattered throughout the formation and are not very persistent along strike.

The main Cu, Pb and Zn anomalies are associated with thicker green or green-weathering grey shales, and generally occur at the three stratigraphic positions, detailed on page 2, especially in the southern areas of COPLEY. Large Cu anomalies also occur lower in the formation on traverse 14B, where the upper interbedded siltstone and dolomite sequence is very thin.

Almost all Zn values in the anomalously low population defined earlier, occur in the northern portion of the Wearing Gorge area, where Cu and Pb values are also generally low. This may be due to secondary redistribution of metal ions.

The largest anomalies recognized on the soil sampling programme are:

TABLE 4

1. Traverse Mean
2. Mean of background values (below defined threshold)
3. Mean of Background values in Purple Shale

Line	Type of Mean	Cu No. of Values	Cu Mean	Cu Standard Deviation	Pb No. of Values	Pb Mean	Pb Standard Deviation	Zn No. of Values	Zn Mean	Zn Standard Deviation
9B	1	40	26	9	40	21	5	40	69	8
	2	35	24	7	36	20	4	39	69	7
	3	14	20	2	14	19	3	14	70	7
10B	1	66	28	30	66	29	34	66	90	48
	2	58	21	9	55	17	11	55	74	17
	3	15	17	2	17	18	3	17	79	8
11B	1	102	28	25	102	28	40	102	62	11
	2	88	21	7	91	19	15	101	62	11
	3	62	17	4	63	18	4	60	58	9
12B	1	72	20	13	72	16	3	72	60	10
	2	66	16	4	72	16	3	72	60	10
	3	59	16	4	63	16	4	63	59	11
13B	1	60	30	11	60	16	5	60	59	9
	2	56	28	5	60	16	5	60	59	9
	3	24	25	23	24	17	4	24	55	6
14B	1	83	34	22	83	22	8	83	73	12
	2	72	29	7	72	20	4	81	73	12
	3	11	19	1	12	19	4	12	65	4
15B	1	80	30	13	80	22	17	80	68	9
	2	69	26	5	74	19	4	80	68	9
	3	28	21	3	28	18	3	28	68	8
16B	1	82	28	7	82	17	4	82	67	7
	2	75	26	5	82	17	4	82	67	7
	3	13	21	2	14	16	4	14	61	7

(1) a Pb-Zn anomaly, with a maximum of 270 ppm Zn and 185 ppm Pb, extending for 90 metres in yellow and green-weathering grey shales near the base of the formation, about 1 km north of the Pinda Spring Ag, Pb, Zn mine on line 10B;

(2) a Cu-Pb anomaly, with up to 290 ppm Pb, extending over 40 m at the top of the formation in interbedded yellow, grey shales and dolomites on line 11B;

(3) a 500 ppm Cu anomaly over the Wearing Dolomite Member in the Wearing Gorge area on line 5B.

Other large but single point Cu anomalies also occur. In general, most anomalies are in the Wearing Gorge area and on lines 10B and 11B, in the south of COPLEY.

Co, Ni, V, Mn and Mo

Mo was not detected. Other element values have a high correlation (Table 5), but vary greatly both across and along strike in the same rock type. This disguises any influence on distribution by changes in geochemical environment reflected by colour of shales, interbeds of dolomite or mineralization (Table 6).

TABLE 5

Correlation Coefficients

	Cu	Pb	Zn	Co	Ni	V	Mn
Cu		.30	.36	.07	.15	.12	.10
Pb			.40	.25	.30	.31	.34
Zn				.18	.23	.25	.26
Co					.65	.58	.37
Ni						.65	.54
V							.50
Mn							

Means for these elements also vary greatly from line to line (Table 7). Co means are high on traverses 10B, 14B and 15B, Ni is high on 10B and 14B, V is high on 10B, 11B and 14B and Mn is high on 10B, 11B and 12B.

Cumulative frequency values on log probability scales give one population group for Mn, but anoamlous populations of Co, Ni and V are recognized, with threshold values of 30, 150 and 70 ppm respectively. Thus most of the anomalous values occur on traverses 10B, 11B and the first half of lines 14B and 15B and these lines also have a higher background mean. Because of this, anomalous values are also defined for each traverse by using the mean plus 2 standard deviations value as the threshold. The most important anomalies are:

(1) line 14B - a Mn, Co and Ni anomaly over green weathering grey shales, 400 m from the start of the traverse;

(2) line 7B - a Co, Ni and V anomaly over interbedded purple shales and dolomites, 150 m from the start of the traverse;

(3) line 4B - a Mn anomaly over purple and yellow shales associated with above background values of Cu, Pb and Zn, 80 m from the start of the traverse;

(4) line 15B - anomalous Mn and Co values in the lower part of the formation associated with purple shales, 70 m from the start of the traverse;

(5) line 1B - a V anomaly in interbedded purple shales and dolomite, 290 m from the start of the traverse. This anomaly was not repeated on line 2B.

TABLE 6

Co, Ni, V and Mn means in Shales of the Bunyeroo Formation

Location & Lithology of Samples	Number of Samples	Co	Ni	V	Mn
Purple Shale (1B-8B)	85	17	26	77	220
Purple Shale (9B-16B)	261	21	52	106	405
Green Shale (1B-8B)	22	12	23	81	185
Green Shale (9B-16B)	19	22	58	103	580
World Average Shales		19	68	130	850

SUMMARY AND RECOMMENDATIONS

Widespread soil sampling in the Bunyeroo Formation confirms the association of mineralization with green shale interbeds which may occur anywhere within the formation, but are generally thin and discontinuous along strike. These shales are more common and sometimes attain greater thickness in three stratigraphic positions within the formation. These are:

(1) near the base of the formation;

(2) in the same position as the Wearing Dolomite Member, beneath a distinctive interbedded dolomite and shale unit. This section contains the most important copper mineralization;

(3) near the top of the formation in the gradational contact with the Wonoka Formation.

There is a definite trend of more prevalent and thicker greenshale beds with associated anomalous values in the southern areas of COPLEY, defined by the traverse lines in the Wearing Gorge area and lines 10B and 11B. Comparison between the background means for lines shows a trend for lower Cu values in the south and lower Zn

TABLE 7

1. Line Mean
2. Mean in Purple shales

Line	No. of Samples	Type of Mean	Co Mean	Co Standard Deviation	Ni Mean	Ni Standard Deviation	V Mean	V Standard Deviation	Mn Mean	Mn Standard Deviation
1B	84	1	9	8	17	8	38	17	190	75
	12	2	8	6	14	6	35	15	195	45
2B	88	1	14	15	27	15	73	25	230	90
		2		Insufficient Samples						
3B	93	1	11	12	28	10	81	17	255	85
		2		Insufficient Samples						
4B	112	1	16	12	27	11	89	24	260	110
	12	2	25	9	29	4	89	10	235	63
5B	100	1	14	11	30	17	88	20	200	105
	23	2	17	10	31	11	91	10	215	55
6B	78	1	16	10	32	17	91	23	255	105
	78	2	17	11	30	17	92	21	245	95
7B	72	1	14	11	25	10	88	26	225	70
		2		Insufficient Samples						
8B	78	1	16	12	29	10	93	27	245	95
		2		Insufficient Samples						
9B	40	1	20	20	58	20	100	17	335	115
	20	2	21	15	55	22	95	10	295	90
10B	66	1	26	13	75	23	132	47	675	300
	15	2	20	13	68	14	120	25	700	255
11B	102	1	21	15	52	23	112	32	660	250
	62	2	24	13	56	20	109	22	630	200
12B	72	1	20	12	46	21	102	25	450	270
	59	2	19	10	45	20	100	18	475	275
13B	60	1	16	11	30	20	97	17	245	70
	22	2	20	11	31	15	97	7	220	80
14B	83	1	32	23	65	27	118	28	390	160
	10	2	20	13	53	22	128	26	300	0
15B	80	1	27	21	52	22	106	22	350	170
	54	2	25	18	56	19	106	21	320	90
16B	82	1	19	11	45	19	100	8	295	65
	19	2	17	10	48	21	99	4	290	30

values in the southwest of COPLEY (Fig. 6).

As there is insufficient coverage of the Copley sheet by the soil traverses (one for about every 45 km of strike), smaller areas of interest are not delineated. The variability in geochemistry and geology along strike in the Wearing Gorge area indicates than an interval of 15 km is most suitable for the purposes of this project. Further work, involving soil sampling on traverses at this interval for delineating areas of greater potential, should be over the areas of green shale interbeds. At this stage of the sampling programme, the Pinda Springs area, where a Pb-Zn anomaly containing 170 ppm Pb was found, is the most promising for further investigation.

27/5/77

BAE:JK

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APPENDIX

Factor Analysis

Introduction

The effect of mineralization in an element value is obscured by many geological factors which have an unequal effect from sample to sample. In this project, such factors are the geochemistry of the major rock types, and surface environment processes such as development of soils or leaching by groundwater. In an attempt to statistically remove these effects to allow an unbiased comparison between samples, classical R-mode factor analysis was used with regression analysis on the multi-element data collected. This produced a predicted element value for each sample and a resultant residual. As mineralization is a statistical rarity, its effects are not likely to be seen in the factors, but may reflect in the residual values.

Method

In this project, the raw data were log transformed before analysis to make the metal distributions approximate more closely to a normal distribution, and the method of rotation was varimax orthogonal rotation. All other choices and decisions in the use of factor analysis for this project follow the limitations of the Statistical Package for the Social Sciences factor analysis programme.

Results

Three factors were extracted and Table 8 shows how much of the element variability they explain. The communality is the percentage of the total variance explained by the combined effect of the three factors.

TABLE 8

Variance and Communality Tables

Factor	% Common Variance
1	73.00
2	21.40
3	5.60

Variable	Communality
Cu	.31
Pb	.42
Zn	.43
Co	.61
Ni	.73
V	.61
Mn	.46

Table 9 shows the factor matrix. Each factor matrix coefficient is a correlation between the factors and variables and its square (given in brackets) shows the proportion of the total variance accounted for by each factor.

TABLE 9

Factor Matrix

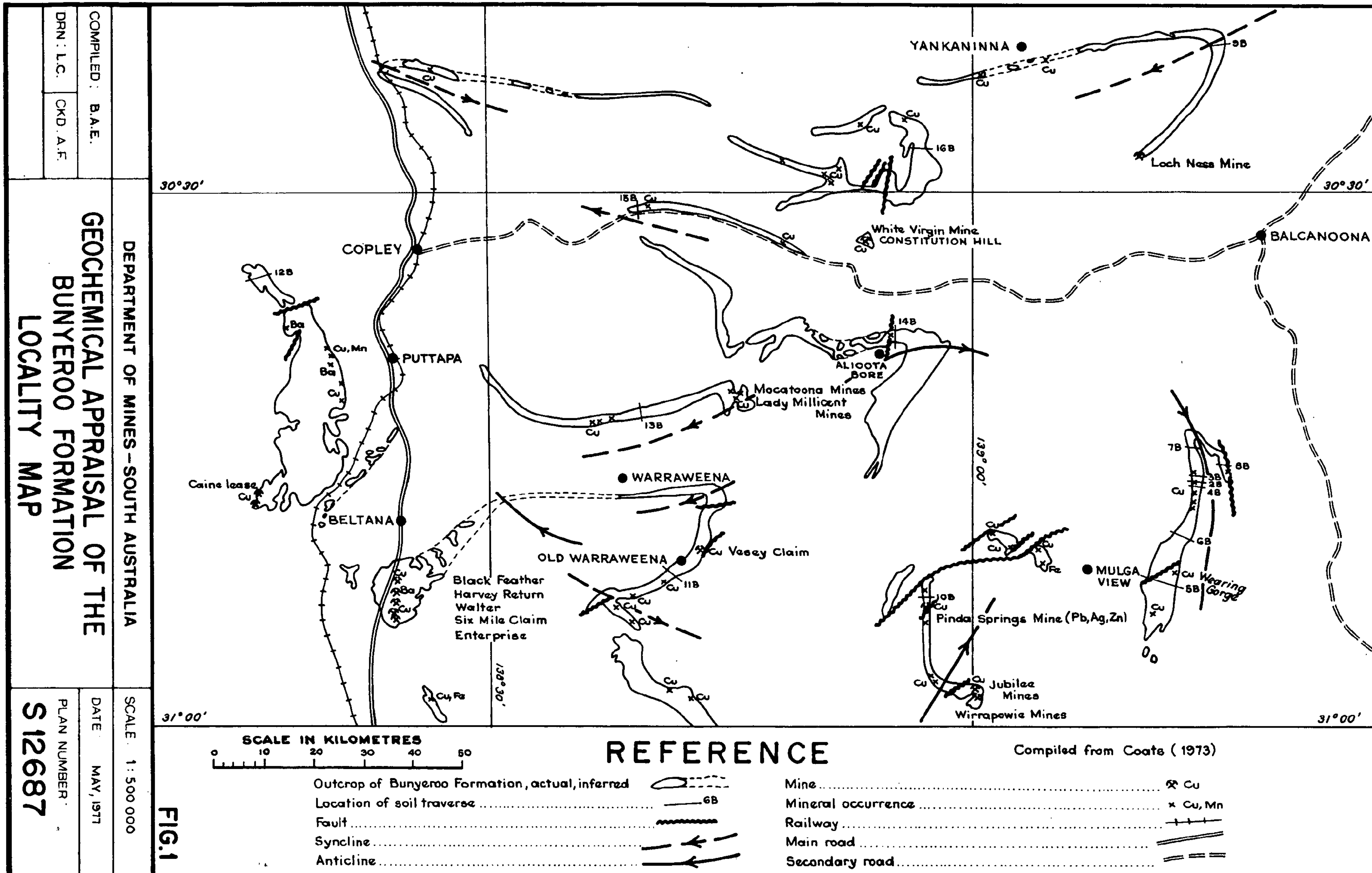
	Factor 1	Factor 2	Factor 3
Cu	.038 (0.00)	.552 (0.30)	.028 (0.00)
Pb	.254 (0.06)	.508 (0.26)	.312 (0.10)
Zn	.167 (0.03)	.616 (0.38)	.156 (0.02)
Co	.764 (0.58)	.119 (0.01)	.121 (0.01)
Ni	.835 (0.70)	.147 (0.02)	.102 (0.01)
V	.747 (0.56)	.156 (0.02)	.161 (0.03)
Mn	.547 (0.30)	.156 (0.02)	.373 (0.14)

Factor 1 largely affects the variance of Co, Ni, V and Mn, factor 2 affects to a much smaller extent the variance of Cu, Pb and Zn, and factor 3 affects the variability of Pb and Mn.

Discussion

The extracted factors are not obviously related to any geological feature. It is difficult to extract factors related to the different lithologies in this project because many element values represent the chemistry of differing combinations of rock types. A different factor model, probably containing more factors, is needed to explain the common variance in terms that separate any geological variables which impose a common variance on the data.

The top 5% of large residuals are considered to be significant. The residuals delineate values of each element which cannot be explained in terms of the factors, and account for the anomalously low population of Zn values on lines 7B and 8B. In this project, the residuals define values which are significantly higher or lower than background, or element values which are at background, but show an unusual element ratio with an associated element (e.g. a negative Zn residual is often associated with an above background Pb value). The residuals are generally associated with anomalies defined using other methods or defined scattered single point areas of interest, so factor analysis did not result in any new useful information.



DEPARTMENT OF MINES—SOUTH AUSTRALIA
GEOCHEMICAL APPRAISAL OF THE BUNYEROO FORMATION
LOCALITY MAP
COMPILED: B.A.E.
DRN: L.C.
CKD. A.F.
SCALE: 1:500 000
DATE: MAY, 1977
PLAN NUMBER: S 12687
FIG.1
YANKANINNA
9B
Cu
16B
Loch Ness Mine
30°30'
15B
White Virgin Mine
CONSTITUTION HILL
BALCANOONA
COPLEY
12B
Ba
Cu, Mn
PUTTAPA
14B
ALIOOTA BORE
Mocatoona Mines
Lady Millicent Mines
13B
139°00'
7B
8B
3B
2B
4B
Caine lease
WARRAWEENA
BELTANA
OLD WARRAWEENA
Vesey Claim
6B
MULGA VIEW
Wearing Gorge
5B
Black Feather
Harvey Return
Walter
Six Mile Claim
Enterprise
11B
10B
Fe
Pinda Springs Mine (Pb, Ag, Zn)
Cu, Fe
138°30'
Jubilee Mines
Wirrapowie Mines
31°00'
SCALE IN KILOMETRES
0 10 20 30 40 50
REFERENCE
Compiled from Coats (1973)
Outcrop of Bunyeroo Formation, actual, inferred
Location of soil traverse 6B
Fault
Syncline
Anticline
Mine .... Cu
Mineral occurrence .... Cu, Mn
Railway
Main road
Secondary road

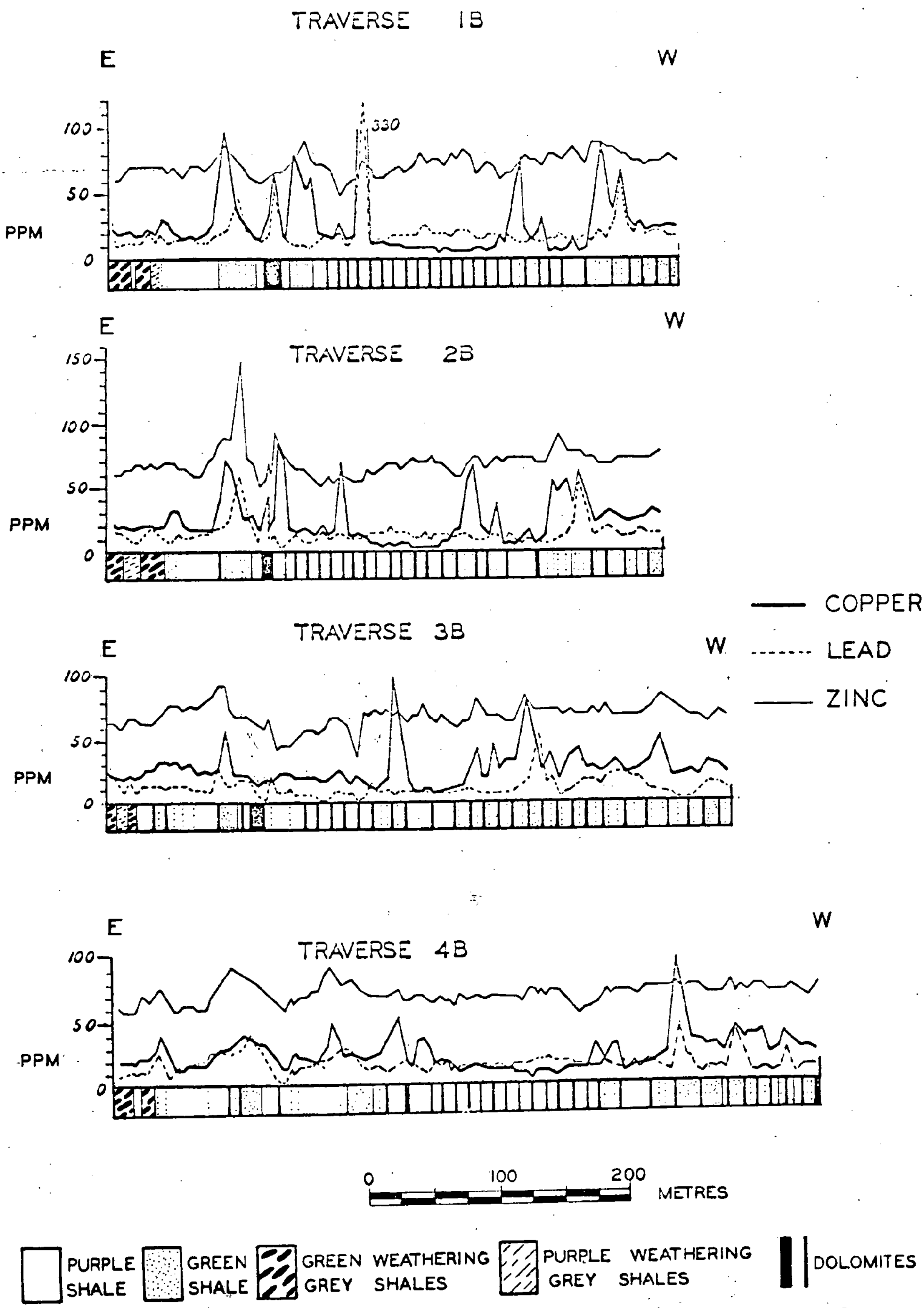


FIG 2

	DEPARTMENT OF MINES–SOUTH AUSTRALIA	Scale: AS SHOWN
Compiled: B.A.E	BUNYEROO FORMATION	Date: MAY 1977
Drn. B.A | Ckd.	GEOCHEMICAL & GEOLOGICAL PROFILES	Drg. No.
	TRAVERSES 1B. 2B. 3B. 4B	S 12691

500–9.75 F9882 O

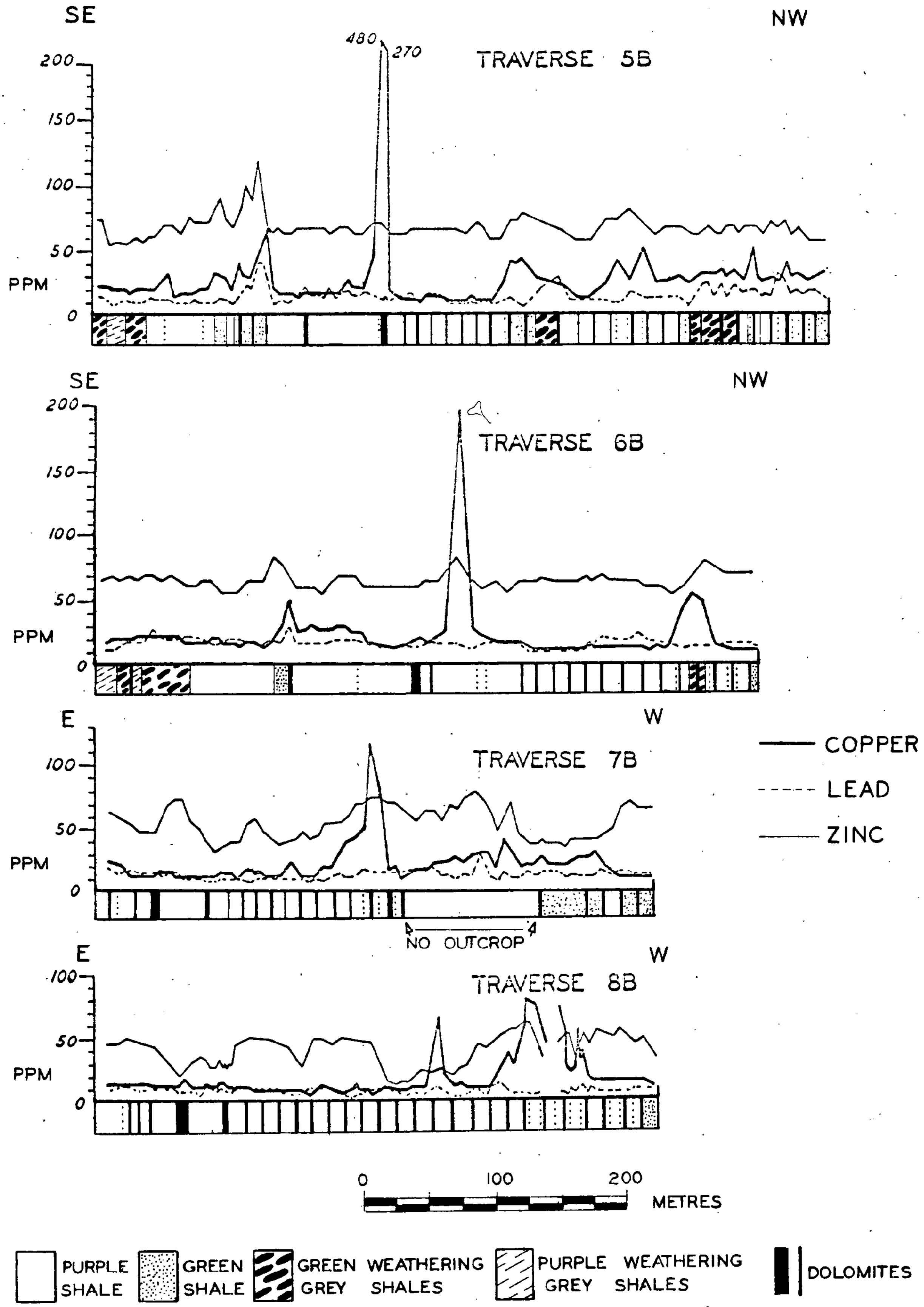


FIG 3

	DEPARTMENT OF MINES–SOUTH AUSTRALIA	Scale: AS SHOWN
Compiled: B.A.E	BUNYEROO FORMATION	Date: MAY 1977
Drn. B.A | Ckd.	GEOCHEMICAL & GEOLOGICAL PROFILES	Drg. No.
	TRAVERSES 5B. 6B: 7B. 8B	S 12692

500–9.75 F9862 O

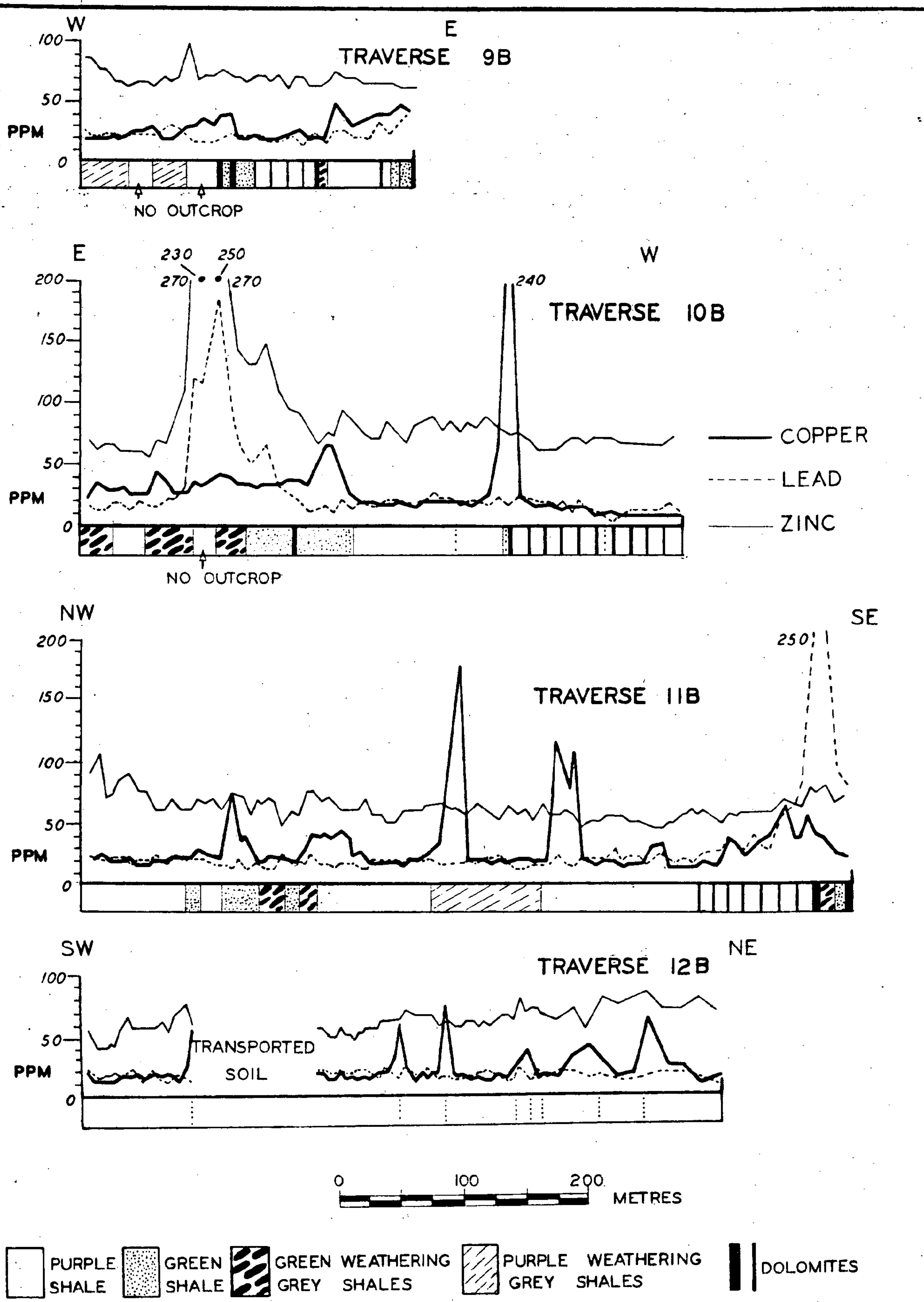


FIG 4

	DEPARTMENT OF MINES–SOUTH AUSTRALIA	Scale: AS SHOWN
Compiled: B.A.E	BUNYEROO FORMATION	Date: MAY 1977
Drn. B.A Ckd.	GEOCHEMICAL & GEOLOGICAL PROFILES	Drg. No.
	TRAVERSES 9B. 10B. 11B. 12B	S 12693

500–9.75 F9882 O

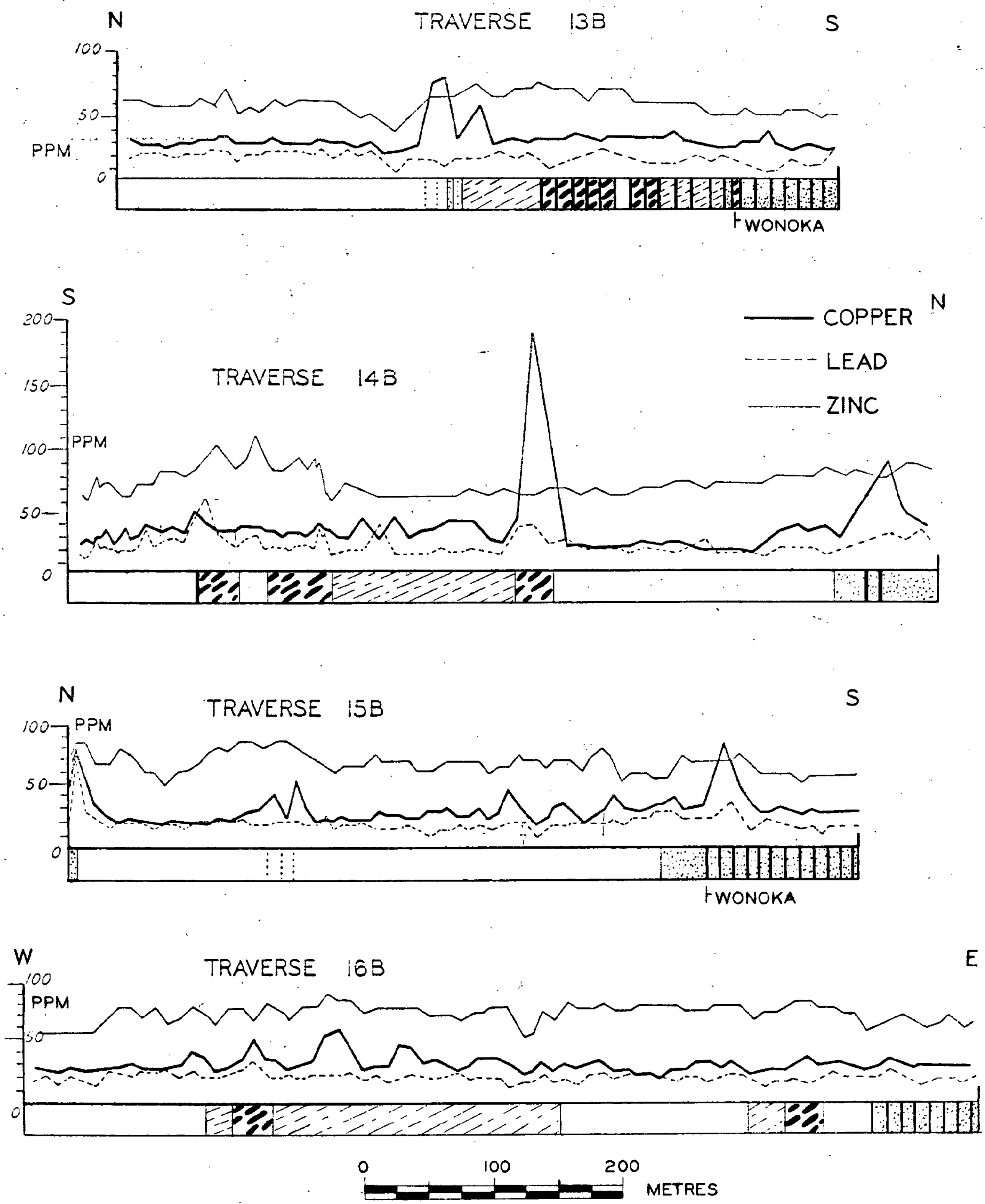
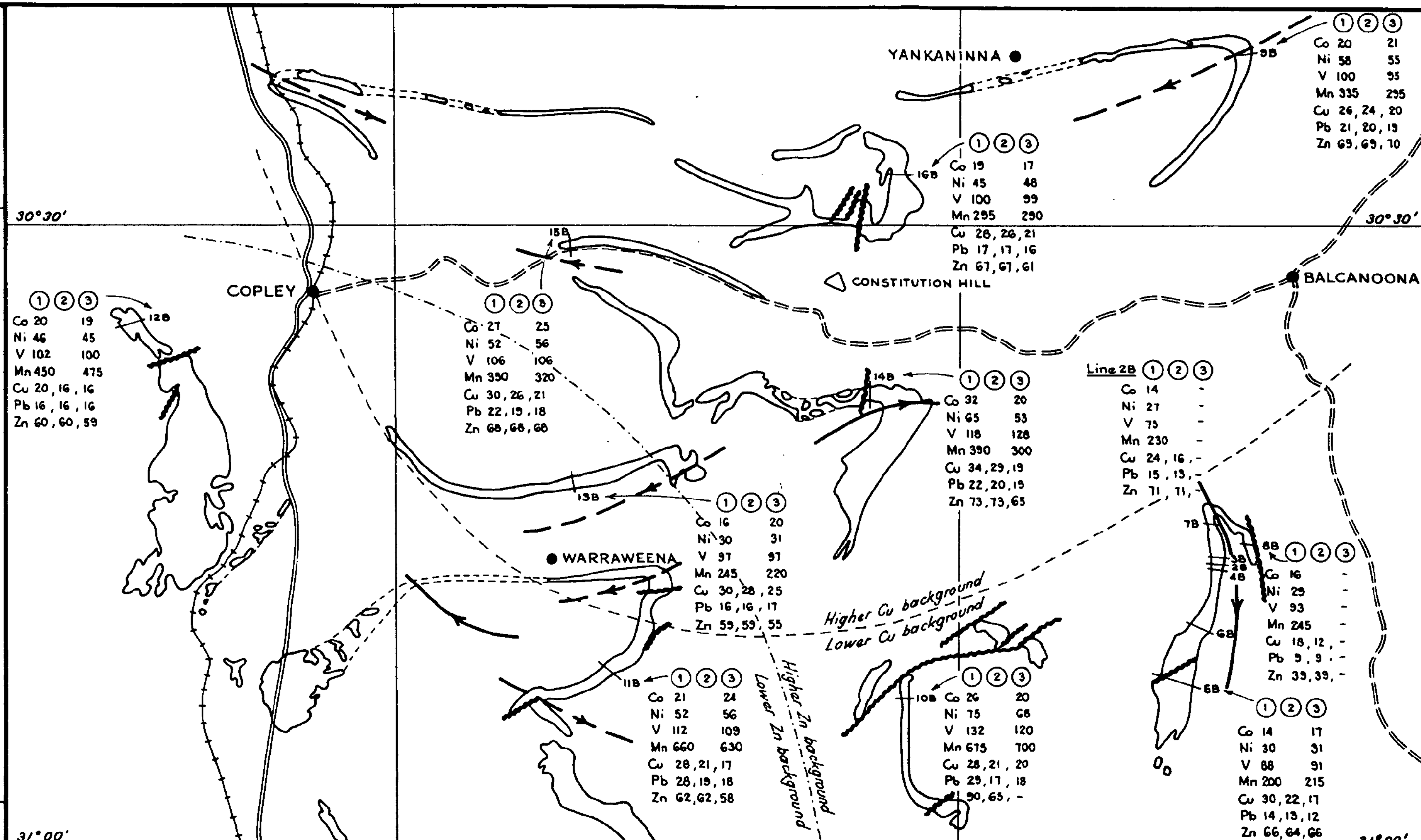


FIG 5

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: AS SHOWN
Compiled: B.A.E	BUNYEROO FORMATION	Date: MAY 1977
Drn. B.A | Ckd.	GEOCHEMICAL & GEOLOGICAL PROFILES	Drg. No.
	TRAVERSES 13B. 14B. 15B. 16B	S 12694

500—11.76 H1081 O



SCALE IN KILOMETRES

0 10 20 30 40 50

138°30'

REFERENCE

139°00'

Compiled from Coats (1973)

Outcrop of Bunyeroo Formation, actual, inferred.		Anticline	Traverse Mean ①
Location of soil traverse	6B	Railway	Mean of Background Values * ②
Fault		Main road	Mean of Purple Shales ③
Syncline		Secondary road	* (see table 1 for definition)

FIG.6

GEOCHEMICAL APPRAISAL OF THE BUNYEROO FORMATION

Co,Ni,V,Mn,Cu,Pb,Zn Soil Traverse Means

DEPARTMENT OF MINES—SOUTH AUSTRALIA

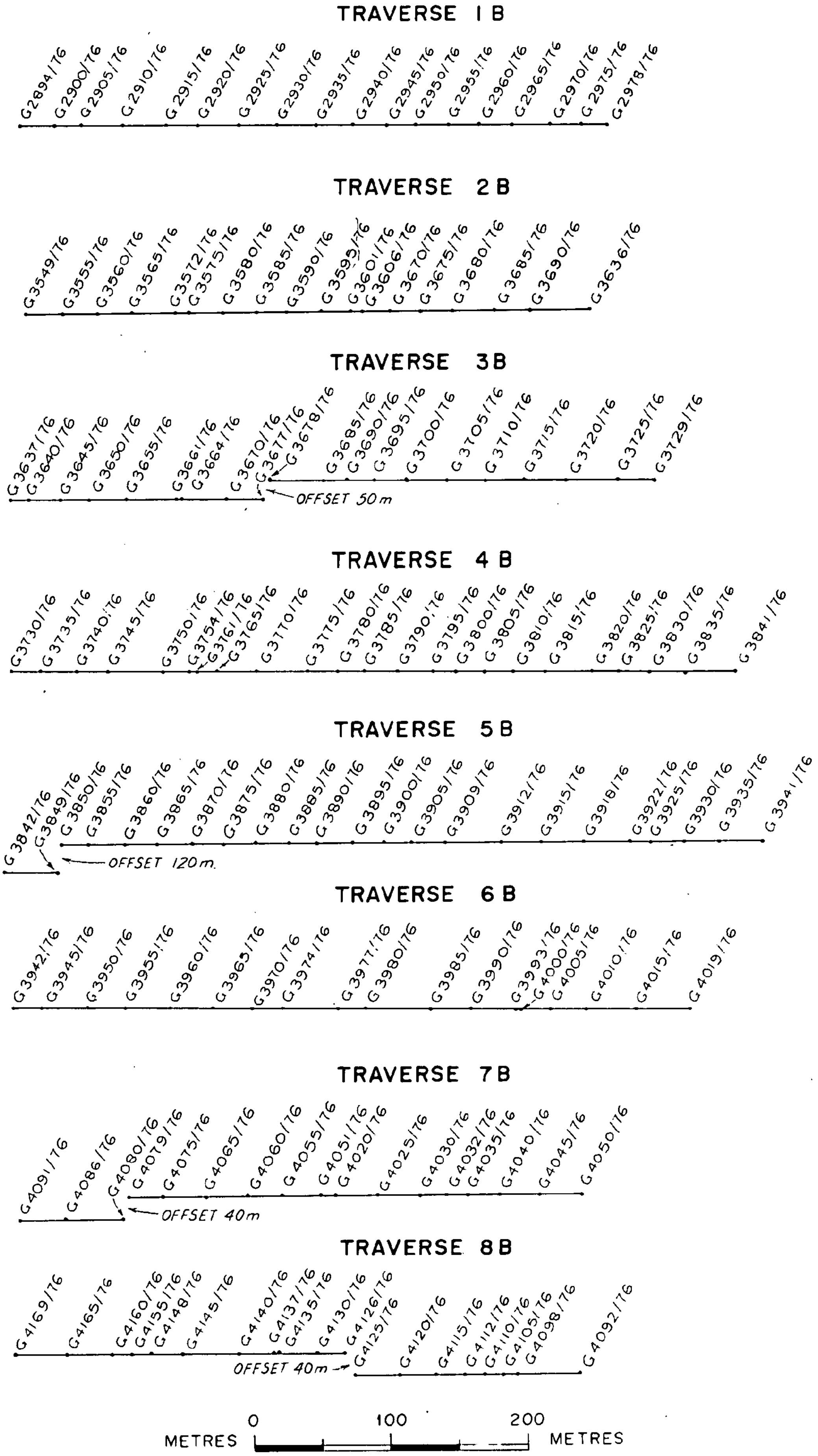
COMPILED: B.A.E.

DRN: L.C. CKD. A.F.

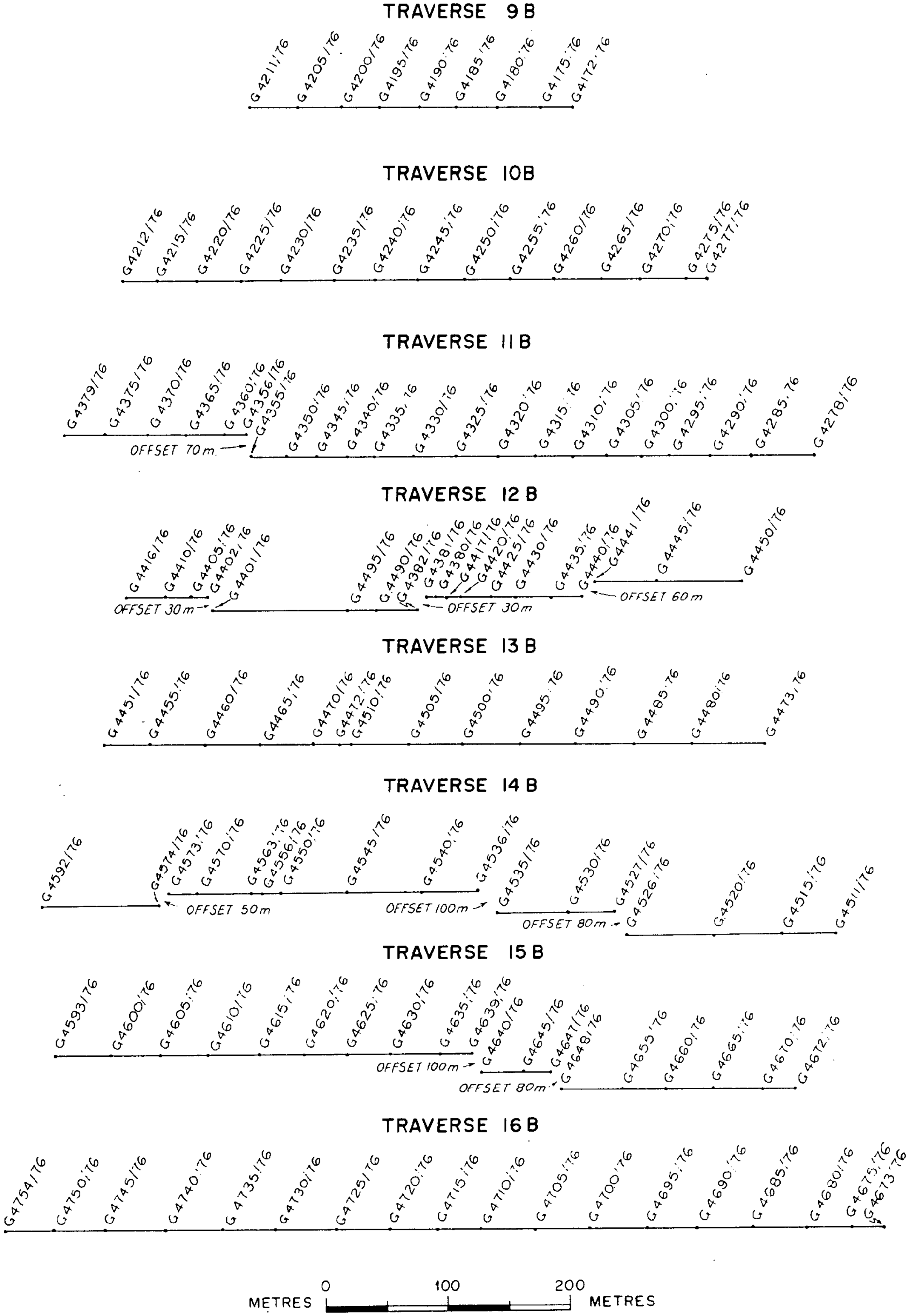
SCALE: 1:500000

DATE: MAY, 1977

PLAN NUMBER: S 12686



	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE: 1 4170
COMPILED: B. A. E	**BUNYEROO FORMATION**	DATE: 17 - 4 - 76
DRN: N. S. / CKD:	SAMPLE LOCATION DIAGRAM	PLAN NUMBER
	TRAVERSES 1 B, 2 B, 3 B, 4 B, 5 B, 6 B, 7 B, 8 B	**S 13349**



	DEPARTMENT OF MINES AND ENERGY SOUTH AUSTRALIA	SCALE 1:4170
COMPILED: B.A.E	**BUNYEROO FORMATION** SAMPLE LOCATION DIAGRAM TRAVERSES 9B, 10B, 11B, 12B, 13B, 14B, 15B, 16B	DATE: 17·4·76
DRN: N.S. CKD:		PLAN NUMBER S 13350

ADDENDUM TO REPORT BOOK 77/58

TRAVERSE 1B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G2894/76	0-4.5 m	G2923/76	165.0	G2952/76	325.0
95	9.0	24	171.0	53	330.0
96	13.5	25	177.0	54	335.0
97	18.0	26	183.5	55	340.0
98	22.5	27	189.0	56	345.0
99	27.0	28	194.0	57	350.0
G2900/76	31.5	29	201.0	58	355.0
1	36.0	G2930/76	207.0	59	360.0
2	39.5	31	213.0	G2960/76	365.0
3	44.0	32	218.5	61	370.0
4	50.0	33	225.0	62	375.0
5	55.5	34	231.0	63	380.0
6	62.0	35	237.0	64	385.0
7	68.0	36	243.0	65	390.0
8	74.0	37	249.0	66	395.0
9	81.0	38	255.0	67	402.0
G2910/76	88.0	39	260.0	68	408.0
11	95.0	G2940/76	265.0	69	414.0
12	101.0	41	270.0	G2970/76	419.0
13	107.0	42	275.0	71	424.0
14	113.0	43	280.0	72	429.0
15	119.0	44	285.0	73	434.0
16	125.0	45	290.0	74	439.0
17	131.0	46	295.0	75	444.0
18	135.0	47	300.0	76	451.0
19	139.5	48	305.0	77	458.0
G2920/76	143.0	49	310.0	78	465.0
21	151.5	G2950/76	315.0		
22	160.0	51	320.0		

TRAVERSE 2B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G3549/76	0-5.5 m	G3579/76	154.0	G3609/76	287.5
G3550/76	11.5	G3580/76	162.0	G3610/76	292.0
51	16.5	81	171.0	11	297.0
52	21.5	82	175.0	12	302.5
53	26.5	83	180.0	13	307.5
54	31.5	84	185.0	14	312.5
55	36.5	85	190.0	15	317.5
56	42.5	86	195.0	16	322.5
57	48.0	87	200.0	17	328.0
58	54.0	88	205.0	18	334.0
59	59.5	89	210.0	19	339.5
G3560/76	65.0	G3590/76	215.0	G3620/76	345.0
61	71.0	91	220.0	21	401.0
62	76.5	92	225.0	22	406.5
63	81.5	93	230.0	23	412.5
64	86.0	94	234.5	24	418.0
65	91.0	95	238.5	25	423.5
66	96.5	96	243.0	26	429.0
67	102.0	97	247.0	27	435.0
68	108.0	98	251.0	28	440.0
69	113.5	99	255.5	29	447.0
G3570/76	119.0	G3600/76	259.5	G3630/76	453.0
71	125.0	1	264.0	31	461.0
72	131.5	2	265.5	32	469.0
73	132.5	3	267.5	33	477.5
74	133.5	4	269.0	34	486.0
75	134.5	5	271.0	35	495.0
76	137.5	6	273.0	G3636/76	504.0
77	142.5	7	277.0		
78	148.5	8	282.0		

TRAVERSE 3B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G3637/76	0-1 m	G3669/76	160.0	G3701/76	318.0
38	4.0	G3670/76	165.0	2	323.0
39	9.0	71	170.0	3	328.0
G3640/76	14.0	72	175.0	4	336.0
41	19.0	73	180.0	5	344.0
42	24.0	74	185.0	6	351.0
43	29.0	75	190.0	7	358.0
44	34.0	76	195.0	8	366.0
45	39.0	77	200.0	9	372.0
46	44.0	78	205.0	G3710/76	378.0
47	49.0	79	210.0	11	383.0
48	54.0	G3680/76	215.0	12	389.0
49	59.0	81	220.0	13	394.0
G3650/76	64.0	82	225.0	14	400.0
51	71.0	83	230.0	15	406.0
52	76.0	84	235.0	16	411.0
53	82.0	85	240.0	17	417.0
54	87.5	86	245.0	18	424.0
55	93.0	87	250.0	19	431.0
56	99.0	88	255.0	G3720/76	438.0
57	104.0	89	260.0	21	446.0
58	110.0	G3690/76	265.0	22	455.0
59	117.0	91	270.0	23	462.0
G3660/76	123.0	92	275.0	24	470.0
61	129.0	93	279.0	25	473.0
62	130.5	94	282.0	26	486.0
63	132.0	95	287.5	27	493.0
64	133.0	96	293.0	28	500.0
65	140.0	97	298.0	G3729/76	509.0
66	145.0	98	303.0		
67	150.0	99	308.0		
68	155.0	G3700/76	313.0		

TRAVERSE 4B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G3730/76	0.5 m	G3767/76	179	G3804/76	378
31	10	68	187	5	383
32	15	69	195	6	388
33	20	G3770/76	202.5	7	390
34	25	71	210	8	394
35	30	72	218	9	399
36	35	73	226	G3810/76	404
37	40	74	233	11	409
38	45	75	238	12	413
39	50	76	243	13	417
G3740/76	55	77	248	14	421
41	60	78	253	15	429
42	65	79	258	16	437
43	71	G3780/76	263	17	445
44	77	81	268	18	453
45	82	82	273	19	461
46	90	83	278.5	G3820/76	466
47	98	84	279.5	21	471
48	106	85	281.0	22	476
49	115	86	282	23	481
G3750/76	124	87	290	24	486
51	133	88	298	25	491
52	137.5	89	306	26	496
53	142.5	G3790/76	312	27	501
54	146.5	91	318	28	506
55	146.5	92	325	29	508
56	146.5	93	331	G3830/76	510
57	146.5	94	336	31	514
58	146.5	95	341	32	519
59	146.5	96	346	33	524
G3760/76	148.5	97	348	34	530
61	150	98	350	35	536
62	154.5	99	354	36	542
63	159	G3800/76	358	37	549
64	164	1	363	38	555
65	169	2	368	39	561
66	174	3	373	G3840/76	569
				G3841/76	577

TRAVERSE 5B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G3842/76	0-5	G3875/76	177	G3908/76	344
43	- 11	76	182.5	9	349
44	- 15	77	187.5	G3910/76	364
45	- 21	78	192.5	11	379
46	- 26	79	198	12	393
47	31	G3880/76	203	13	406
48	36	81	208.5	14	419
49	41	82	213.5	15	428
G3850/76	46	83	219	16	438
51	52	84	224	17	448
52	57.5	85	229	18	458
53	62	86	234	19	468
54	68	87	239	G3920/76	478
55	72	88	240	21	488
56	78	89	241	22	498
57	83	G3890/76	247.5	23	503
58	88	91	255	24	508
59	93	92	261	25	513
G3860/76	98	93	266	26	518
61	104	94	271	27	523
62	109	95	276	28	529
63	114	96	281	29	534
64	120	97	287	G3930/76	539
65	125	98	292	31	544
66	130	99	297	32	550
67	135	G3900/76	302	33	555
68	141	1	307.5	34	560
69	146	2	312.5	35	566
G3870/76	151	3	318	36	571
71	156.5	4	323	37	576
72	162.5	5	328.5	38	581
73	167	6	333.5	39	586
74	172	7	338.5	G3940/76	591
				41	597

TRAVERSE 6B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G3942/76	0 - 6.5m	G3968/76	184	G3994/76	397
43	13.5	69	192	95	397
44	20.5	G3970/76	198	96	397
45	27.5	71	205	97	397
46	34	72	212	98	397
47	41	73	219	99	397
48	47.5	74	222	G4000/76	399
49	54.5	75	236	1	401
G3950/76	61.5	76	251	2	403
51	68.5	77	264	3	435
52	75	78	268	4	413
53	82	79	275	5	421
54	89	G3980/76	285	6	428
55	95	81	295	7	435
56	102	82	305	8	442
57	109	83	315	9	449
58	116	84	325	G4010/76	454
59	123	85	335	11	462
G3960/76	130	86	345	12	469
61	137	87	355	13	478
62	144	88	365	14	486
63	151	89	365	15	494
64	157	G3990/76	365	16	503
65	164	91	365	17	516
66	171	92	365	18	528
67	177	93	378	G4019/76	541

TRAVERSE 7B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4020/76	246-253m	G4044/76	406	G4068/76	132
21	259	45	413	69	125
22	266	46	420	G4070/76	120
23	272	47	426	71	120
24	279	48	432	72	120
25	285	49	439	73	120
26	292	G4050/76	446	74	120
27	298	51	246-240m	75	114
28	304	52	234	76	107
29	311	53	228	77	101
G4030/76	317	54	221	78	94
31	323	55	215	79	87
32	330	56	209	G4080/76	81
33	336	57	201	81	75
34	343	58	195	82	69
35	351	59	189	83	62
36	355	G4060/76	183	84	55
37	362	61	176	85	50
38	370	62	171	86	43
39	375	63	164	87	37
G4040/76	381	64	158	88	28
41	387	65	151	89	18
42	394	66	144	G4090/76	9
43	400	67	139	1	0-9

TRAVERSE 8B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4092/76	450	G4118/76	316	G4144/76	141
93	441	19	310	45	133
94	431	G4120/76	304	46	124
95	421	21	295	47	115
96	414	22	289	48	107
97	404	23	283	49	105
98	396	24	275	G4150/76	103
99	394	25	271	51	102
G4100/76	392	26	264	52	101
1	389	27	258	53	99
2	387	28	251	54	97
3	386	29	244	55	95
4	384	G4130/76	238	56	93
5	382	31	231	57	92
6	381	32	226	58	85
7	379	33	219	59	81
8	377	34	212	G4160/76	77
9	370	35	206	61	73
G4110/76	MISSING	36	204	62	69
11	MISSING	37	202	63	59
12	356	38	194	64	49
13	349	39	185	65	39
14	342	G4140/76	176	66	30
15	335	41	168	67	20
16	328	42	159	68	10
17	321	43	150	G4169/76	0

TRAVERSE 9B

Sample No.	Co-ords	Sample No.	Co-ords
G4172/76	280	G4192/76	132
73	273	93	125
74	264	94	118
75	255	95	111
76	247	96	104
77	239	97	97
78	231	98	90
79	224	99	82
G4180/76	216	G4200/76	75
81	208	1	67
82	201	2	59
83	194	3	52
84	188	4	45
85	181	5	38
86	175	6	31
87	168	7	25
88	160	8	18
89	154	9	12
G4190/76	147	10	6
91	140	11	0

TRAVERSE 10B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4212/76	7	G4234/76	178	G4256/76	352
13	14	35	188	57	361
14	21	36	195	58	370
15	28	37	203	59	379
16	35	38	210	G4260/76	387
17	43	39	217	61	395
18	51	G4240/76	225	62	403
19	59	41	233	63	410
G4220/76	65	42	241	64	417
21	74	43	249	65	423
22	82	44	257	66	430
23	90	45	264	67	436
24	97	46	273	68	443
25	105	47	281	69	451
26	112	48	289	G4270/76	460
27	120	49	296	71	469
28	128	G4250/76	304	72	477
39	135	51	312	73	484
G4230/76	144	52	321	74	492
31	152	53	328	75	500
32	160	54	336	76	509
33	169	55	343	77	518

TRAVERSE 11B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4278/76	648	G4312/76	427	G4346/76	208
79	641	13	419	47	203
G4280/76	634	14	413	48	198
81	626	15	406	49	194
82	618	16	398	G4350/76	187
83	612	17	391	51	181
84	604	18	385	52	175
85	597	19	377	53	169
86	589	G4320/76	371	54	162
87	582	21	363	55	156
88	576	22	356	56	151
89	568	23	348	57	146
G4290/76	562	24	343	58	140
91	555	25	336	59	135
92	547	26	328	G4360/76	131
93	541	27	321	61	126
94	533	28	314	62	119
95	526	29	306	63	112
96	520	G4330/76	298	64	105
97	515	31	289	65	97
98	510	32	281	66	91
99	505	33	273	67	83
G4300/76	500	34	267	68	76
1	495	35	262	69	69
2	488	36	257	G4370/76	62
3	481	37	253	71	55
4	475	38	248	72	48
5	471	39	244	73	40
6	466	G4340/76	238	74	32
7	461	41	233	75	26
8	456	42	228	76	21
9	448	43	223	77	15
G4310/76	441	44	218	78	8
11	433	45	213	79	0

TRAVERSE 12B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4380/76	280	G4407/76	45	G4434/76	375
81	275	8	40	35	380
82	270	9	35	36	385
83	265	G4410/76	30	37	390
84	260	11	25	38	395
85	255	12	20	39	400
86	250	13	15	G4440/76	413
87	245	14	10	41	425
88	240	15	5	42	438
89	235	16	0	43	452
G4390/76	230	17	290	44	464
91	225	18	295	45	477
92	220	19	300	46	490
93	215	G4420/76	305	47	505
94	210	21	310	48	520
95	205	22	315	49	535
96	255	23	320	G4450/76	550
97	260	24	325		
98	90	25	330		
99	85	26	335		
G4400/76	80	27	340		
1	75	28	345		
2	70	29	350		
3	65	G4430/76	355		
4	60	31	360		
5	55	32	365		
6	50	33	370		

TRAVERSE 13B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4451/76	10	G4471/76	210	G4491/76	420
52	20	72	220	92	410
53	30	73	600	93	400
54	40	74	590	94	390
55	50	75	580	95	380
56	60	76	570	96	370
57	70	77	560	97	360
58	80	78	550	98	350
59	90	79	540	99	340
G4460/76	100	G4480/76	530	G4500/76	330
61	110	81	520	1	320
62	120	82	510	2	310
63	130	83	500	3	300
64	140	84	490	4	290
65	150	85	480	5	280
66	160	86	470	6	270
67	170	87	460	7	260
68	180	88	450	8	250
69	190	89	440	9	240
G4470/76	200	G4490/76	530	G4510/76	230

TRAVERSE 14B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4511/76	710	G4539/76	349	G4567/76	160
12	698	G4540/76	337	68	153
13	685	41	324	69	146
14	672	42	311	G4570/76	138
15	659	43	298	71	129
16	646	44	285	72	121
17	633	45	272	73	112
18	620	46	259	74	105
19	607	47	247	75	95
G4520/76	595	48	233	76	87
21	581	49	220	77	77
22	568	G4550/76	208	78	69
23	555	51	206	79	62
24	543	52	204	G4580/76	55
25	530	53	202	81	48
26	518	54	200	82	42
27	505	55	198	83	37
28	492	56	195	84	32
29	478	57	194	85	28
G4530/76	465	58	194	86	24
31	453	59	194	87	20
32	440	G4560/76	194	88	17
33	426	61	194	89	13
34	414	62	194	G4590/76	10
35	402	63	187	91	5
36	388	64	180	92	0
37	375	65	174		
38	362	66	166		

TRAVERSE 15B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4593/76	0	G4620/76	219	G4647/76	435
94	6	21	226	48	442
95	13	22	233	49	450
96	18	23	241	G4650/76	460
97	25	24	249	51	467
98	34	25	257	52	476
99	42	26	265	53	483
G4600/76	49	27	272	54	492
1	56	28	280	55	500
2	65	39	288	56	508
3	73	G4630/76	296	57	517
4	81	31	305	58	524
5	89	32	314	59	533
6	97	33	322	G4660/76	541
7	105	34	330	61	550
8	115	35	339	62	556
9	123	36	347	63	560
G4610/76	132	37	356	64	574
11	141	38	364	65	583
12	151	39	372	66	591
13	161	G4640/76	379	67	600
14	171	41	387	68	609
15	180	42	394	69	617
16	188	43	402	G4670/76	626
17	196	44	410	71	635
18	205	45	418	72	642
19	212	46	426		

TRAVERSE 16B

Sample No.	Co-ords	Sample No.	Co-ords	Sample No.	Co-ords
G4673/76	778	G4701/76	507	G4729/76	250
74	768	2	497	G4730/76	240
75	758	3	487	31	230
76	748	4	477	32	220
77	738	5	467	33	210
78	728	6	457	34	200
79	718	7	447	35	190
G4680/76	708	8	437	36	180
81	698	9	427	37	170
82	688	G4710/76	418	38	160
83	678	11	409	39	150
84	668	12	402	G4740/76	140
85	658	13	395	41	130
86	648	14	389	42	120
87	638	15	382	43	110
88	728	16	375	44	100
89	618	17	367	45	90
G4690/76	609	18	358	46	80
91	601	19	350	47	70
92	593	G4720/76	340	48	60
93	584	21	330	49	50
94	576	22	320	G4750/76	40
95	567	23	310	51	30
96	557	24	330	52	20
97	547	25	290	53	10
98	537	26	280	54	0
99	527	27	270		
G4700/76	517	28	260		