Rept. Bk. No. 64/85
G.S. 3698

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

EXPLORATION SERVICES DIVISION

THE DISTRIBUTION OF METALS

IN SOILS AND STREAM SEDIMENTS NEAR LYNDHURST

Grid J/5

by

J.E. MARTIN
ASSISTANT SENIOR GEOLOGIST
GEOCHEMICAL EXPLORATION SECTION

11th May, 1967 D.M. 1461/65

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COLLATED BY G.F. WHITTEN

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11th May, 1967

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept. Bk. No. 64/83
G.S. 3698
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THE DISTRIBUTION OF METALS IN SOILS AND STREAM SEDIMENTS NEAR LYNDHURST

Grid J/5

ABSTRACT

Analyses of soil and stream samples from the arid Lyndhurst region of the Northern Flinders demonstrate a bimodal distribution of metals which is related to the mineralogy of the sized-fractions.

Geochemical dispersion is dominantly mechanical.

For soil surveys the -80 mesh fraction is recommended. In stream sampling -1 +½ mm. material yields longer, more contrasted drainage trains than -80 sediment.

INTRODUCTION

These notes present data relating to the distribution of copper, lead, zinc, cobalt and nickel in samples of soil and stream sediment collected within the area of the Lyndhurst Diapir during 1966.

They include discussion of the mode of geochemical dispersion in the Northern Flinders Ranges, and comments upon geochemical exploration field techniques.

LOCATION AND ACCESS

The Lyndhurst Diapir is situated in the Northern Flinders Ranges, some 400 miles north of Adelaide and approximately 30 miles north of Leigh Creek.

Access is from Lyndhurst Siding by graded gravel road. It is 14 miles east of the siding to the area investigated.

CLIMATE AND PHYSIOGRAPHY

The present climate is arid. Records from Leigh Creek aerodrome show that over the past six years the annual rainfall has averaged 5.76 inches. Between 30 and 40 days each year are wet, but about half the annual precipitation may take place over a period of two to three days, causing widespread episodic flooding.

Dissection of the area is mature, with ridges of resistant rocks rising 4-500 feet above the surrounding pediments and alluviated plains. Hill slopes tend to be concave; gradients are low over the pediments increasing gradually to about 17° over the debris slopes and reaching up to 25° over outcrop of the free faces.

Drainage is radially away from Mount Lyndhurst via a dendritic complex of intermittant streams feeding into creeks which flow into Lake Eyre.

Amongst the hills the gullies occupy well defined channels with steep banks, but as they debouch onto the pediments they anastomose through low fans.

GEOLOGY

Stratigraphy

The area forms part of the Adelaide geosyncline. Dolomitic and arenaceous beds of the Burra Group are overlain unconformably by glacigene sediments of the Yudnamutana Sub-Group. There then follows the dominantly argillaceous sequence of the Umberatana Group and the lowermost formations of the Wilpena Group.

Structure

These beds have been folded about axes trending E-W, and dislocated along two major strike faults.

Two episodes of diapiric intrusion are evident. The initial phase pre-dates the Yudnamutana sediments, while the last phase, of major significance locally, post-dates the folding. During diapirism immense volumes of shale, quartzite and dolomite, probably of pre-Burra age, were emplaced as a vast breccia within the younger beds. Crudely circular plugs of altered diorite occur in the diapiric breccia.

Mineralization

Small deposits of copper are common within the area and usually occur as veins cutting a variety of host-rocks. The most extensive, but low grade mineralization known as the White Lead prospect, is present in Yudnamutana siltstone forming the southern flank of the diapir, where, for a strike length of nearly two miles copper minerals occur in small quartz veins and joints formed in slect beds. It is probable, to judge from geochemical results and diamond drilling, that the diapiric breccia north of the siltstone is also extensively mineralized; both vein-type and disseminated mineralization have been noted in brecciated fine quartzite.

Cupriferous veins are also present in large blocks of pyritic carbonaceous shale within the diapir, and it is noteworthy that certain of the dioritic plugs are cut by metalliferous veins and that malachite has been observed scattered through dump specimens of diorite.

At surface these deposits have been oxidised with the production of malachite and cuprite, and more rarely chalcocite and tenorite. Oxidation probably took place some time before the present, for cuprite and chalcocite pebbles have been seen in the oldest stream gravels.

There are two occurrences of lead-zinc mineralization. At Avondale, west of the diapir, three quartz veins cut across argillaceous quartzites of the Burra Group, and bear galena and sphalerite and their oxidation products. Just over a mile east of Avondale, thin siderite veins with galena transect Tapley Hill Shales.

Surficial Deposits

As the area is one of positive relief, the surficial deposits are young and thin, comprising skeletal soils and alluvium.

The oldest of the soils, probably of Recent age, is represented by a limy gypseous silt, found in places at surface or below a stiff red-brown earth covering many of the hill slopes. The youngest soils, on the pediments, are light brown limy silts. These amorphic soils are alkaline and of colluvial origin. Fractional analyses have shown that the soils usually contain less than 5% of clay, and that they are sandy-silts.

The alluvial deposits consist of gravels overlain by layered sandy silts. In many places these are terraced, and are now being eroded by streams of the present cycle. Bed gravels in the upper reaches of the streams contain less than 1.5% clay.

GEOCHEMISTRY

General

Results of the general geochemical investigation of the Lyndhurst Diapir have been presented in Report Books 62/132 and 63/127, which also contain further geological information. The following discussion relates specifically to soil samples collected along line 124 East at Avondale, and line 244 East at White Lead, and to selected stream sediment samples.

Separation of most of the samples into sized fractions was achieved by dry-sieving through graded nylon meshes after gentle crushing in a porcelain mortar. Fractions greater than -60 mesh were crushed to -80 before submission to AMDEL for analysis by atomic absorption spectrophotometer.

Dry sieving results in inefficient separation, particularly of finer grains, and cannot yield a clay fraction. Yet from the stand-point of practical sample preparation dry sieving is desirable. To check results, therefore, and to obtain the clay fraction, 10 samples were submitted to AMDEL for wet separation, as described in appendix A. Again the coarser fractions were crushed to -80 mesh before chemical analysis.

The shortcomings of dry separation are apparent from study of the attached histograms, but it will be noted that the metal contents of the various dry-sieved fractions compare reasonably well with those of wet-sievings, even although identical sample material was not used. The technique of dry sieving is therefore fully justified by the practical considerations of the results.

Distribution of metals in soil samples

On diagram 1, histograms present the particle size analyses and the metal contents of the various fractions of eight soil samples which had been wet sieved. Pairs of samples were taken at each of four localities; one representative of the top inch of soil the second of the soil from 1 inch to 4 inches. Four samples are from the Avondale area, and four from the White Lead prospect.

Study of the histograms shows a marked similarity between the sieve analyses of the top and bottom samples taken at each point, demonstrating lack of eluviation.

The study will also show that there are two distinct patterns of metal distribution within the samples. Where a metal forms a major constituent of the sample, its distribution is bimodal, with one peak occurring near to the -1200 +470 micron fraction, and the other in the clay fraction. The intervening low is always in the fine sand fraction of -120 +70 microns.

Examination of the fractions under the binocular microscope shows that this bimodal metal distribution is related to mineralogical composition. The highly metalliferous coarse fractions consist dominantly of rock fragments with minor quartz and other mineral grains. Although the clay minerals have not yet been identified, they are undoubtedly very sorptive. The fine sand fraction, bearing minimal metal contents comprises over 80% quartz grains.

In contrast to the above distribution, where a metal is present in minor amounts it is concentrated in the clay fraction and exhibits a unimodal distribution.

For example, Cu at Avondale is minor and unimodal; yet at White Lead it is major and bimodal. Ni is usually unimodal, yet cobalt, present in equivalent amounts to Ni, is bimodal.

It will be noted that although there is little evidence of mechanical eluviation, there may be a case for chemical migration, to judge from the general relationship that there is more metal in fractions of the underlying soil than in those of the top inch.

Diagrams 2, 3 and 4 show the mechanical and chemical analyses of soils from Avondale, White Lead, and in breccia north of White Lead respectively. These samples were dry sieved (New material from 118/124, 119/124, 122/244 and 137/244 was collected for well sieving to afford comparison).

The inefficiency of the sieving is apparent from comparison with diagram 1. It is to be noted, however, that the looser material of the top inch sample is better separated than the stiffer soil below.

Because of this inefficient separation, and inability to obtain a clay fraction, information concerning the distribution of minor metals is largely obscured. Despite this shortcoming, however, important facts about the distribution of major elements may be discerned. For example, the histograms clearly show their bimodal distribution, and confirm that the lower sample contains more metal generally than the top inch sample.

From the viewpoint of practical sample preparation, which is invariably done dry, the results show a fairly even distribution of metals in grades less than -60 mesh. Thus, although greater absolute amounts of metal may be detected by use of the coarser soil fractions, ease of sample preparation coupled with eveness of metal distribution resulting in high repeatibility, ratify the use of -80 mesh material for soil surveys.

Distribution of metals in stream samples

The mechanical and chemical analyses of 10 stream samples are shown on diagram 5. These were collected from four localities, and include bank and bed gravels. Two of the bed gravels were separated by wet sieving, but the remainder were all dry sieved, the finest fraction being -80 mesh in the latter instance.

It will be seen that dry sieving of loosely aggregated stream sediment gives a more efficient separation than that of stiff soils, there being a reasonable comparison between the wet and dry mechanical analyses of stream samples. The sediments show a bimodal mechanical distribution, with more silt and clay in the bank than in the bed material.

In the two wet-separated samples, the distribution of metal is similar to that in soil, there being a bimodal pattern for the dominant Cu while the minor Pb, Co and Ni. Zn, is unimodal, with highest concentrations in the clay. Again, microscopic examination shows this distribution to be related to mineralogy, in a similar manner to the soils.

Most samples dry sieved show a unimodal distribution for the metals, the maximum contents usually occurring in the -14 +32 or -32 +60 mesh fractions. The one exception, Cu in sample 19a, must be classed as suspect. Attention must be drawn to the low values in the -80 mesh fraction, the portion normally used in routine stream surveys. Once again the exception is zinc. Where this is present in low amounts the finest fraction contains most of the metal.

From consideration of practicalities, therefore, it is evident that use of a coarse fraction in stream sampling yields greater contrast of anomalies and greater defined length of the drainage train, as will be seen from study of the stream profiles presented in diagrams 6, 7 and 8.

The comparison of the metal contents of bank samples with bed samples shows a variable relationship. As discussed in Report Book 63/127, in areas of low or back-ground metal contents, Cu, Pb, Ni and Co show a more even distribution amongst the size-~~fractions of banks than amongst~~ those of beds i.e. the coarser fractions of the bank samples contain less of these metals than the coarser fractions of the bed samples, and the finer bank fractions contain more metal than the bed fines. Zinc is exceptional; there being more of this metal in bank materials than in bed materials.

Where the source of the metal is close to the stream, however, and particularly in cases where the stream drains through a concentration of metal in soil, the bank samples will contain as much as or more metal than those from the bed. This relationship is attributable to dilution within the bed gravel.

Comparison of metal distributions

On diagram 9 there are shown the distribution of zinc, copper and tin as determined by Hawkes and Webb (Table 9-2, 1962). The graphs are characteristic of chemically and mechanically dispersed elements respectively. From the plots of the Lyndhurst data on the same diagram, it will be seen that the distribution of Cu, Pb, Zn, Co and Ni (in samples containing appreciable amounts of these metals) display characteristics of both types of dispersion.

Geochemical dispersion at Lyndhurst

From consideration of environmental factors at Lyndhurst, i.e., nature of rainfall, steepness of many slopes and thalwegs, alkalinity and amorphism of soils, and from consideration of the distribution of metals in the various sized-fractions of soils and stream sediments, it is evident that dispersion is mainly mechanical, with modification by chemical processes.

It is considered that the main movement of the soil is by sheet-flooding, with the day-light surface material moving most and being subjected to greatest mechanical and chemical disintegration. This accounts for the chemical differences between the top inch and lower section of soil.

In the streams the bed material probably constitutes to a large degree reworked bank alluvium. Minor amounts of the bed gravels will be derived from influx of soil and erosion of bedrock. Thus during the reworking of the bank alluvium (which, it will be remembered is much muddier than the bed alluvium) the fine material is winnowed out, and the coarser grains which are denser because of their metal content probably tend to become mechanically concentrated. It is believed that this is the reason for the chemical differences between bank and bed samples.

CONCLUSIONS AND RECOMMENDATIONS

Further investigation is required to establish all the factors involved in the dispersion of metals in the arid Lyndhurst environment, but weight of present information strongly suggests mechanical dispersion is dominant.

It would be of interest to make a detailed mineralogical study of the fractions, and establish the composition of the clays. Cold extraction may yield information on the chemical mobility of the metals and should be coupled to pH Eh, and base exchange studies.

From the viewpoint of routine geochemical surveys, collection of soils from below 1 inch and use of -80 mesh fractions are satisfactory. In stream sampling, however, it would appear wiser to use the -1 +½ mm. fraction of bed gravels. This should permit wider spacing of samples. During follow-up of anomalies closer sampling of bank and bed, and concentration of coarser fractions by panning for microscopic examination, may well yield information on the location of the source and nature of the mineralization giving rise to the anomaly.

JEM;SMA
11.5.1967

J.E. MARTIN
ASSISTANT SENIOR GEOLOGIST
GEOCHEMICAL EXPLORATION SECTION

APPENDIX A

REPORT ML2173-67

YOUR REFERENCE:	Application dated 24th February, 1967.
MATERIAL:	Sands and Sediments.
LOCALITY:	Lyndhurst.
IDENTIFICATION:	JM10/67 to JM19/67.
DATE RECEIVED:	24th February, 1967.
WORK REQUIRED:	Separation into size fractions.

INTRODUCTION

Ten samples of sands and sediments were supplied for separation into size fractions from 2 mm to 2 microns. As the sample resulted from a geochemical survey, special precautions were taken to prevent contamination.

MATERIAL EXAMINED

Ten samples, designated JM10/67 to JM19/67 were received. Each sample was collected from a surface location in the Lyndhurst area and ranged in size downwards from gravel sizes.

Demineralised water was used throughout the work.

PROCEDURE AND RESULTS

A 200 g portion (500 g for JM18 and JM19) was obtained from each sample by riffling after first screening (1) to reject material coarser than 2 mm.

Each sample was wet screened at 70 microns followed by dry screening of the oversize material on a Ro-tap mechanical shaker.

The minus 70 micron material was further separated at 2 microns by decantation. Decantation was repeated until separation was substantially complete. No dispersants were used in this work.

The minus 2 microns fractions were reclaimed by centrifuging.

Sizings of the samples are given in Table 1.

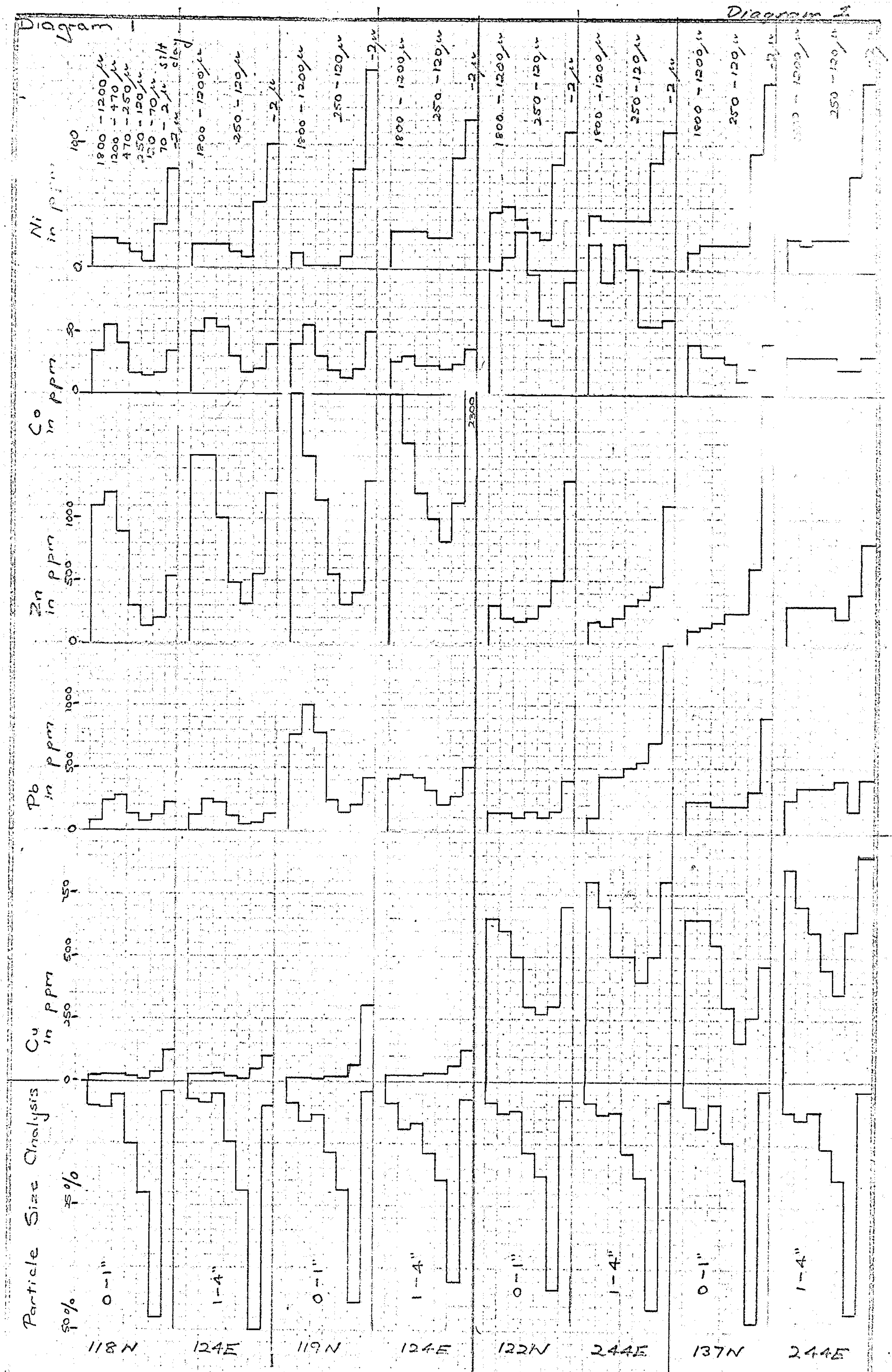
Size fractions and sample residues were collected by the Sponsor on 3rd April, 1967.

TABLE 1: SIZING OF SAND-SAMPLES

Particle Size micron	Weight Retained, %									
	JM10	JM11	JM12	JM13	JM14	JM15	JM16	JM17	JM18	JM19
-1800 +1200	4.8	3.9	4.0	4.8	8.7	4.7	4.9	5.9	22.4	23.6
-1200 + 470	5.5	4.5	7.8	9.0	11.8	6.2	9.2	7.6	34.2	40.6
- 470 + 250	3.1	2.9	6.6	8.2	7.2	5.9	4.2	6.0	10.1	19.9
- 250 + 120	13.1	12.4	14.1	13.7	10.6	14.4	12.2	12.8	8.0	6.5
- 120 + 70	23.1	21.7	21.7	20.3	16.2	19.1	19.6	19.4	6.8	2.7
- 70 + 2	48.3	50.0	43.8	40.1	41.6	45.7	48.1	46.7	17.2	6.5
-2	2.1	4.6	2.0	3.9	3.9	4.0	1.8	1.6	1.3	0.2
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Applicant's Mark	Dept. Sample No.	Location				Information Required
		Hundred	Sects.	*Other Locality Information		
JM10/67	Please note.			Lyndhurst 118/124	0-1"	Please size into following fractions using <u>Metal-free</u> water, and retain all fractions for further investigation.
11	These sized fractions were submitted			" 118/124	1-4"	
12	for Atomic Absorption			" 119/124	0-1"	
13	Scheme 1 under the numbers:			" 119/124	1-4"	2 mm - 1mm.
14	G2518/67 to			" 122/244	0-1"	1 mm - ½mm.
15	G2587/67 inclusive.			" 122/244	1-4"	½ mm - ¼mm. 500-250 m.µ
16				" 137/244	0-1"	250 mµ -125m µ
17				" 137/244	1-4"	125 mµ - 62m µ
18				" 16 Stream	sed.	62 mµ - 2m µ silt
JM19/67				" 19 "	"	-2 mµ clay

Diagram 2



To accompany report by J.E.Martin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Drn. Tcd. M.L.B Ckd. Exd.	WHITE LEAD Cu PROSPECT AVONDALE Pb-Zn PROSPECT Wet Sieved Soil Samples Metal Contents in ppm	SCALE: S5825 Cc DATE:

AVONDALE LEAD-ZINC PROSPECT

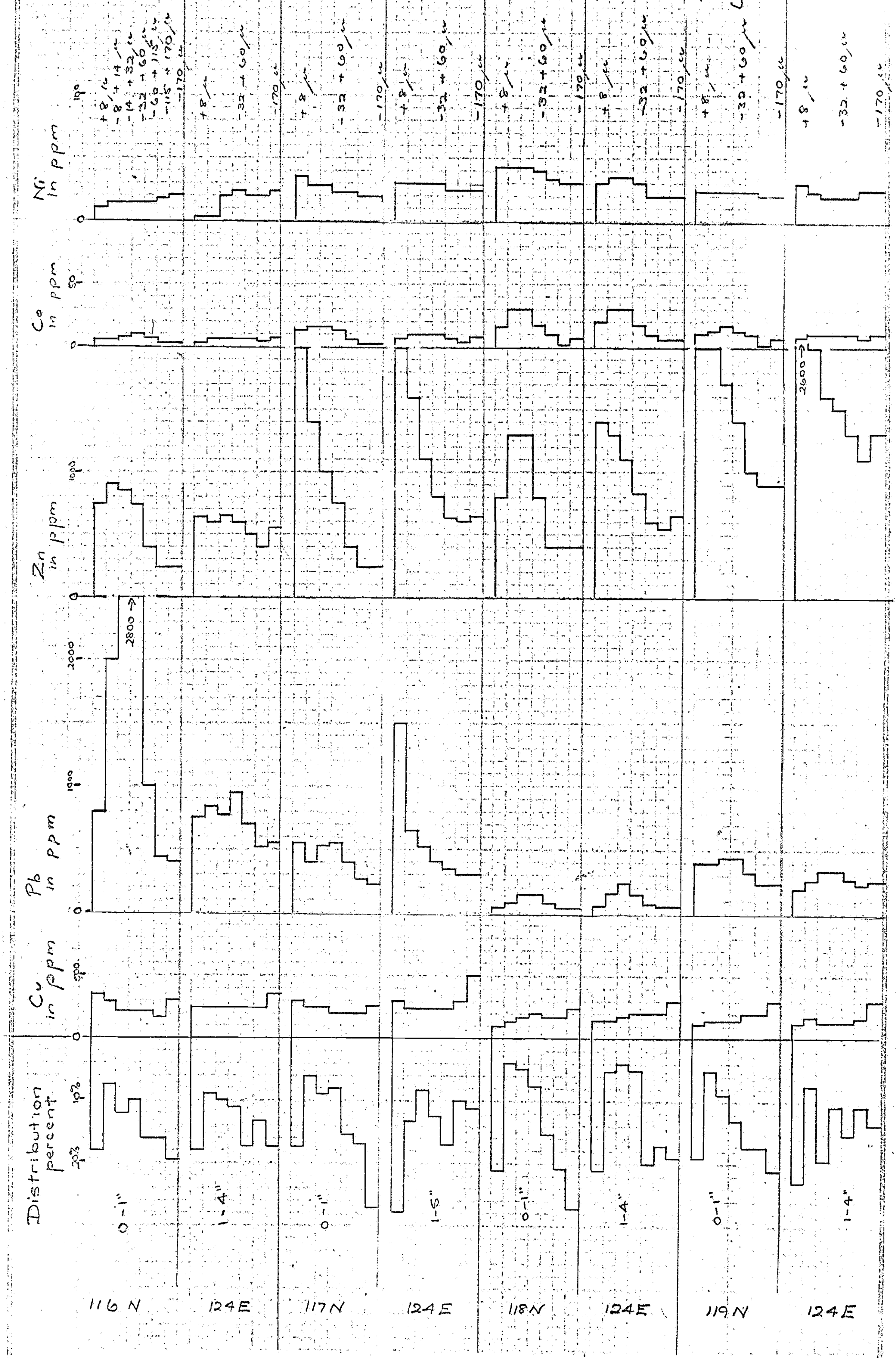
WHITE LEAD-COPPER PROSPECT

S 5825

J. E. Martin Asst. Senior Geologist

S.A. Department of Mines

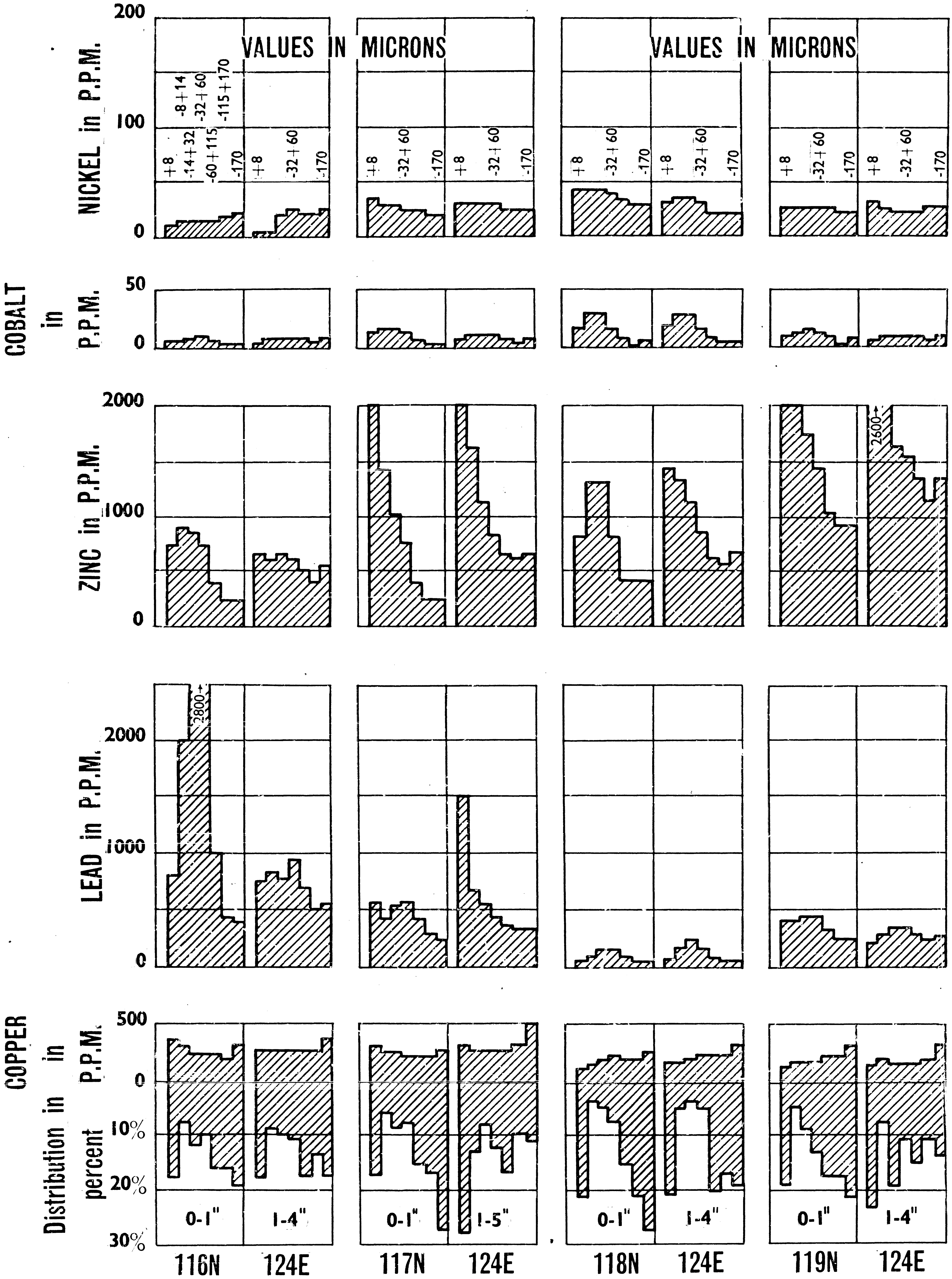
Diagram 2



To accompany report by J.E. Martin.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

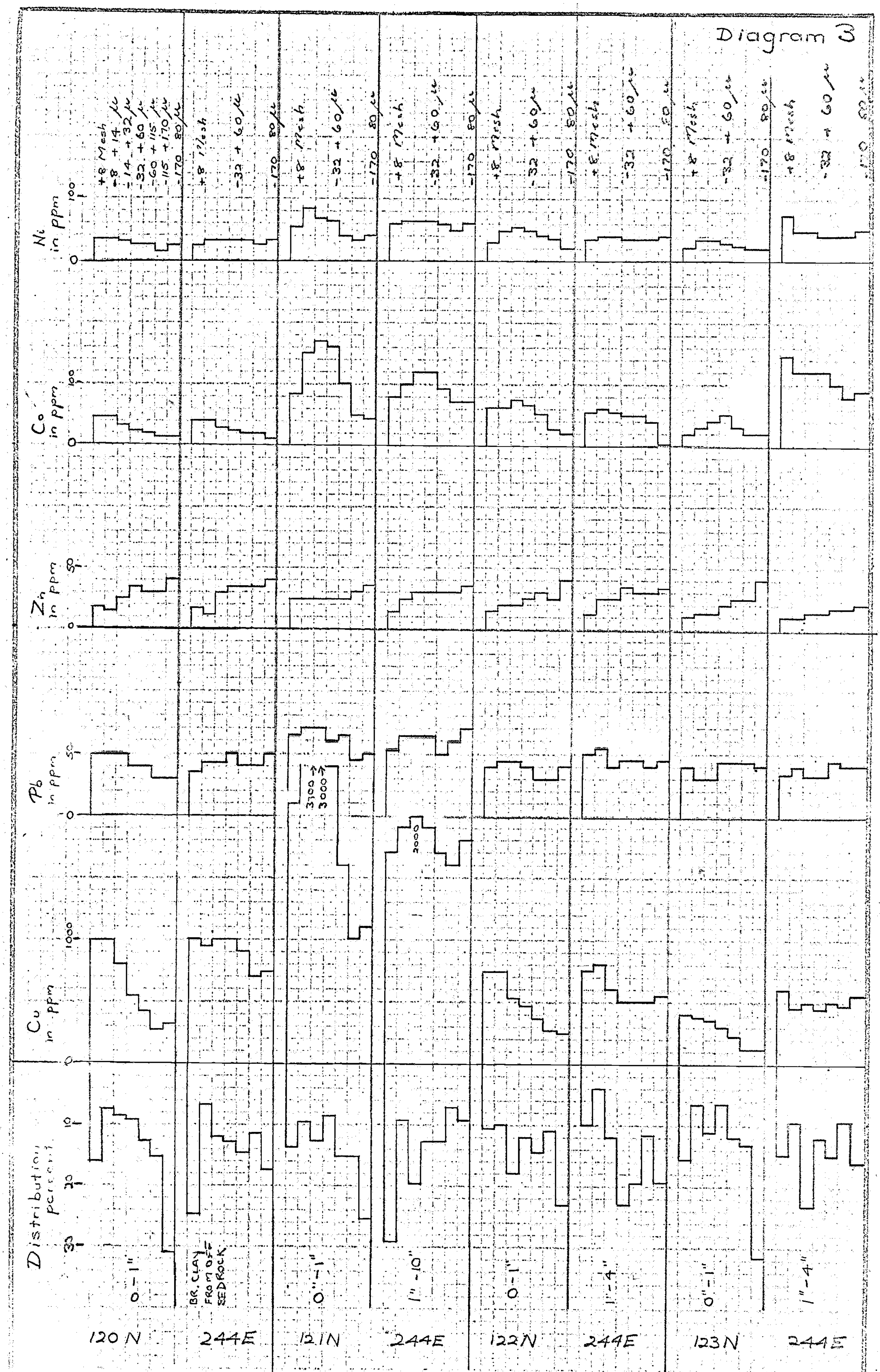
Drn.	AVONDALE Pb-Z PROSPECT	SCALE:
Tcd. M.L.B	Dry Sieved Soil Samples	S5826 Cc
Ckd.	Metal Contents in ppm	
Exd.		DATE:



AVONDALE LEAD — ZINC PROSPECT

S 5826 J. E. Martin Asst. Senior Geologist S.A. Department of Mines

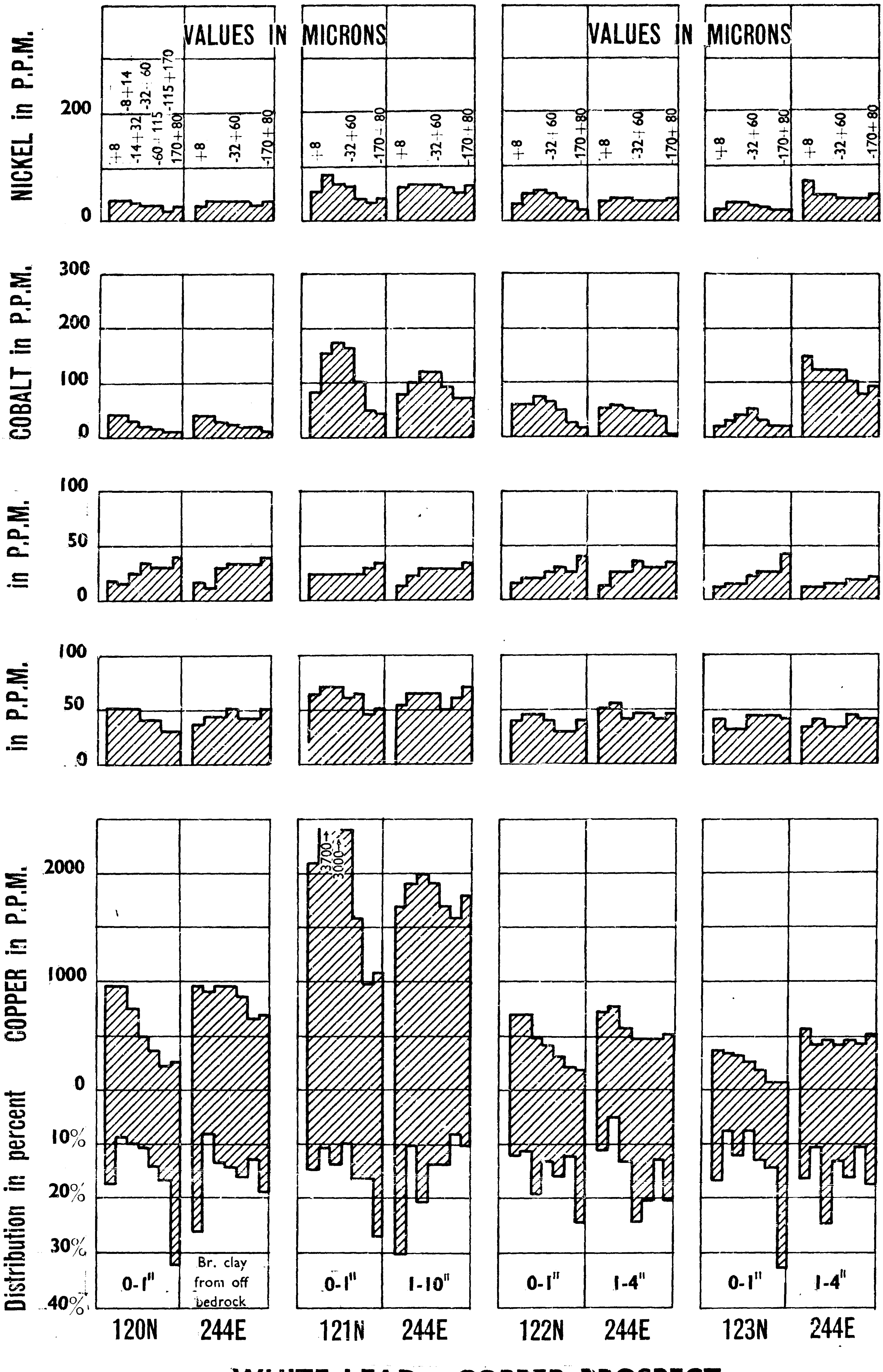
GRAPHS SHOWING DRY SIEVED SOIL SAMPLES (METAL CONTENTS IN P.P.M.) AVONDALE Pb-Zn PROSPECT



To accompany report by J. E. Martin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Drn.	WHITE LEAD Cu PROSPECTS	SCALE:
Tcd. M.L.B.	Dry Sieved Soil Samples	S5827 Cc
Ckd.		
Exd.	Metal Contents in ppm	DATE:

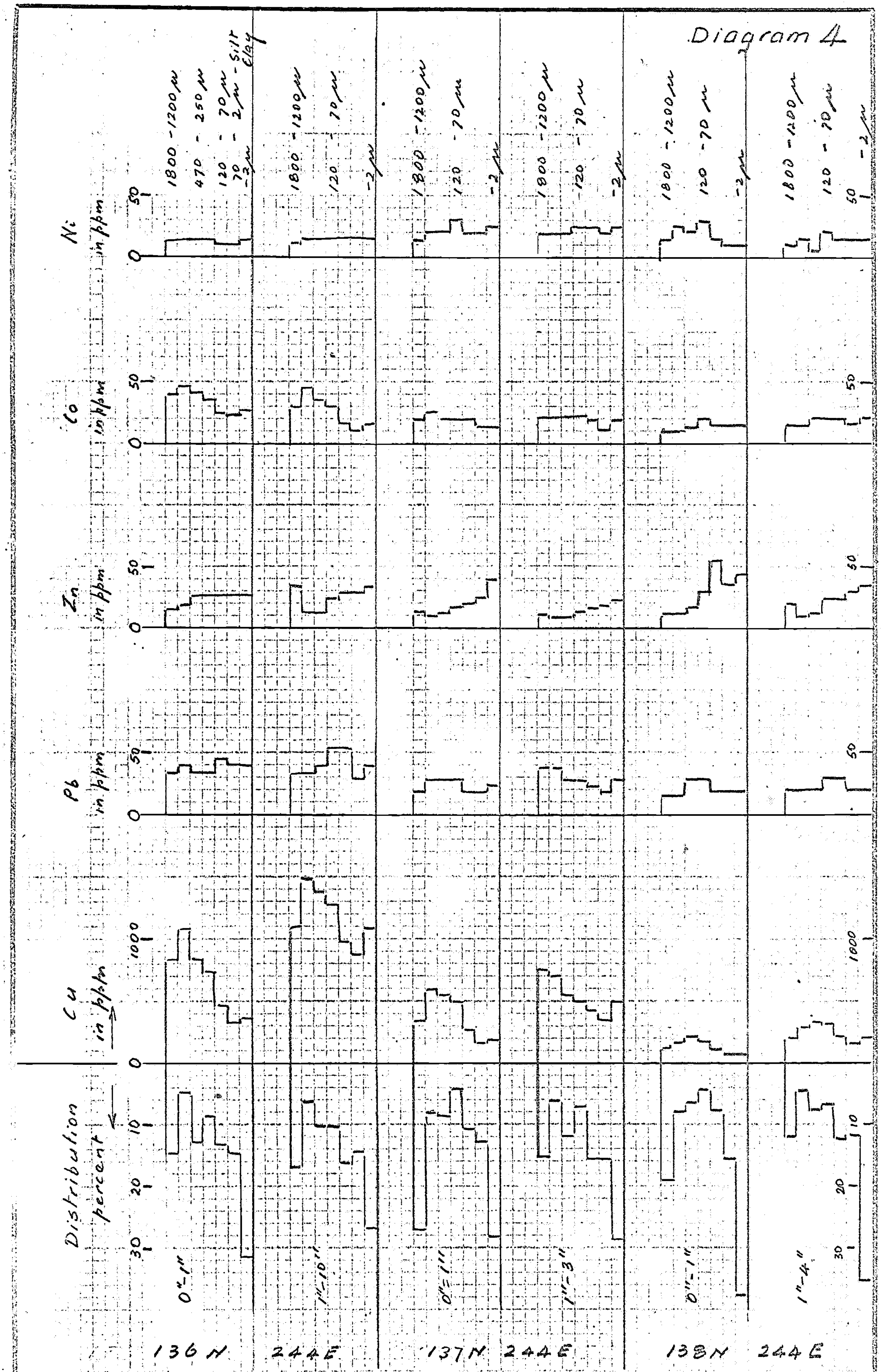


WHITE LEAD — COPPER PROSPECT

S 5827 J. E. Martin Asst. Senior Geologist S.A. Department of Mines

GRAPHS SHOWING DRY SIEVED SOIL SAMPLES (METAL CONTENTS IN P.P.M.) WHITE LEAD - Cu PROSPECTS

	Drn. TMH	S5827/4
	Ckd.	Cc
Director of Mines	Passed	Date 6-8-68

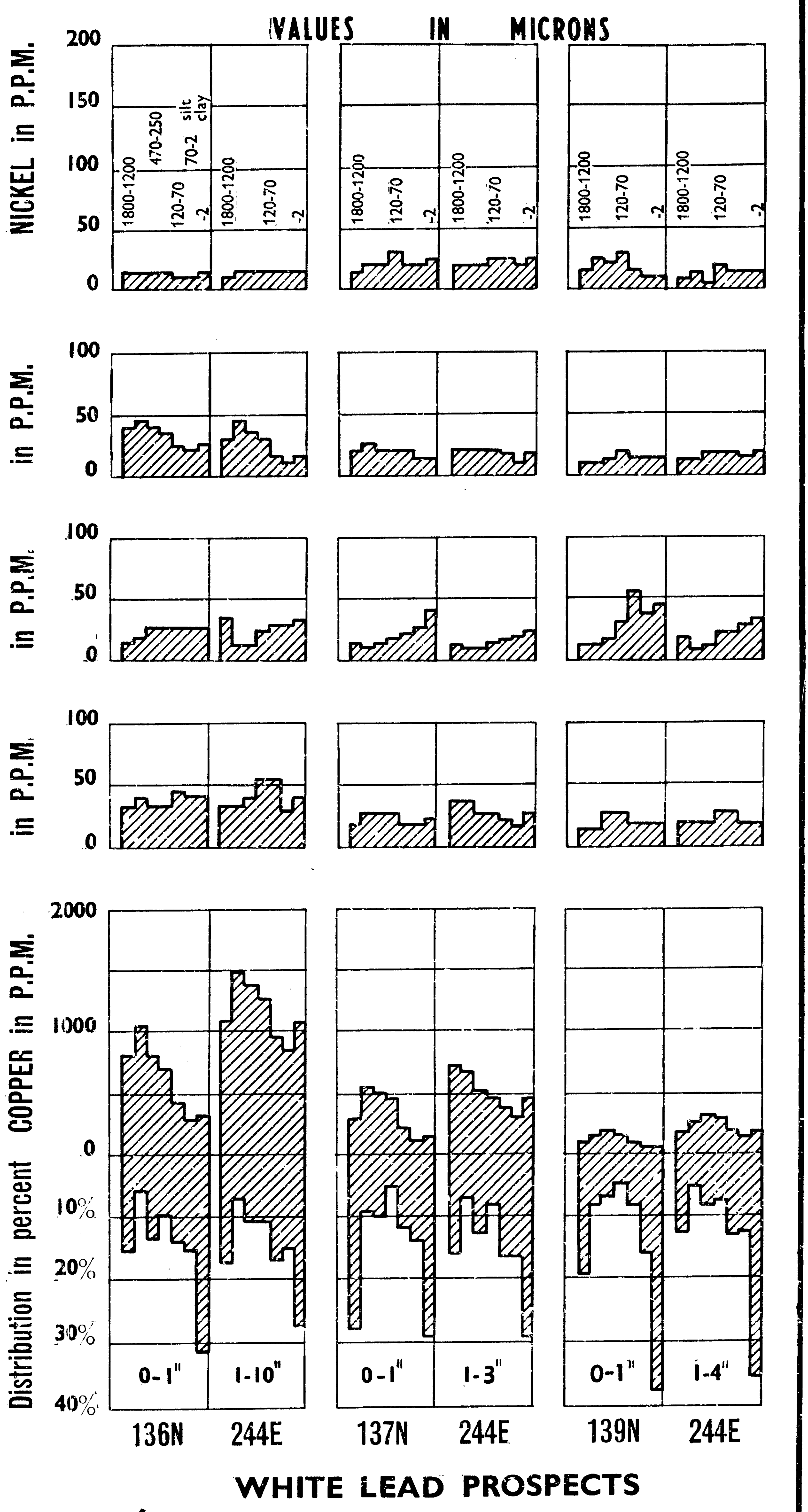


To accompany report by J.E. Martin.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

G. Whitten 8 V 67	Drn.	WHITE LEAD PROSPECTS (inside diapir) Dry Sieved Soil Samples Metal Contents in ppm	SCALE: Diag
	Tcd.		S5828 Cc
	Ckd.		
	Exd.		DATE:

REDUCE TO 6½"

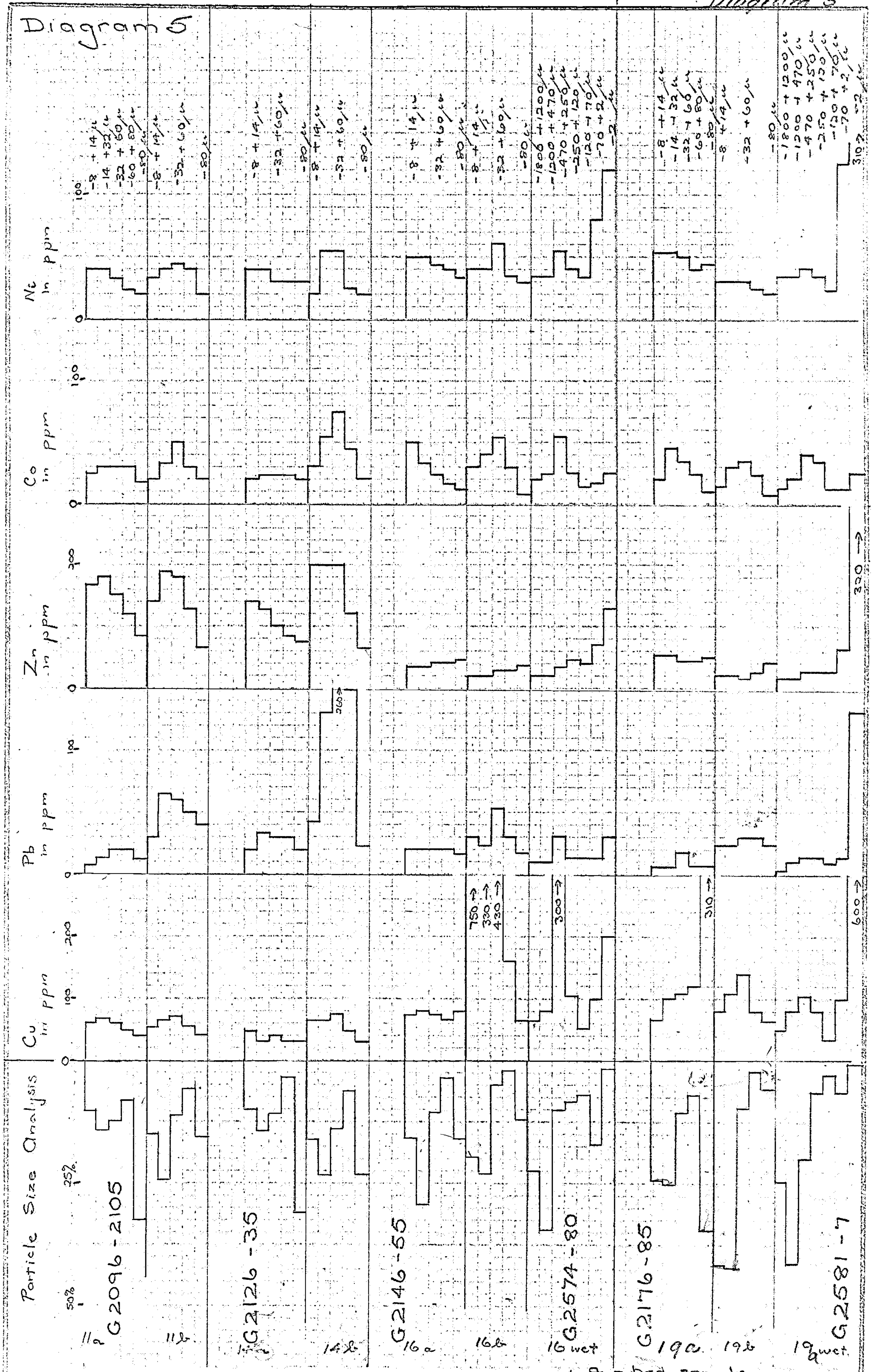


S 5828 J. E. Martin Asst. Senior Geologist S.A. Department of Mines

GRAPHS SHOWING DRY SIEVED SOIL SAMPLES (METAL CONTENTS IN P.P.M.) WHITE LEAD PROSPECTS (INSIDE DIAPIR)

S5828/4
Cc
6-8-68

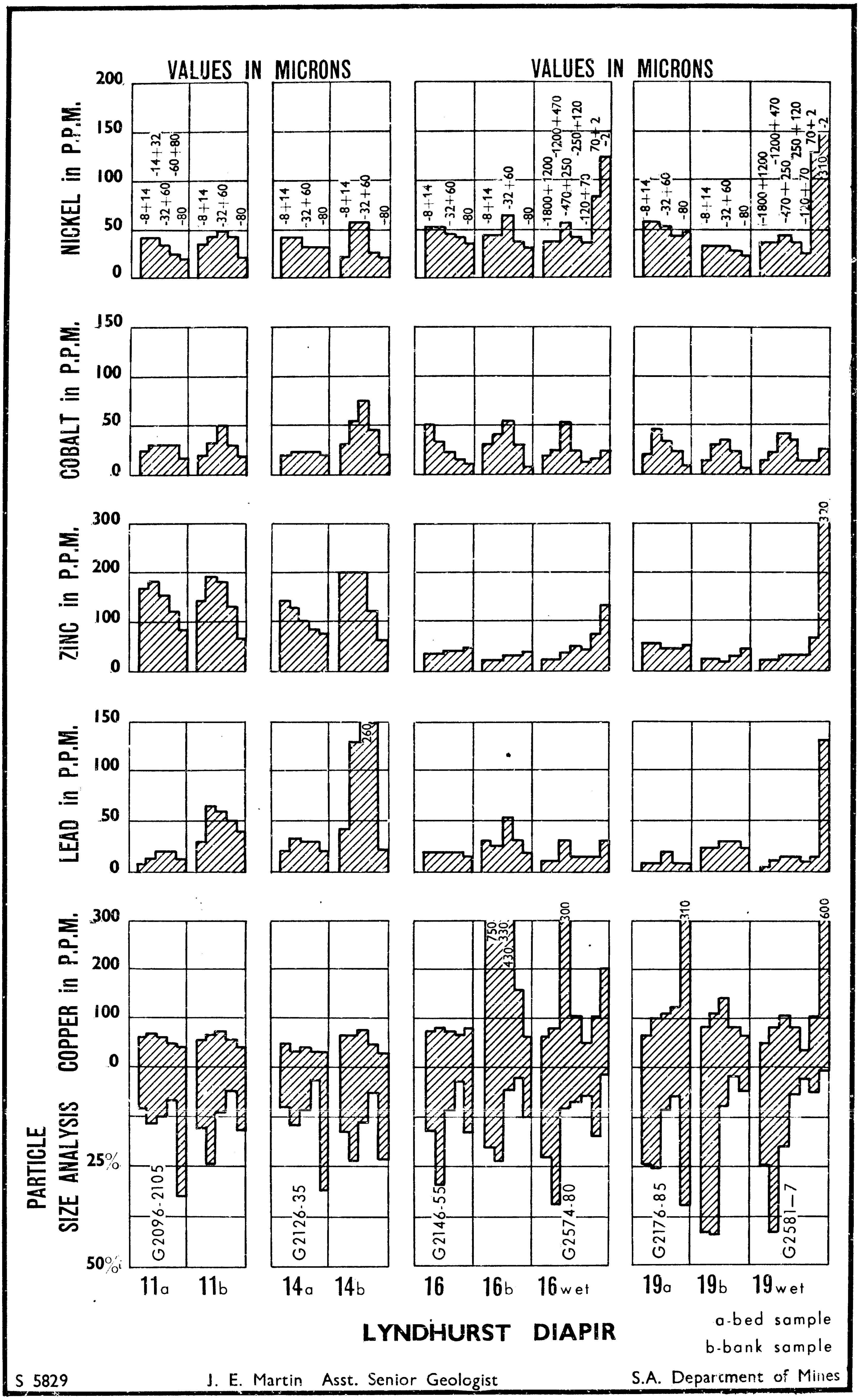
Diagram 5



To accompany report by J.E. Martin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

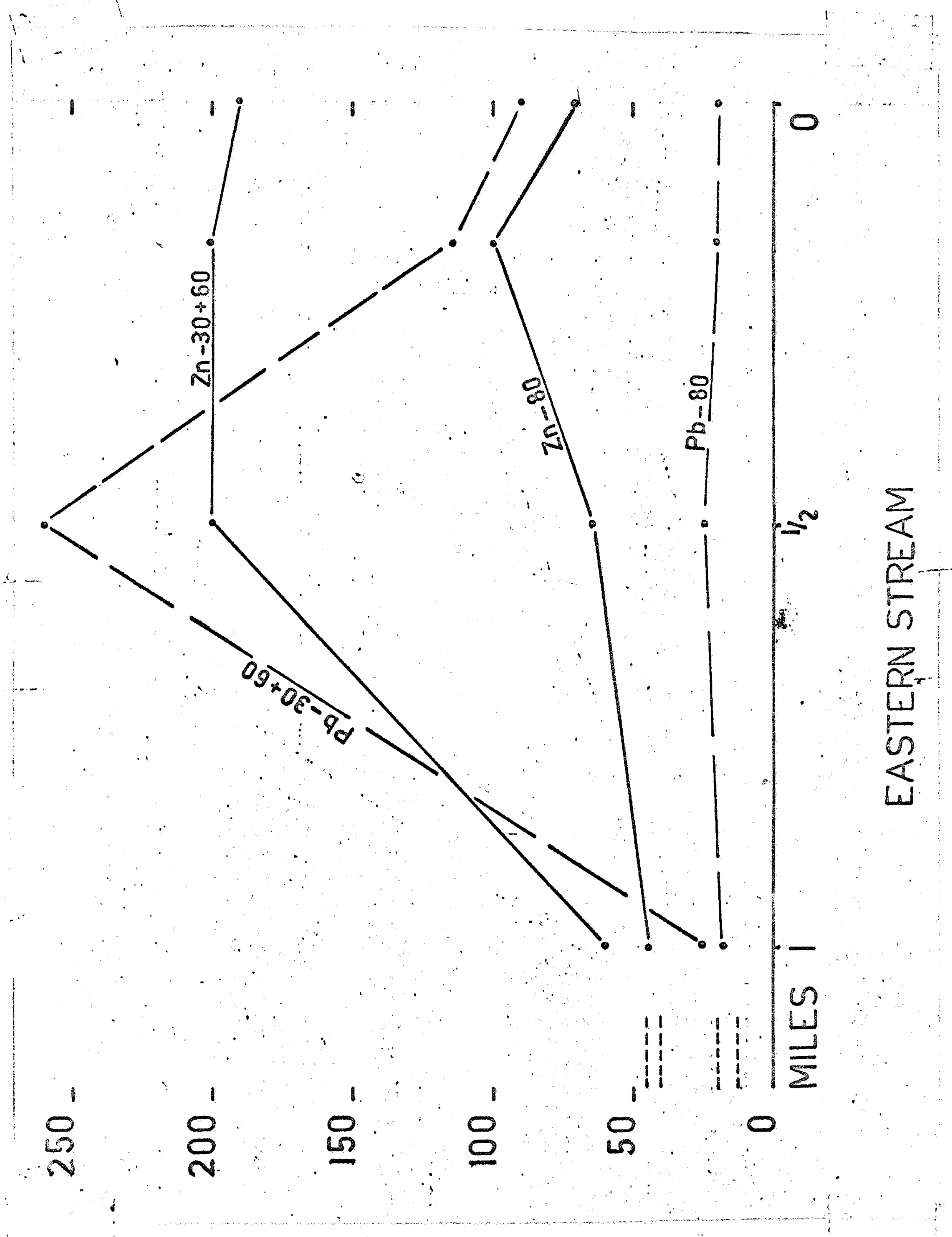
	Drn.	LYNDHURST DIAPIR	SCALE:
	Tcd. M.L.B	Physical & Chemical Analysis	S 5829 Cc
		of Ten Stream Sediments	
	Exd.		DATE:



GRAPHS OF PHYSICAL AND CHEMICAL ANALYSIS
OF TEN STREAM SEDIMENTS
LYNDHURST DIAPIR

S5829/4
Cc
6-8-68

Diagram 6



To accompany report by J.E. Martin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

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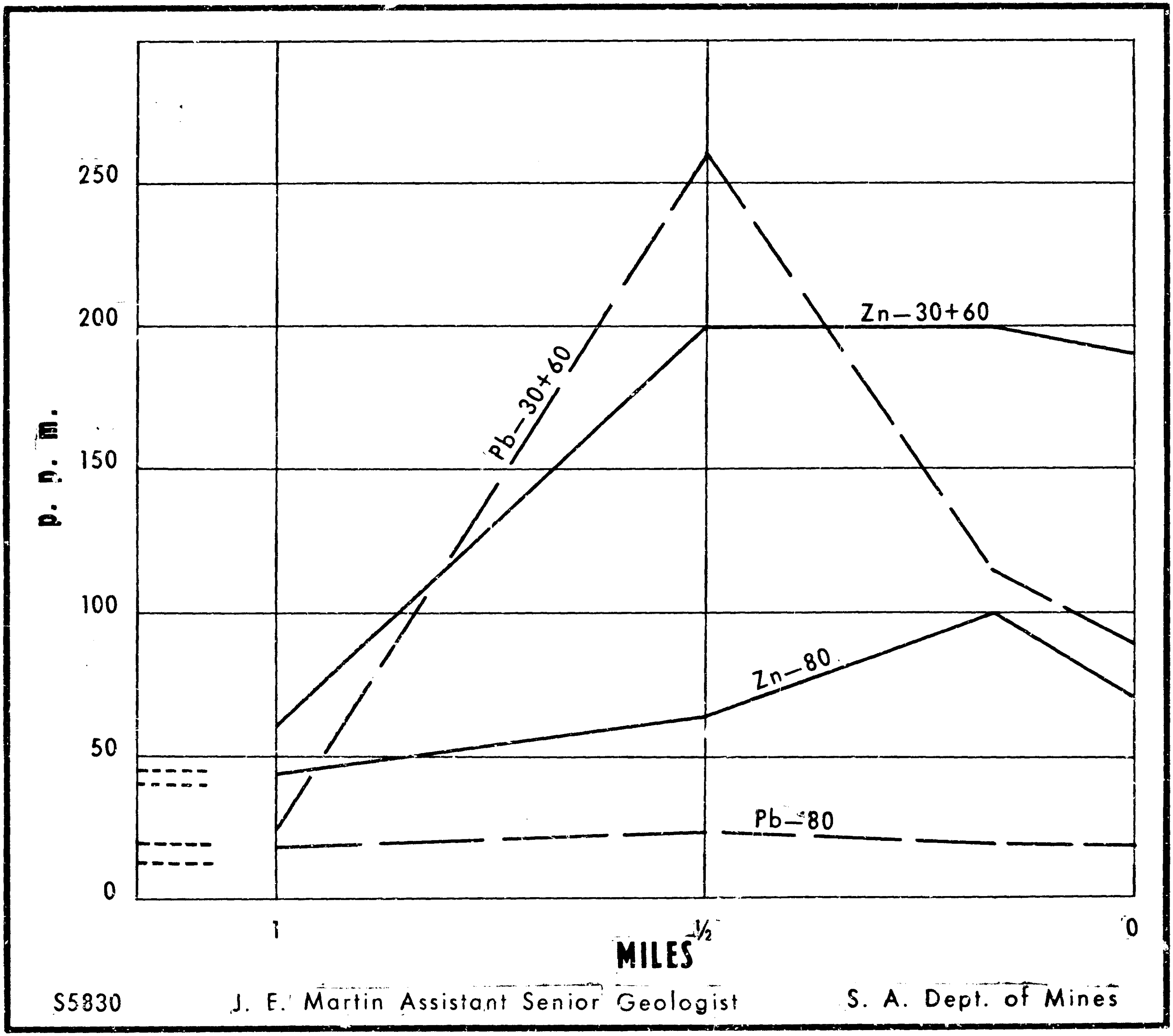
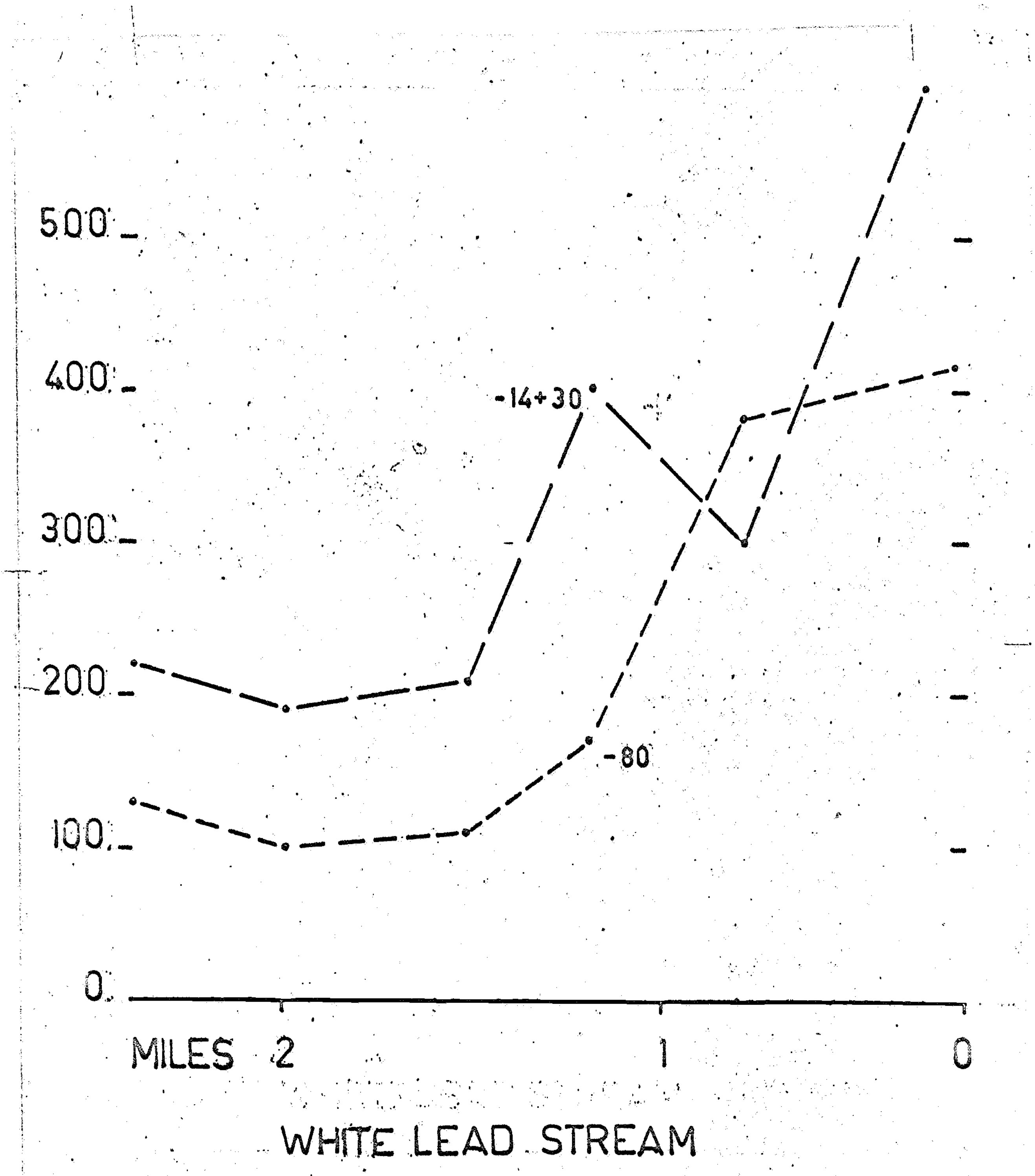
	Ckd.		
	Exd.		DATE:



GRAPH SHOWING Pb-Zn ANOMOLIES IN DRAINAGE TRAIN EASTERN STREAM LYNDHURST DIAPIR R 126

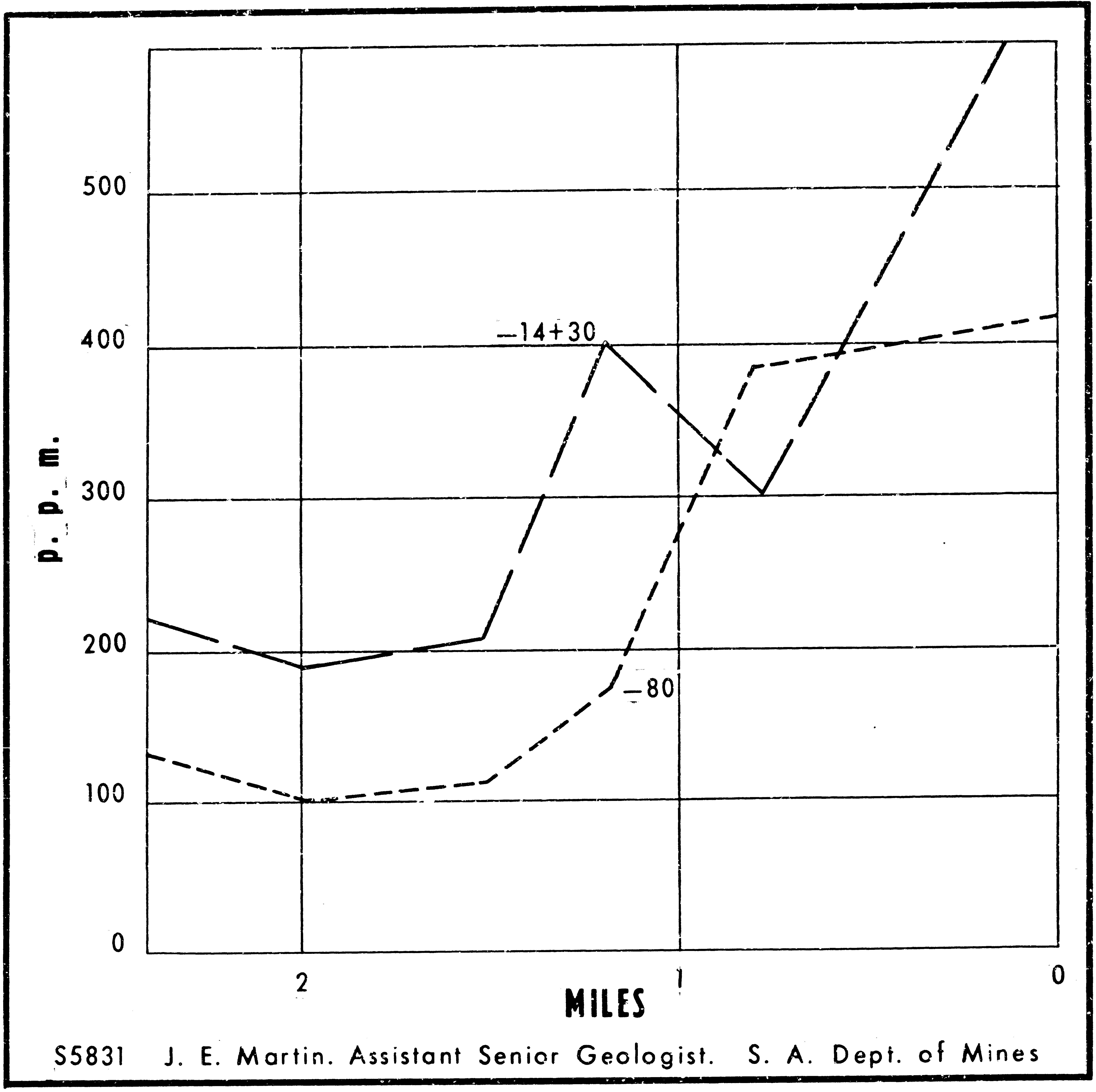
Diagram 7



To accompany report by J. E. Martin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

8 V 67	Drn.	LYNDHURST DIAPIR	SCALE:
	Tcd.	Cu in Drainage Train	S5831 Cc
	Ckd.	White Lead Stream	
	Exd.		DATE:

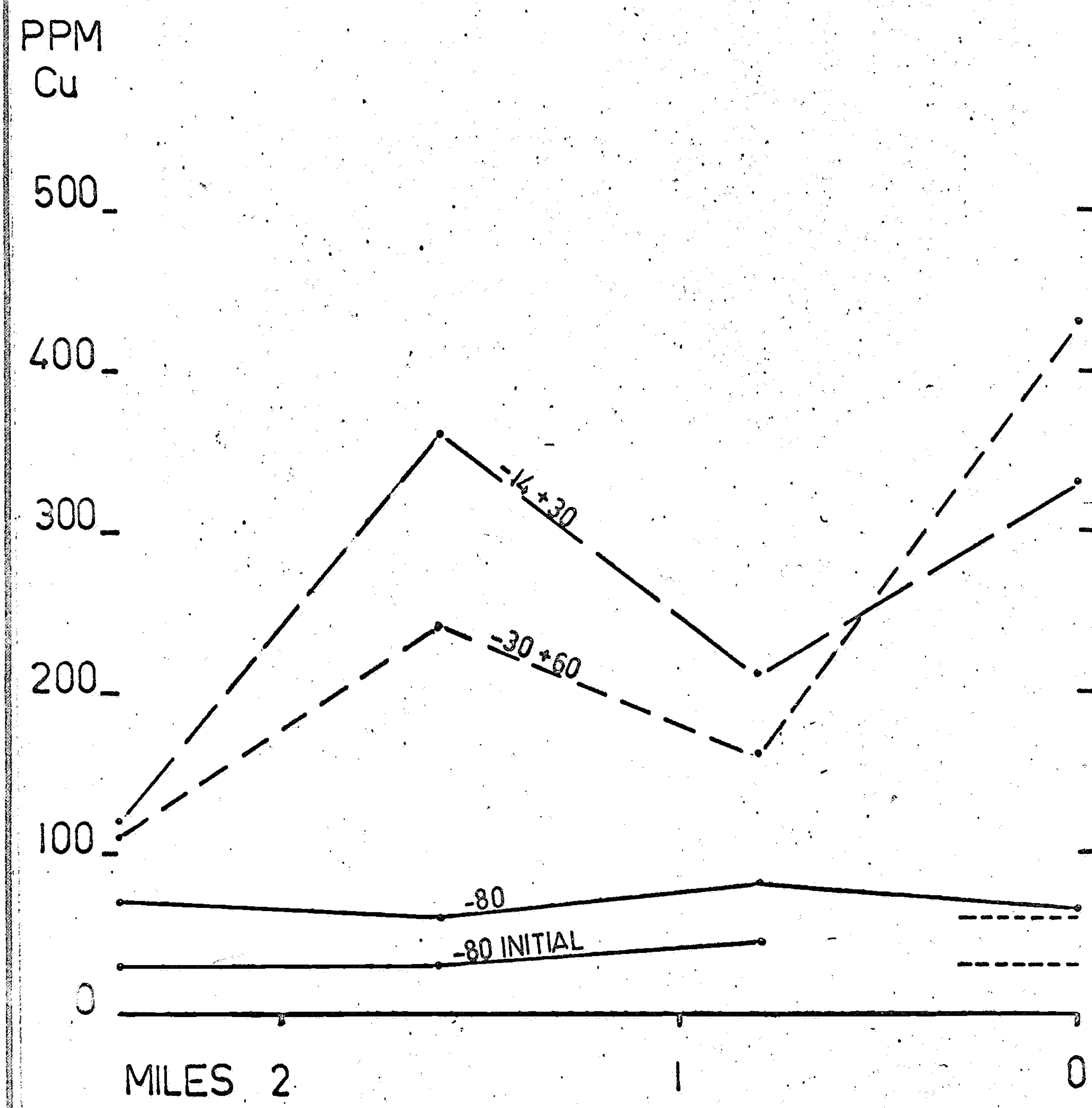


GRAPH SHOWING – Cu IN DRAINAGE TRAIN
WHITE LEAD STREAM
LYNDHURST DIAPIR R126

J.M.H.

S5831/4
Cc
25-6-68

Diagram 8



GR. MT. LYNDHURST STREAM

To accompany raport by J.E. Martin.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

8 I 67	Drn.	LYNDHURST DIAPIR	SCALE:
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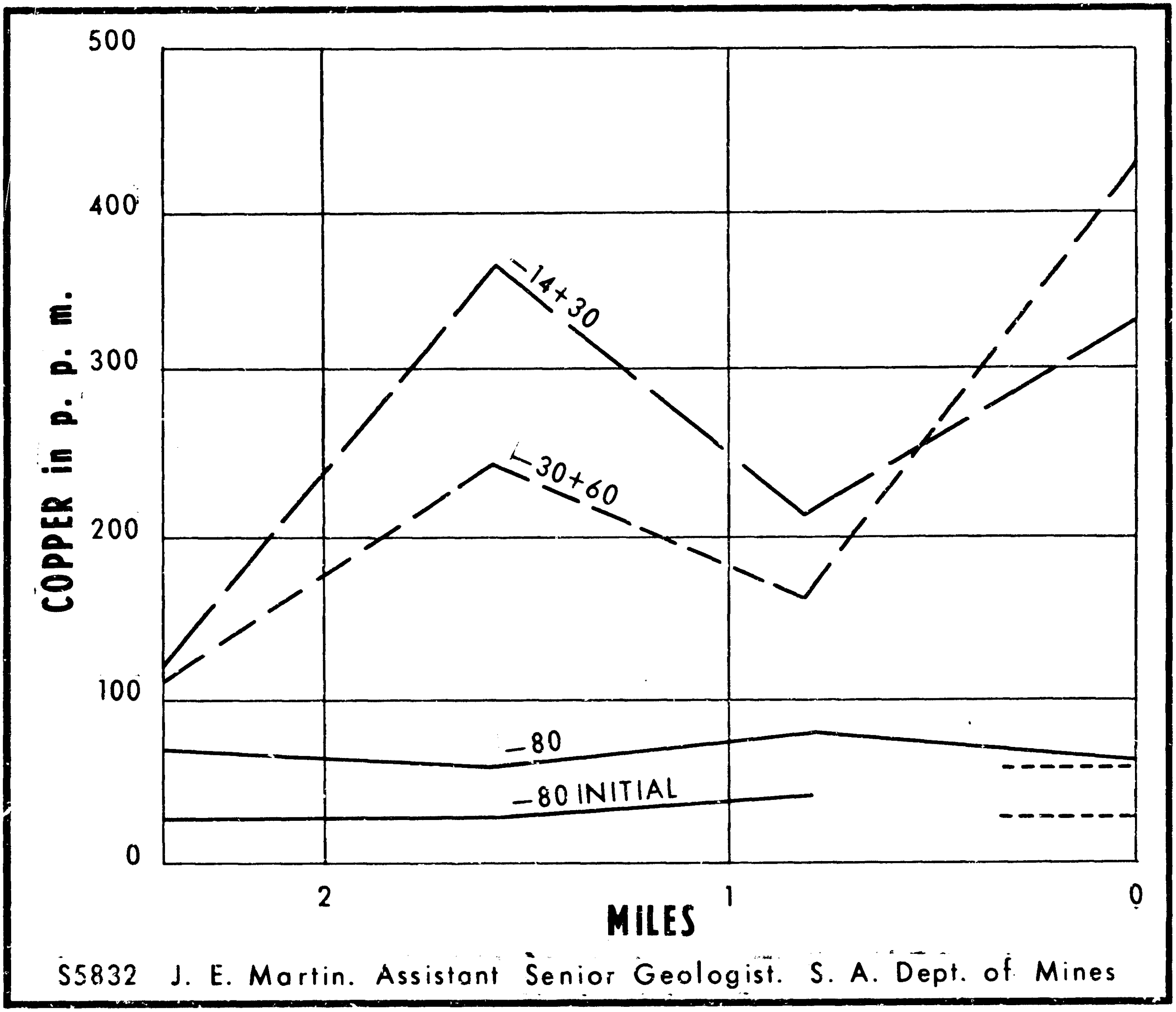
	Ckd.	Gr. Mt. Lyndhurst Stream	
	Exd.		DATE:

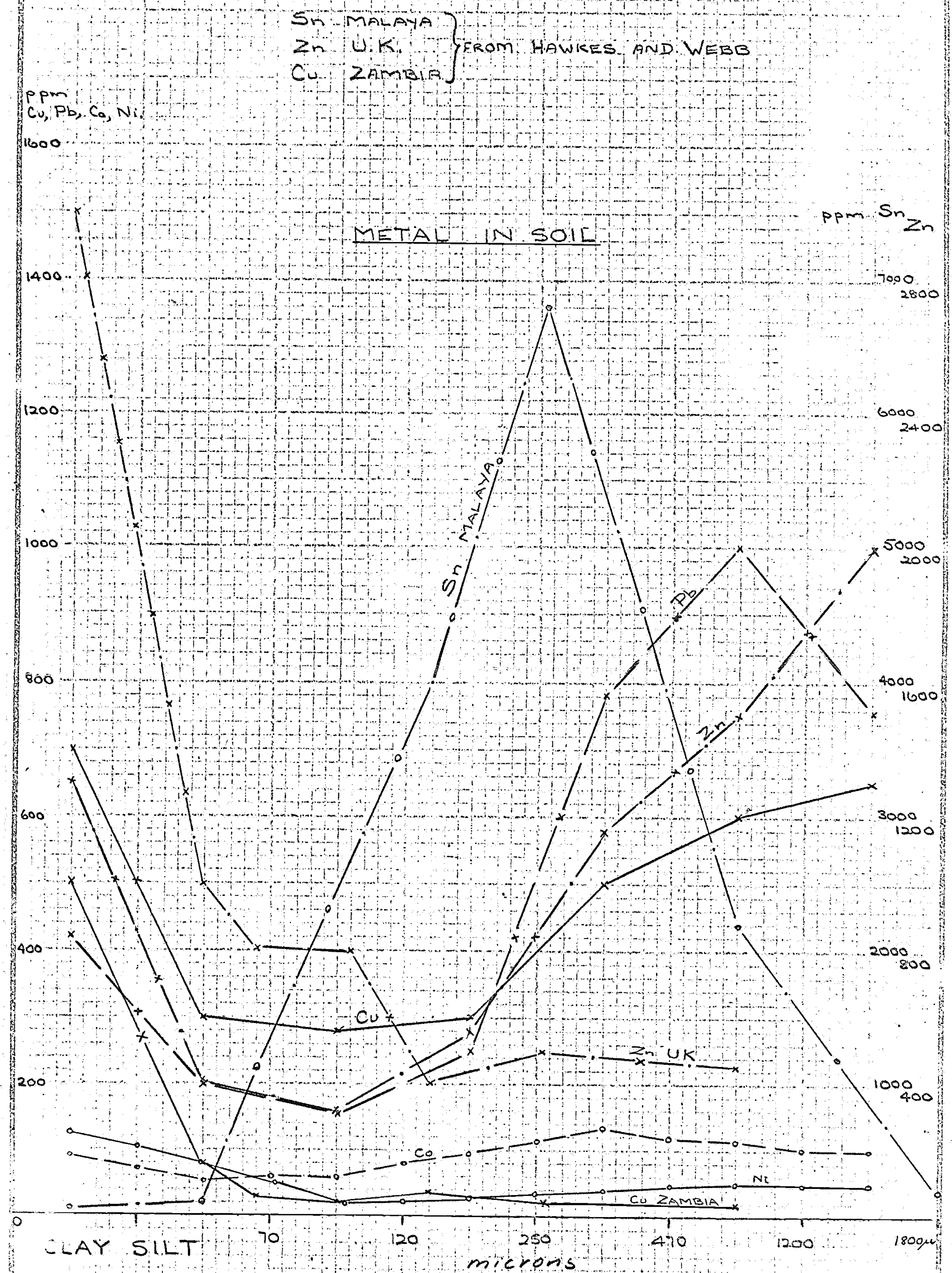


GRAPH SHOWING -- Cu IN DRAINAGE TRAIN
GR. MT. LYNDHURST STREAM
LYNDHURST DIAPIR R126

TMH

S5832/4
Cc
25-6-68

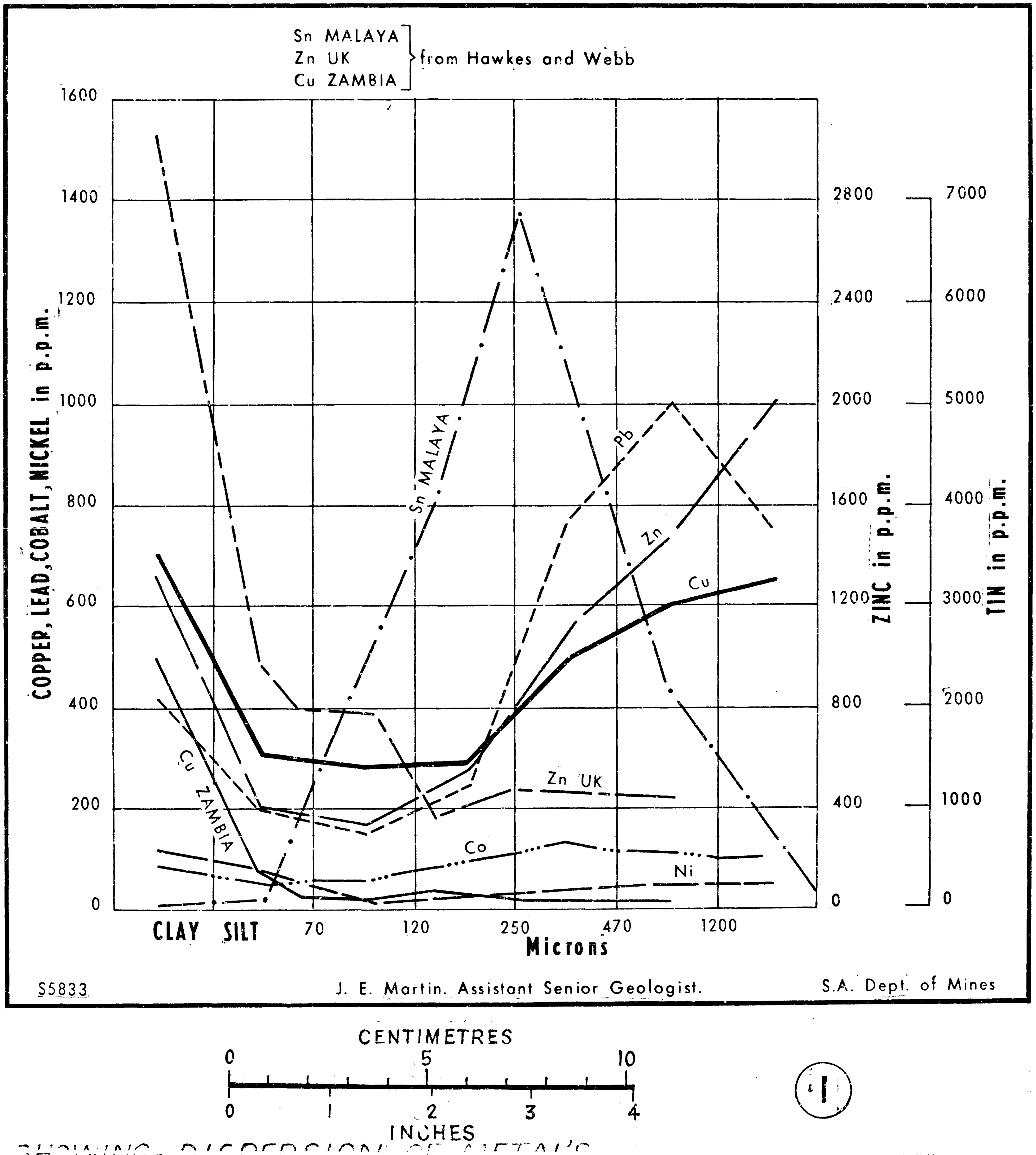
Diagram 9.



To accompany report by J.F. Marlin

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Drn.	LYNDHURST DIAPIR	SCALE:
Tcd. M.L.B.	Dispersion of Metals compared with Hawkes and Webb.	S5833 Cc
Ckd.		
Exd.		DATE:



GRAPH SHOWING DISPERSION OF METALS COMPARED WITH HAWKES AND WEBB.
LYNDHURST DIAPIR R126

S5833/4
Cc
25/6/68