GEOCHEMICAL EXPLORATION AROUND THE ACLARE MINE

AND

MINERAL DEPOSITS OF THE SURROUNDING REGION

BY

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CONTENTS

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Mr. T. J. Bradley prepared the polished sections and Mr. S. Trzicky prepared the X-ray photographs.

The project area is currently held by Mines Exploration Pty. Ltd. under an Authority to Enter for exploration purposes. Therefore I must thank them for permission to work in the area. Mr. J. Roberts gratefully gave his time to discuss their geochemical exploration program.

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I INTRODUCTION

1. Location (see fig. 1)

The investigation centred roughly around the abandoned Aclare Mine which lies about 3 miles west of Callington and 4 miles south-south-west of Kanmantoo. Most parts of the area can be reached by dirt tracks from Kanmantoo or Callington.

Geochemical investigations were confined to about six square miles surrounding the Aclare Mine, but examination of ore types extended further afield to Brukunga and Strathalbyn.

2. Aim of Investigation

.1 Geochemical Exploration

The area has scattered abandoned Pb, Zn, Ag and Cu mines and prospects, therefore the metals analysed were Pb, Zn and Cu. The aim was to determine the optimum sampling and analytical technique and then apply these in order to detect anomalous values.

.2 Examination of Mineral Deposits

Petrographic, mineragraphic and structural examination of the metalliferous deposits and their enclosing rocks was carried out to determine their composition, texture and morphology.

.3 Theoretical Aspects

By compiling all available information of the known mineral deposits, and by comparison with deposits of other regions, it was hoped to advance some hypotheses of their genesis.

.4 Directive for Future Work

Clearly a project such as this can only superficially cover the several aspects mentioned so an important aim is to formulate problems and launching points for future investigations.

3. Methods Employed

The work fell into 3 divisions:

(a) field work

(b) laboratory determinations

(c) literature search.

Details of the field and laboratory methods appear elsewhere in appropriate sections.

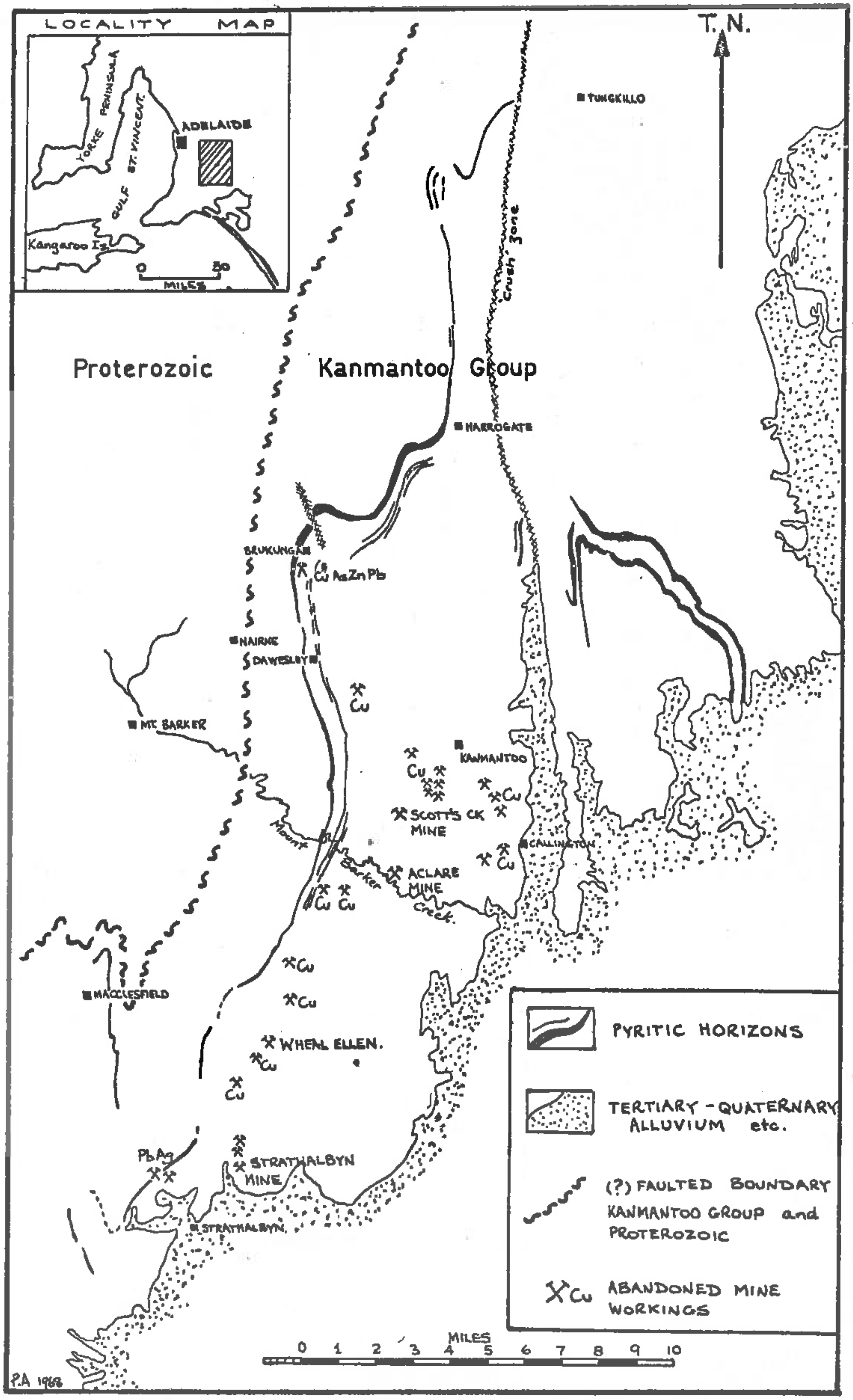


FIG. 1

LOCALITY PLAN AND GENERAL GEOLOGY OF REGION (after Mirams 1962)

II REGIONAL GEOLOGY

Basement rocks in the region consist of metasediments of the Kanmantoo group. To the east they are intruded by the coarse grained Murray Bridge granite and intruded by or transformed into fine grained often gneissic Monarto granite. In places high hills are capped by ferruginous grits and laterites, which are apparently remnants of a late Tertiary peneplain surface. From east of Callington the basement is extensively covered by thin Tertiary and Quaternary deposits. A generalized regional geology is shown on fig. 1.

Kanmantoo Group

(a) Rock Types

The Kanmantoo group rocks are regarded as being of Cambrian age (Sprigg & Campana 1953). The position of and nature of their boundary with the underlying Proterozoic rocks of the Adelaide 'System' is controversial. It is regarded as faulted (Sprigg et al, 1951), unconformable (Campana & Horwitz, 1956 and Horwitz et al, 1959), conformable (Kleeman & Skinner, 1959), and thrust faulted (Kanmantoo thrust west over the Proterozoic) (Rutland 1968). The rocks consist of unfossiliferous mica schists, metasiltstones, micaceous quartzites, several pyritic schist horizons and some arkose near the base of the group to the west. The total thickness, assuming that isoclinal folding is not a complicating factor, is over 40,000 feet.

(b) Metamorphism

Andalusite and some kyanite are commonly developed in the more aluminous rocks, and locally fibrolite or sillimanite is present. Staurolite and almandine garnet are common. Offler (1960) places the rocks in a quartz-staurolite subfacies of the almandine-amphibolite facies.

(c) Structure

The metasediments are both folded and faulted. Folds in bedding exist on all scales of magnitude, and the more pelitic rocks have a well developed axial plane schistosity. This schistosity is folded in some areas as broad folds and in most areas as small scale crenulations. Some of the fabric elements are described in more detail in later sections.

The most prominent faults of the region trend N-S. Some of these form fault scarps and hence were probably active relatively recently, but all may be originally ancient faults.

III LOCAL GEOGRAPHY

1. Topography

The area in which exploration geochemistry was carried out has a maximum relief of about 300 feet. It is dissected by the valley systems of Mount Barker Creek and Scott's Creek, forming rolling hills whose slopes are usually less than 35° but sometimes greater than 55° at meander bends.

2. Degree of Outcrop

Rock exposures along the main valley floors approach about 70% exposure. The slopes and hill crests have only about 20% outcrop, consisting mainly of the more resistant psammitic rock types, or pyritic schists. These pyritic schists, presumably because of released sulphuric acid during weathering, have little overlying vegetation and hence have little organic soil cover. The depth of soil cover on the slopes and hill crests appears to be mainly between 6 and 18 inches. It is residual soil. Colluvium on valley floors is up to 15 feet deep where exposed by erosion. Soil cover increases to 100% and probably attains much greater depths in the southern and north-eastern parts of the area where the land is cropped.

3. Rainfall and Vegetation

The area receives an annual rainfall of 15 inches. Before April 1968 the area had been under drought, but after April to the present time there was much higher than average rainfall. It is unlikely that this would have significantly affected the geochemical dispersion pattern in the drainage systems but most parts of the stream beds became overgrown with grasses and weeds and this made the collecting of sediment samples more difficult.

The area is cleared of timber and, except where cropped, it is grassed for grazing purposes.

4. Morphology of the Drainage Systems

Scott's Creek and Mount Barker Creek are the only streams which flow continuously (or nearly so) throughout the year.

Scott's Creek is flat and swampy. Its channel varies between 15 and 70 feet wide.

Mount Barker Creek is an active stream with a steeper gradient. It is widest at pools and narrowest at riffles, varying from a few feet to 30 feet wide.

The main tributaries to these creeks are unnamed. They flow intermittently after rains and most have eroded gullies in colluvium. These gullies are up to 15 feet deep and 20 feet wide.

Smaller streams extending to the top of the watersheds drain the slopes. They are active only after each rain. In some places their channels are on bedrock and reach a few inches across, elsewhere they are more broad and diffuse and are largely covered by soil and grass.

No apparently permanent springs or seepages were observed, with the possible exception of an area around pyritic schist near sample location no. 82 (see fig. 7). Caked white salts exist in the soil at the edge of the stream here, suggesting that the ground is soggy at least for much of the year. (All ground was soggy at the time of this investigation, so definite conclusions are not possible).

Many streams are oriented approximately north-south, parallel to the trends of bedding and schistosity of the rocks. This control of drainage pattern by structure is especially noticeable in the streams to the south of Mount Barker Creek.

IV LOCAL GEOLOGY

1. Stratigraphy and Petrology

Rocks in the area include interlayered varieties of:

Schistose quartzites

Biotite-muscovite schists

Quartz-feldspar-biotite-garnet schists

Andalusite-(staurolite) schists

Pyritic schists and pyritic schistose quartzites.

The distribution of these rocks has been mapped by Grasso and McManus (1954) and the petrography was described by Herath and Joseph (1954). (The latter thesis could not be found.) They did not recognize pyritic schists as such but mapped them either as iron stained sericite schists or tuff beds.

Distinctive rock types of possible stratigraphic use as marker beds are the andalusite schists and the pyritic schists. Owing to the folded nature of the rocks, sound structural mapping is needed to determine stratigraphic relations accurately.

The mapping of Grasso and McManus shows that the main development of andalusite schists is in a U shaped sector extending northwards from the Aclare Mine. (fig. 2). They interpret this sector as a contact metamorphic zone apparently caused by an underlying granite. Their zone transgresses bedding trends. However thin andalusite schist layers which may persist along stike for several miles are common in other parts of the area and throughout the region (see, for example, Kloeman and Skinner, 1958, p.65). Hence it is most likely that the andalusite schists represent originally more aluminous layers which have been transformed during the same regional metamorphism as that which affected the remainder of the rocks. This immediately casts doubts on Grasso and McManus' map showing the andalusite zone transgressing bedding trends. It may be that it represents an original sedimentary facies change, but in view of the degree of folding of the area it is more likely that it represents a folded andalusite-rich unit.

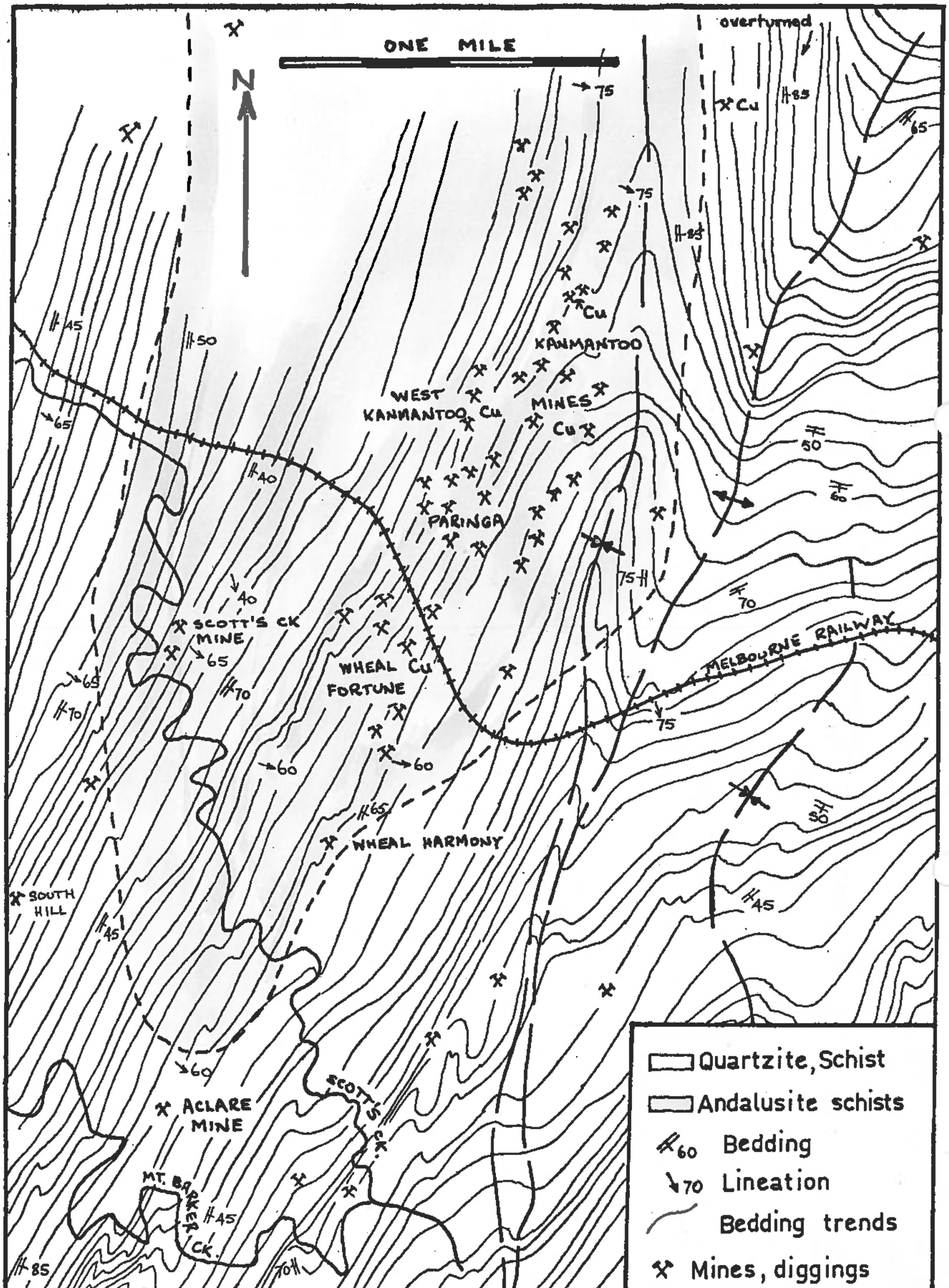


FIG. 2 PORTION OF GEOLOGICAL MAP BY GRASSO & McMANUS 1954

Assuming a southerly plunge, which is common to all observed folds in the area, this would then be a large anticline.

Numerous apparently discontinuous pyritic schist layers are scattered throughout the area. Most vary between 5 and 15 feet in width. The number of separate horizons is not known because of the repetitions caused by folding.

All pyritic schist layers are weathered in outcrop to a leached, sericitic, yellow or red stained rock. Alunite and jarosite are present as a coating in the fine cellular boxwork, or as small cubes apparently pseudomorphing pyrite, or as cross-cutting veinlets. (see X-ray determination, Appendix 9). No fresh sulphides were seen.

2. Structural Elements

(a) Bedding (S_0)

Lithological layers of differing composition, grainsize, and texture occur throughout the area. These vary in size from persistent psammitic rock layers several yards across and clearly visible on the ground and on air-photographs, to layers as fine as 1 mm or less, visible in hand-specimen of more pelitic rock types. Lithological layering in hand-specimen is produced by varying amounts of micas, quartz, garnet and andalusites in each band. This is the first recognizable layering and is regarded as preserved bedding. Andalusite-rich layers and pyritic schist layers are parallel to other layers and so are considered to be beds.

(b) Schistosity (S_1)

Schistosity is defined particularly by the planar preferred orientation of mica plates within the rock. It appears to be parallel to the axial plane surfaces of folds in S_0. It is developed in all rock types, but is most distinct in the more pelitic rock types.

Transposition of S_0 by S_1 has apparently occurred on a small scale in places in the pelitic rocks, (fig. 3).

(c) Crenulations and Kink bands

Crenulations in the schistosity are common. Their amplitude

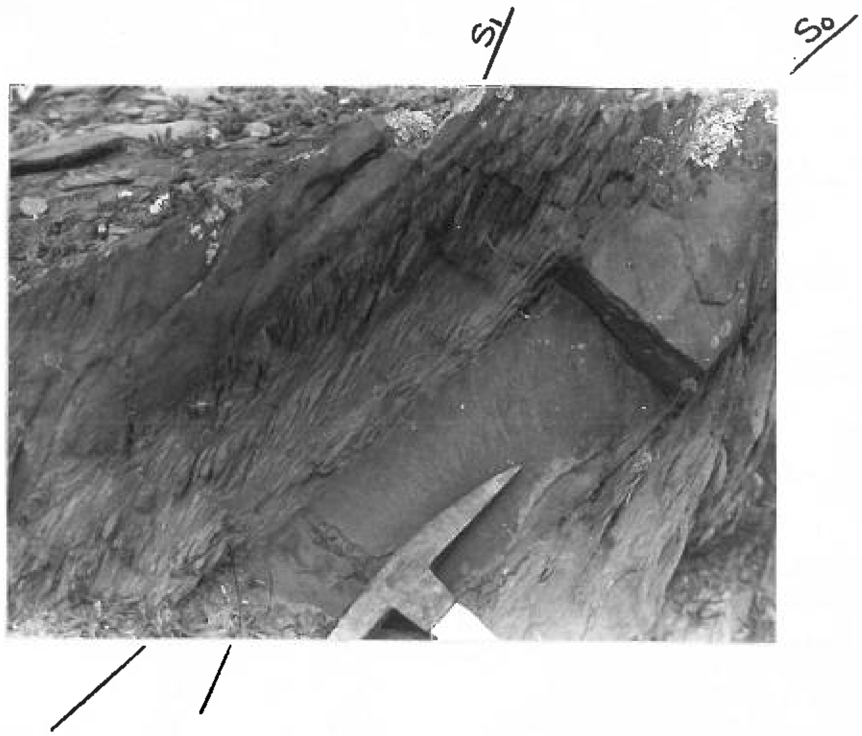


FIG 3

Layer of andalusite schist between two quartzite layers. The quartzite layers define S_0. Small psammitic lenses in the schist lie parallel to the schistosity, S_1, though their gross trend is parallel to S_0. This is apparently small scale transposition by folding of S_0 parallel to S_1.

is usually of the order of 2mm. They define a lineation.

Kink bands are developed in places in the more schistose rocks. The bands are usually less than an inch wide.

(d) Mineral Lineation (L).

This lineation is developed throughout the area in all rocks. It is defined by a preferred orientation of elongate mica grains lying within the schistosity. In many places a crenulation lineation is parallel.

(e) Folds (Fold axes, B)

Except for small crenulations in the schistosity the only folds observed in the area are folds in bedding. They vary in size from large open regional folds traceable on air photographs to small folds of fine bedding layers in hand-specimen. Folds of hand-specimen size were seen in only the more pelitic rock types. They are commonly asymmetrical, tightly appressed and attenuated along one limb, and have the schistosity as axial plane.

(f) Joints, Faults, Quartz veins.

These have had little bearing on this study. Suffice it is to say that quartz veins and blows are common (several supposedly different types of quartz veins are described by Grasso and McManus (1954), and the main joint set is nearly vertical and trends E-W. (See Grasso and McManus (1954)). No major faults have been recognized in the area.

3. Structural Geometry

A. Kirk in 1964 commenced, but did not complete, an investigation of the structure of the area. His measurements of bedding, schistosity, lineation, fold axes, and schistosity-bedding intersections were plotted (fig. 4d).

Schistosity S_1 has a fairly constant orientation with an average dip of 50° towards 120° (true). It is obvious from the diagram that over much of the area bedding (S_0) parallels schistosity (S_1). Measured fold axes are distributed within the schistosity and have a plunge varying from nearly horizontal south to about 55° east. S_0-S_1 intersections are similarly distributed. A constant feature is the lineation which lies down dip on the schistosity; it has a plunge of 50° towards 115°.

Observed and measured crenulation lineations around the Aclare Mine, and those measured by A. Kirk over the entire area have varying orientations. They lie within the schistosity and have varying plunges to the south-east. Observed Kink bands have a variable but fairly flat orientation.

The various structural elements around and in the Aclare Mine, around the Scott's Creek Mine and around the anomalous pyritic schist horizon, were measured (Fig. 4 a, b, c). Their geometry is equivalent to those measured by A. Kirk. For comparison Fig. 5 shows measurements taken by Lindqvist (1966) around the Kanmantoo Mines. Their geometry is also equivalent.

Figure 4.

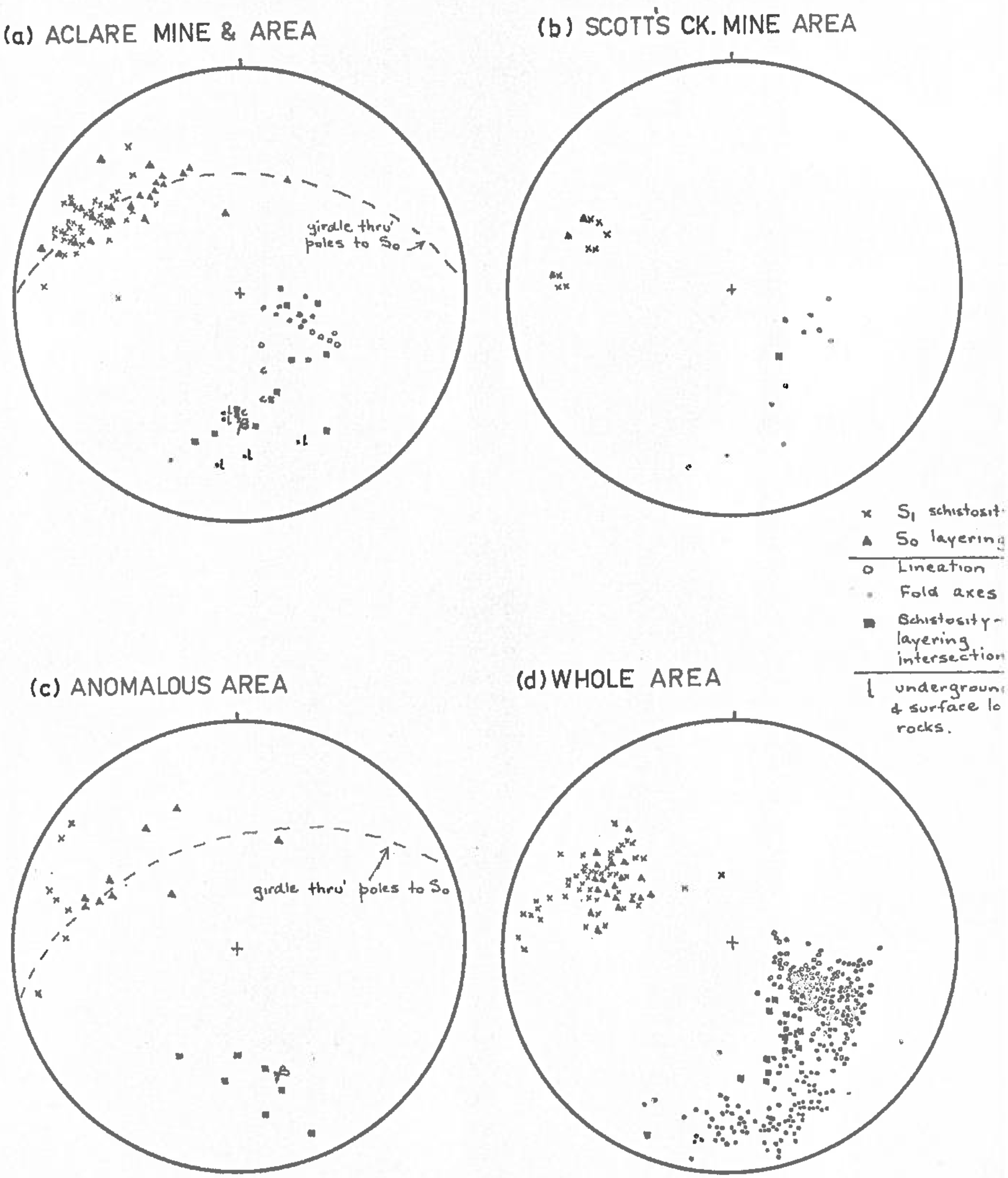
Equal area plots of poles to layering (bedding), S_0, poles to schistosity, S_1, mineral lineations, fold axes.

(a) measured in the Aclare Mine and surrounding the mine

(b) measured around Scott's Creek Mine.

(c) measured around the geochemically anomalous area associated with pyritic schists (for location see figs. 7+16.

(d) measurements taken over whole area by A. KIRK.



(a) ACLARE MINE & AREA
girdle thru' poles to So
(b) SCOTT'S CK. MINE AREA
(c) ANOMALOUS AREA
girdle thru' poles to So
(d) WHOLE AREA
S1 schistosit
So layering
Lineation
Fold axes
Schistosity-layering intersection
underground & surface lo rocks.

FIG. 4

Figure 5.

Measurements of Lindqvist (1967), Kanmantoo Mine area.

(a) Equal area plot of 105 S_0 (bedding) poles outside the mine area. The girdle defines a statistical fold axis, β Contours are 1%, 3%, 5%, and 7% per 1% area.

(b) Equal area plot of 150 poles to S_1 (axial plane schistosity) for the whole area. Contours are 1%, 5%, 20%, and 50% per 1% area.

(c) 41 mesoscopic fold axes from the whole area, distributed within S_1. Contours are 2%, 6%, 10%, per 1% area.

(d) 47 mineral lineations and fine crenulations on the schistosity. Contours are 2%, 17%, 35%, and 50% per 1% area.

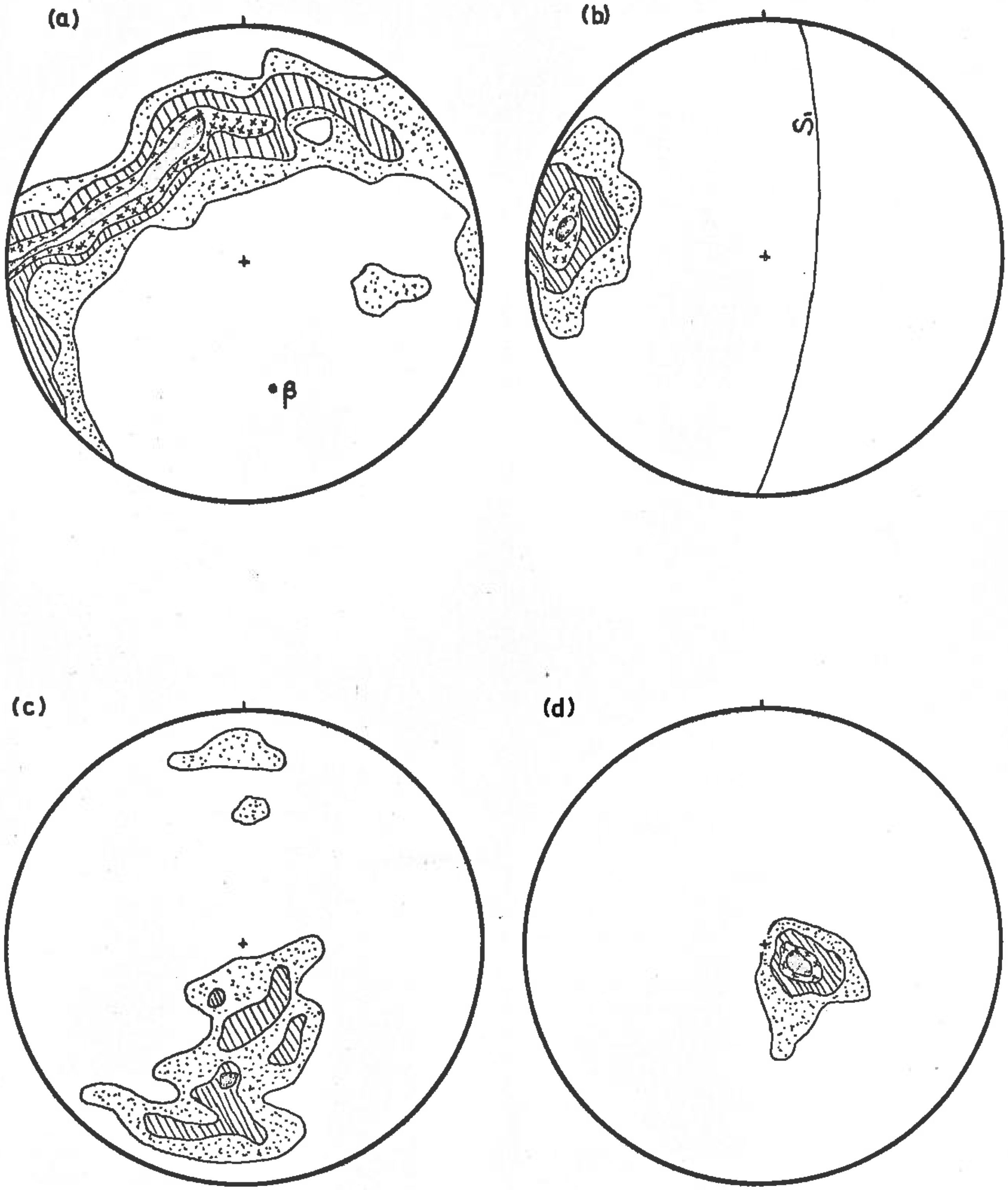


FIG.5

V GEOCHEMICAL EXPLORATION

1. Introduction

Scattered abandoned Pb-Zn-Ag and Cu mines and prospects occur in the area. Hence the exploration was directed at Pb, Zn and Cu by analysing for these metals. Arsenopyrite is common to most ore types, hence As was considered as a useful pathfinder element, but suitable analytical equipment was not available.

Samples were collected in the field between March and August 1968. Preparation of samples for analysis, and analyses, were performed in the laboratory.

Previous geochemical exploration in the region has been by the South Australian Department of Mines and by Mines Exploration Pty. Ltd. The Department of Mines commenced a regional geochemical survey several years ago. They completed a traverse collecting rock chips through the Kanmantoo Group along Mount Barker Creek (Fig. 6). The most significant high values occur with Pb, Zn, and Cu associated with pyritic rocks lying in the folded rocks in the central part of the sketch section. They also collected rock chip samples scattered along the strike length of the Nairne pyrite members. Several zones of higher than average Cu values were found.

Marshall (1961) collected soil samples in one traverse across the Nairne Pyrite horizon, and analysed for Cu, Pb, Zn, and Ni. Highest values for these metals were found associated with the pyrite horizon. The Department of Mines ceased their geochemical program when Mines Exploration Pty. Ltd. took out an Authority to Enter in the Kanmantoo area. Mines Exploration Pty. Ltd. have taken augered soil samples in a grid system over South Hill (for locality see fig. 7) as part of their exploration for Cu. This outlined an anomalous zone which they tested by diamond drilling, but no significant widths or grades of mineralization were intersected. Because of contamination from old mine workings their surface geochemical work was not successful around the Kanmantoo mines

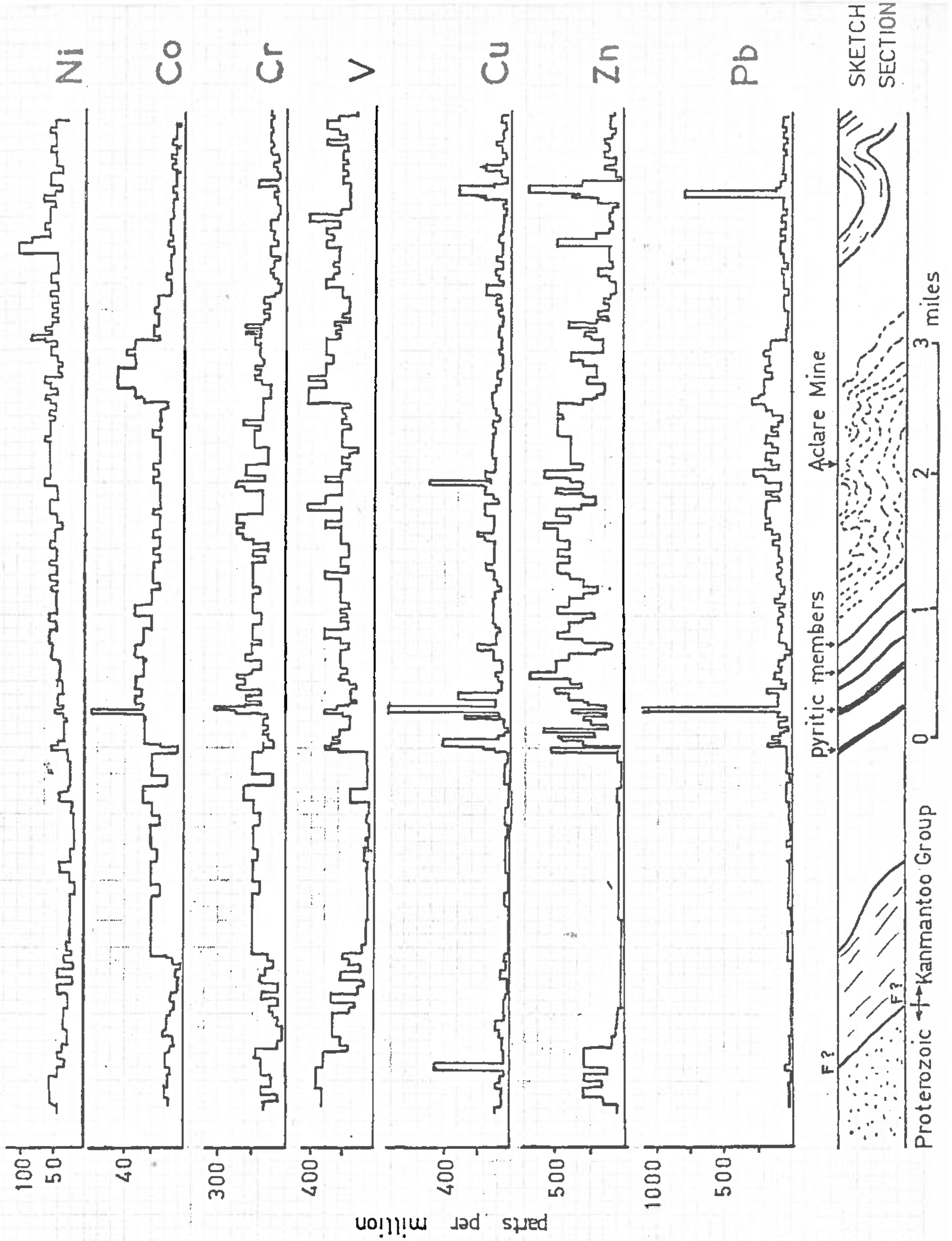


FIG. 6

REGIONAL GEOCHEMICAL TRAVERSE - ROCK CHIPS ALONG MT. BARKER CREEK - source , B.P.Thomson, S.A.Dept. Mines.

2. Orientation Survey

The investigation commenced with an orientation survey. This was to firstly determine the best suited type of exploration method and then to determine the optimum sampling spacing, the optimum mesh fractions for analysis, and the optimum analytical technique.

The air photographs of the region showed that the area was dissected by numerous streams. The watershed of the Kanmantoo Mines, a major source of stream contamination, (experienced by Mines Exploration Pty. Ltd.) lies to the north of, and separate from, the drainage systems around the Aclare Mine. Contamination from the Aclare Mine was likely to have been confined to the downstream parts of Scott's Creek and Mount Barker Creek. The area showed no evidence of transported, especially wind blown, soils. Considering all these factors, the most logical primary geochemical exploration method was stream sediment sampling. This had not been previously attempted anywhere in the area.

To study the dispersion of Pb and Zn and also Cu, for orientation purposes, samples were collected at regular intervals in Mount Barker Creek draining the known Pb-Zn mineralization at the Aclare Mine, and in the creek draining the known Cu mineralization at South Hill (fig. 7).

Sampling

The Pb-Zn dispersion:-

Samples were collected at intervals of about 200 feet (fig. 7). Where possible only active stream sediment (i.e. from within the flowing stream) was collected. Most samples were composite, from the full width of the creek bed.

The Cu dispersion:-

Here samples were collected at about 500 feet intervals. They were composite samples scooped from within the stream channel at several points. Organic-rich patches, for example associated with semi-stagnant pools, were, if possible, avoided.

Sieving and Analysis

Each sample was sieved into the following mesh fractions (British Standard Sieve Size):-

1.	- 14+ 44	(-1.20 mm+0.36 mm)
2.	- 44+ 75	(-0.36 mm+0.22 mm)
3.	- 75+140	(-0.22 mm+0.12 mm)
4.	-140+220	(-0.12 mm+0.065mm)
5.	-220	(-0.065mm)

Two methods of acid extraction were used on each fraction:-

1. Cold 1.0M HNO_3. One gram of soil, added 10.0ml. of acid, left 24 hours, shaken twice during the 24 hours; analysed.
2. Hot 25% HNO_3. One gram of soil, added 5.0ml. acid, heated over steam bath for one hour, cooled overnight, made up to 10.0ml. with distilled water; analysed.

Each solution was then analysed separately for Pb, Zn and Cu, using the AA-100 Atomic Absorption Spectrophotometer.

Results

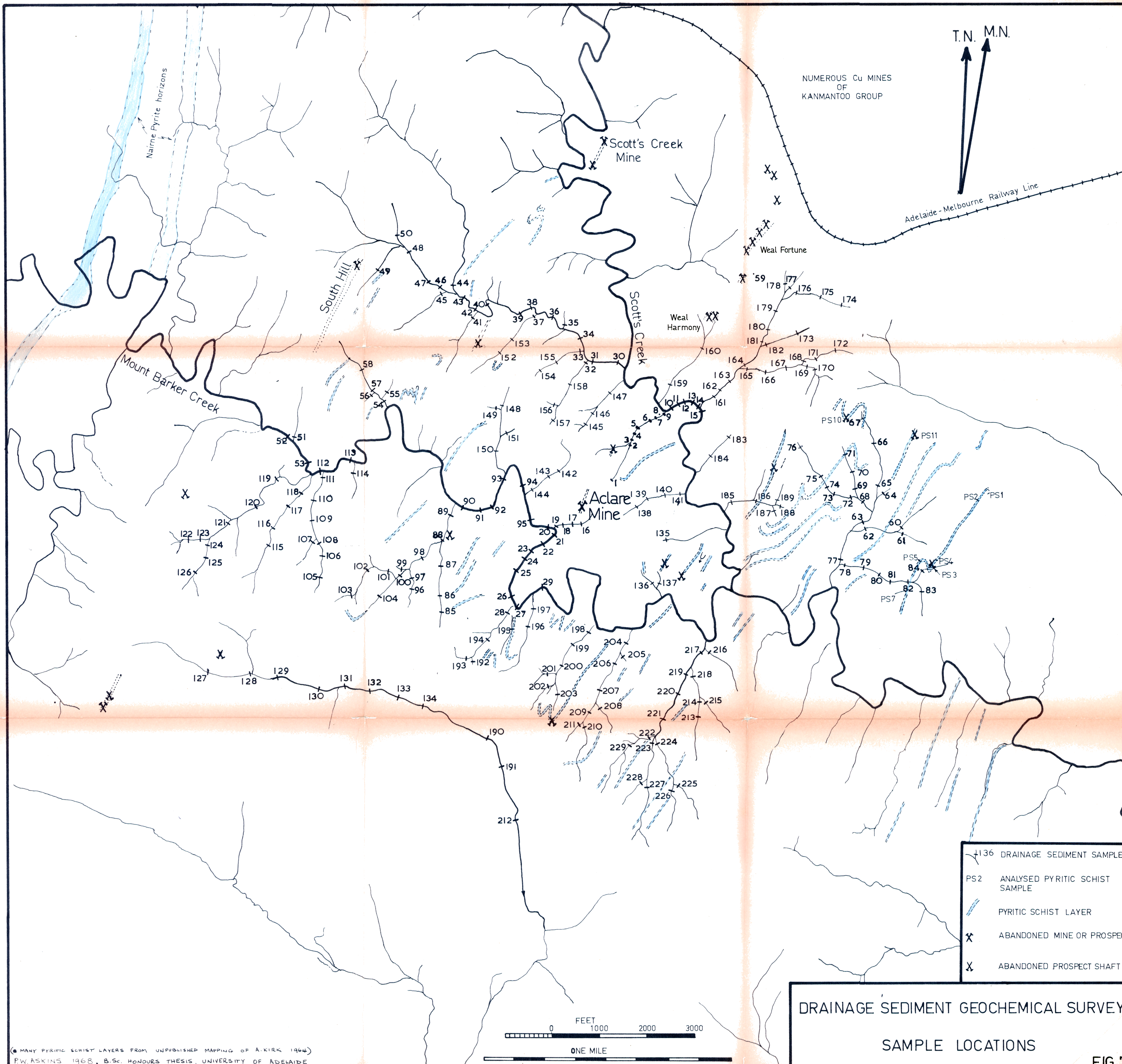
Results of the orientation survey are tabulated as Appendix 1 and 2. Many of the values for hot acid exceed double those for cold acid extraction. The Pb and Zn decay from the Aclare Mine is shown, for the various fractions, diagrammatically in figs. 11 and 12.

Several water samples were collected from Mount Barker Creek, but even when concentrated by evaporation to $\frac{1}{4}$ volume, they contained immeasurable quantities of Pb, Zn, Cu, Ag.

Discussion of Results

An aim of the analytical method in geochemical exploration is to obtain the greatest contrast between background and anomalous values, so that the likelihood of missing anomalous ground is reduced. (Hawkes & Webb, 1962) and (Langford, 1965):

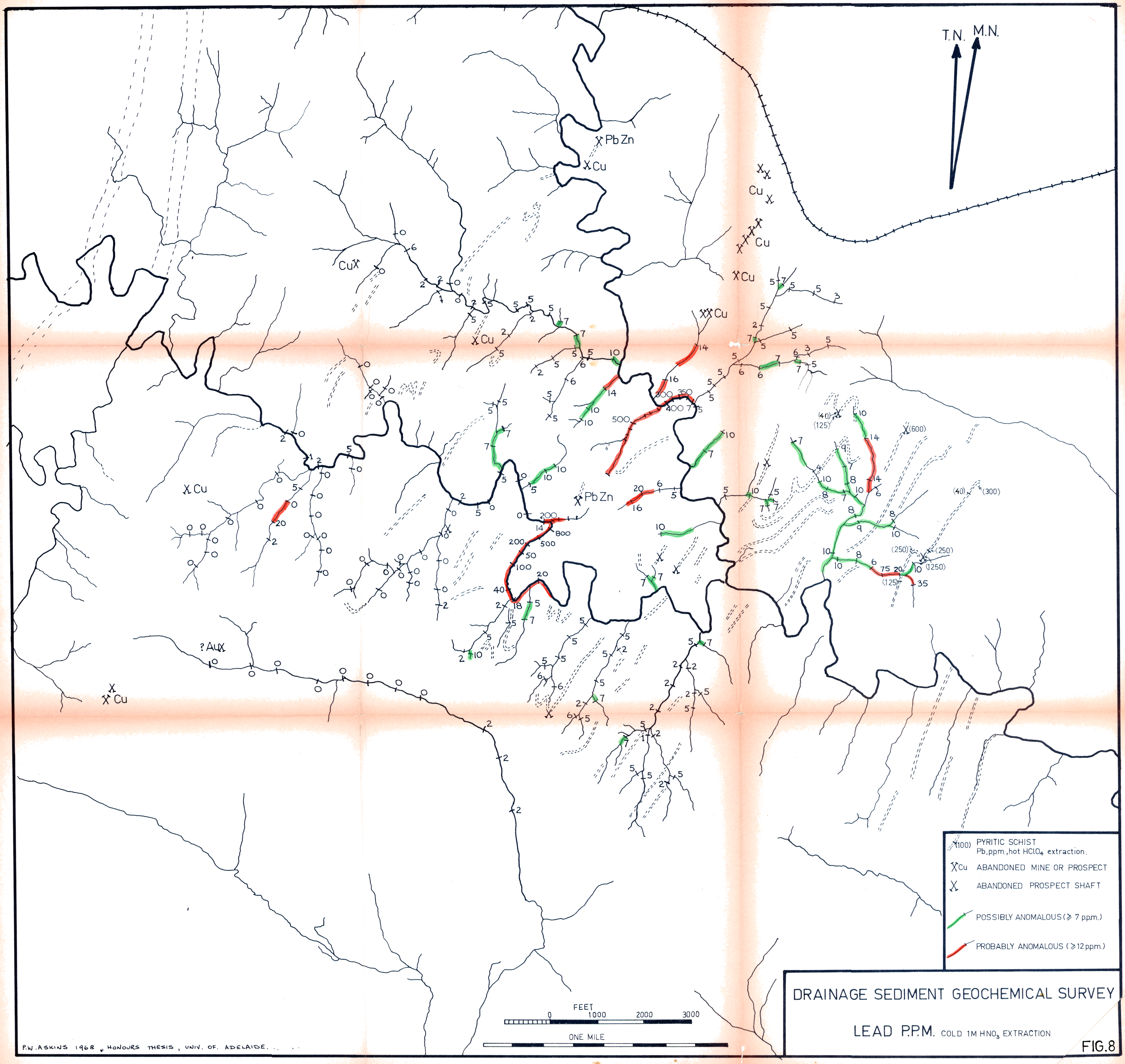
The Pb-Zn dispersion: Table 1 tabulates the contrast (ratio of anomalous to background) for each mesh fraction and for both the hot and cold acid extractions (referred to for convenience as



DRAINAGE SEDIMENT GEOCHEMICAL SURVEY

SAMPLE LOCATIONS

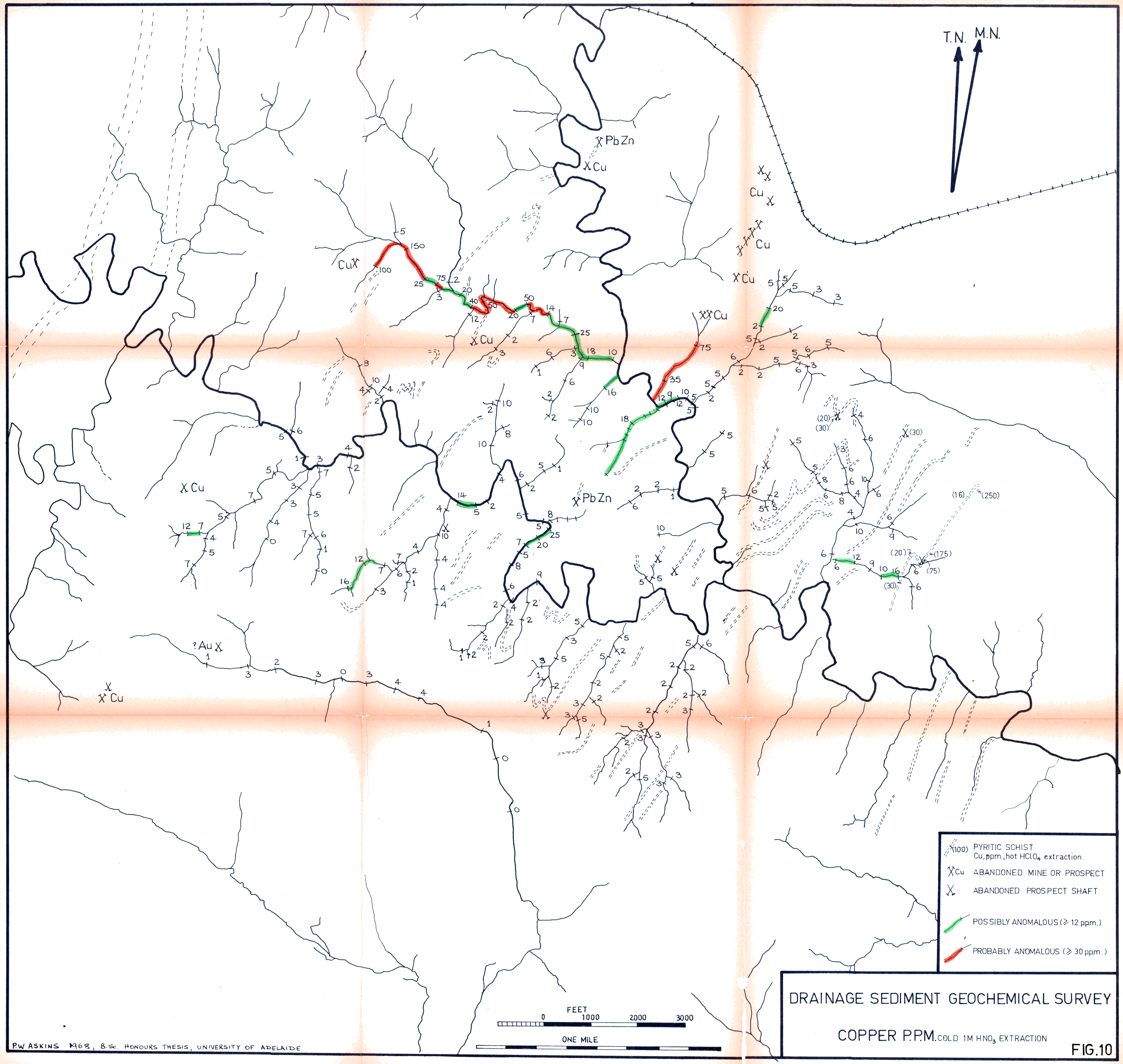
FIG. 7



DRAINAGE SEDIMENT GEOCHEMICAL SURVEY

LEAD P.P.M. COLD 1M HNO_3 EXTRACTION

FIG. 8



DRAINAGE SEDIMENT GEOCHEMICAL SURVEY

COPPER P.P.M. COLD 1M HNO_3 EXTRACTION

FIG.10

P.W. ASKINS 1968, B.Sc. HONOURS THESIS, UNIVERSITY OF ADELAIDE

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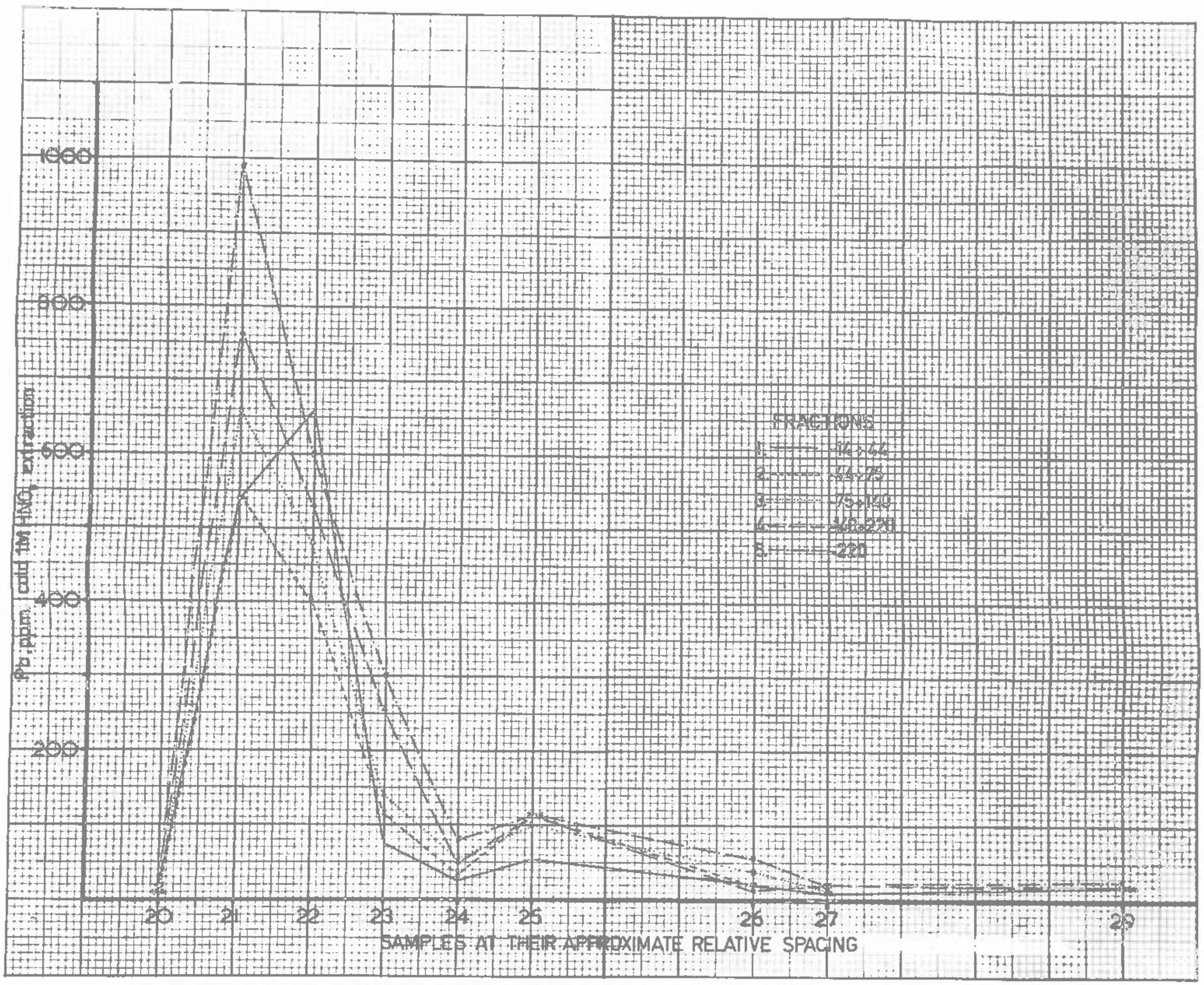

FIG.11 Pb DECAY CURVES OF VARIOUS FRACTIONS MT. BARKER CK. DOWNSTREAM FROM ACLARE MINE

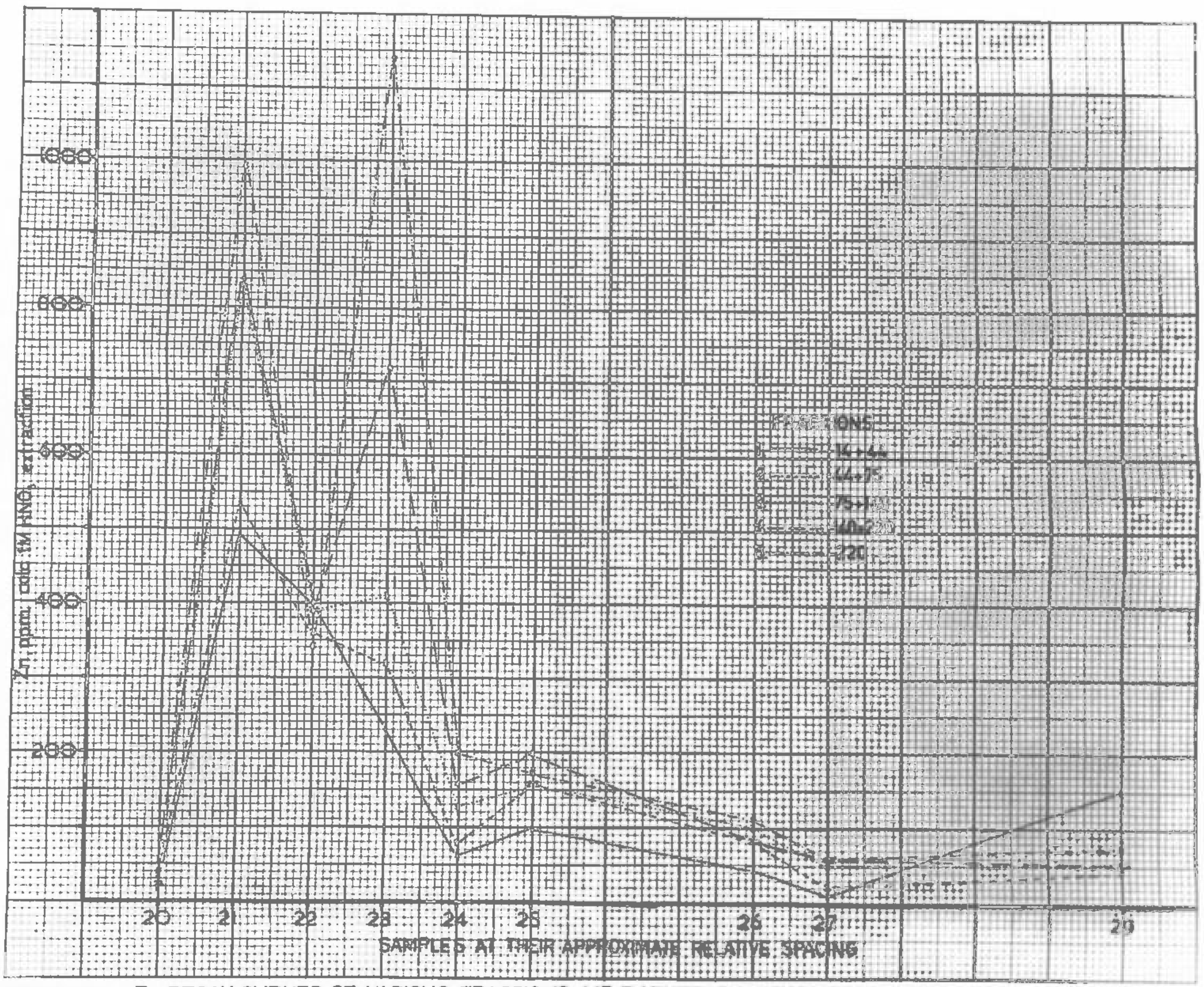

FIG.12 Zn DECAY CURVES OF VARIOUS FRACTIONS, MT. BARKER CK. DOWNSTREAM FROM ACLARE MINE

hx and cx - though cold 1.0M HNO_3 is too strong an acid to be regarded in the normal geochemical sense as cx. Weaker acids were not practicable in this survey, because, especially for Pb, most values would be below or near the analytical detection limit.) Background was taken to be the values at locations 20 and 29 and anomalous was taken at the not too extreme but moderate value at location 24.

The greatest contrast exists in the (-75+140) mesh fraction. This is consistent with results found in many other areas, (see for example Hawkes & Webb, 1962, p.257). There is little contrast difference between the cx and hx methods.

The Cu dispersion: Table 2 tabulates contrasts similar to Table 1. Here background was taken to be the low value at location 30 and anomalous was taken to be the moderate value at location 48. Greatest contrast is obtained in the -220 mesh fraction, and in the cx method.

Rather than separate the (-75+140) and (-220) mesh fractions for each sample to determine Pb, Zn and Cu on the respective fractions, it was decided to take the whole -75 mesh fraction and analyse its content of all three metals. Tables 1 and 2 show that there is little or no loss of contrast for the -75 mesh fraction.

Since cx methods are less time consuming than hx methods, and since the cx method gives greater contrast for Cu, it was decided to use cx as the standard procedure in the rest of the survey.

Decay distances (distance from anomalous to background) are in excess of 1,000 feet for all metals. Hence a sampling interval of about 500 feet was decided on as the standard procedure. With this spacing a drainage-sediment anomaly should be covered at least once, and probably twice.

3. Interpretation of mode of occurrence of anomalies and decay pattern

The ratio of cold extracted metal to total metal is a method of ascertaining whether the anomalous material is of residual

TABLE 1

	Size Fraction	Weight percent -75 fraction		cx			hx		
		Sample 20	Sample 24	p.p.m. 20 (background)	p.p.m. 24 (anomalous)	CONTRAST 24/20	p.p.m. 20 (background)	p.p.m. 24 (anomalous)	CONTRAST 24/20
Pb	- 14+ 44			10	27	2.7	15	34	2.3
	- 44+ 75			7	37	5.3	14	49	3.5
	- 75+140	52.8	47.6	10	55	5.5	17	70	4.1
	-140+220	18.4	20.8	20	50	2.5	30	77	2.6
	-220	28.8	31.6	22	80	3.6	34	147	4.3
	- 75			15	61	4.0	24	95	4.0
Zn	- 14+ 44			17	65	3.8	32	91	2.8
	- 44+ 75			18	77	4.3	36	119	3.3
	- 75+140			20	117	5.9	34	172	5.0
	-140+220			30	157	5.2	61	251	4.1
	-220			37	205	5.5	78	359	4.6
	- 75			26	154	5.8	50	248	5.0

TABLE 2

	Size Fraction	Weight percent -75 fraction		cx			hx		
		Sample 30	Sample 48	p.p.m. 30 (background)	p.p.m. 48 (anomalous)	CONTRAST 48/30	p.p.m. 30 (background)	p.p.m. 48 (anomalous)	CONTRAST 48/30
Cu	- 14+ 44			6	240	40	22	330	15
	- 44+ 75			13	200	15.4	37	232	6.3
	- 75+140	34.0	67.5	10	128	12.8	41	168	4.1
	-140+220	36.2	18.4	9	156	17.3	39	240	6.2
	-220	29.8	14.1	11	282	25.6	42	340	8.1
	- 75			11	156	14.2	40	205	5.1

origin or precipitated from aqueous solution onto, or adsorbed onto, the surface of clastic fragments. (Hawkes & Webb, 1962, p.255). However cold 1M HNO_3 used in this survey is too strong to be regarded as a normal cold extraction reagent because it is strong enough to remove some lattice held metal, as well as adsorbed or precipitated material. Therefore cx:hx metal ratios cannot be used to ascertain the nature of the anomalous material.

There is acid leaching of the surface downslope from the Aclare Mine, suggesting that much metal is carried into Mount Barker Creek in solution. This in turn suggests that much of the metal in the sediment is adsorbed or precipitated.

The highest values for Zn are not only <u>at</u> the point of discharge into Mount Barker Creek but also 800 feet downstream at location 23 (fig. 12). A possible explanation for this phenomenon, if it is not simply one of sampling error, is that the first peak represents largely detrital Zn minerals, and the second peak represents precipitated Zn minerals formed after thorough mixing of the acidic metal bearing solutions with neutral creek waters.

4. <u>Main Survey</u>

.1 <u>General</u>: After completion of the orientation survey, rains had caused Scott's Creek and Mount Barker Creek to flood. For this reason Mount Barker Creek was sampled only sporadically and Scott's Creek not at all. (Scott's Creek would not have been sampled even so because of its broad swampy nature, making samples difficult to collect and any dispersion patterns difficult to interpret.)

The distribution of all sample points is shown on fig. 7 (in pocket).

Most samples collected were wet. Where possible active sediment was collected, but in some places (usually because of the restrictions caused by overgrowth of grasses and weeds) the sediment was largely colluvium, bank material, or soil from the A-horizon. Pertinent features such as these were noted and are presented in Appendix 3.

Samples were dried, then sieved and analysed using the optimum method determined from the orientation survey.

.2 <u>Results</u>: Analysed values are tabulated in Appendix 3. Separate plans with the distribution of values of Pb, of Zn and of Cu are figs. 8, 9 and 10 respectively (folded, in pocket).

All values were plotted on histograms of number of samples vs. log concentration. Treating these separately:-

<u>Pb</u> (fig. 13) Values below 5 p.p.m. are irregular because they are below the analytical detection limit. The average of determined values below 5 p.p.m. is therefore shown dotted.

For a single population of values that are distributed symmetrically, it is conventional to take possibly-anomalous values as between 2 and 3 standard deviations above the mean and probably-anomalous values as greater than 3 standard deviations (Hawkes & Webb, 1962, p.30). Subjective visual estimation of these values on the histogram is 7 and 12 p.p.m. respectively.

<u>Zn</u> (fig. 14) This diagram, though a log-normal plot is markedly skewed, therefore calculated values of standard deviation are of little use in determining possibly and probably-anomalous values. These have again been determined visually and are 10 p.p.m. and 20 p.p.m. respectively.

<u>Cu</u> (fig. 15) This histogram is symmetrical for the lower background values, and hence the standard deviation could be readily calculated. However in keeping with the Pb and Zn systems, the possibly and probably-anomalous values were estimated visually. They are 12 and 30 p.p.m.

.3 <u>The Anomalies</u>: Anomalous samples were reanalysed to check possible gross analytical errors. These are tabulated in Appendix 3.

A few anomalous areas were discovered:

Contamination Anomalies: An anomalous zone especially of Pb and Zn surrounds the Aclare Mine. This is probably due to contamination from the mine workings from old tracks or from wind blown dump material.

Significant Anomalies: <u>Cu</u>. Several recurrent Cu anomalies occur along the creek draining South Hill (fig. 7). This creek was

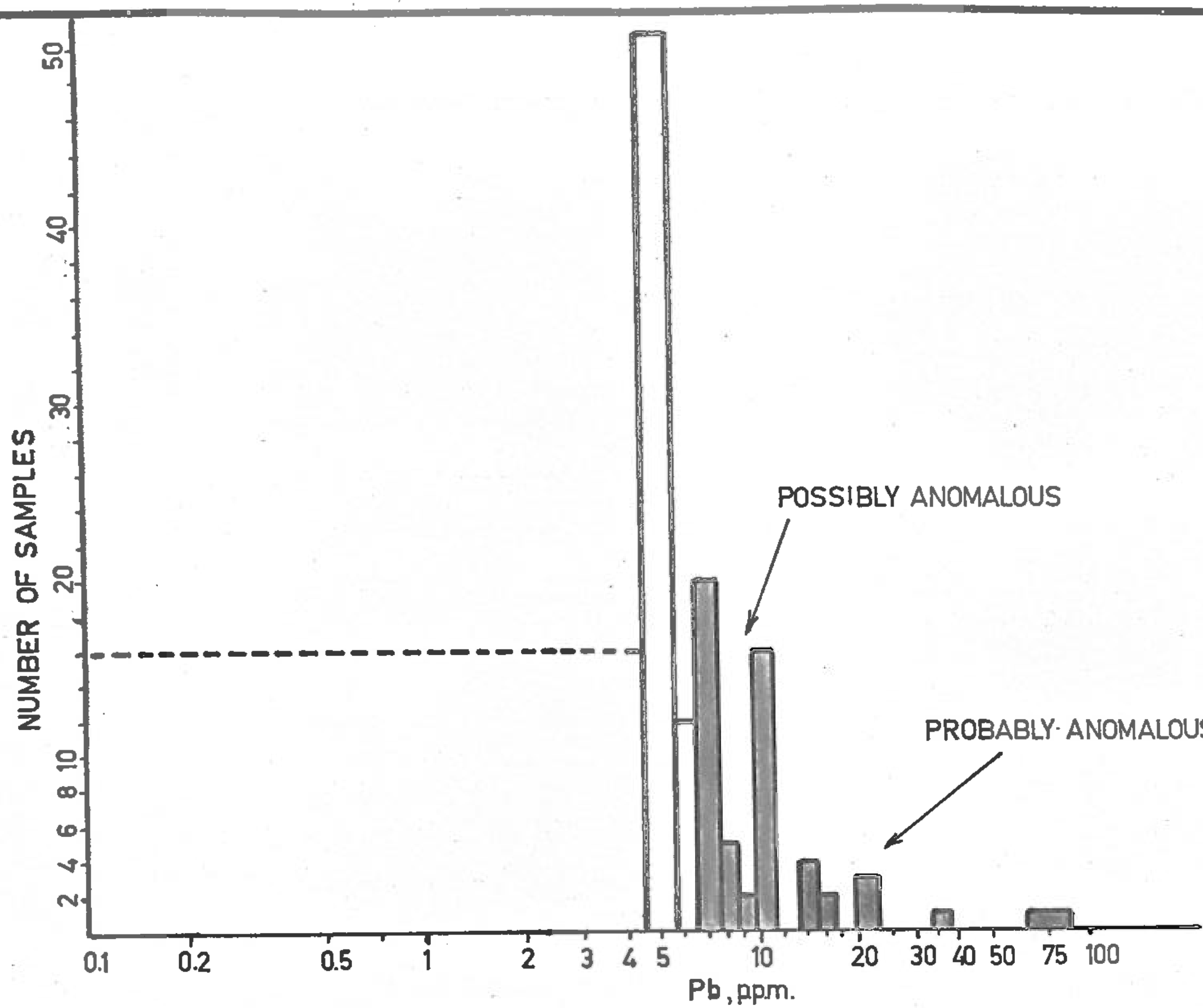

FIG.13 FREQUENCY DISTRIBUTION OF Pb OF 200 SAMPLES COLD 1M HNO_3 EXTRACTION

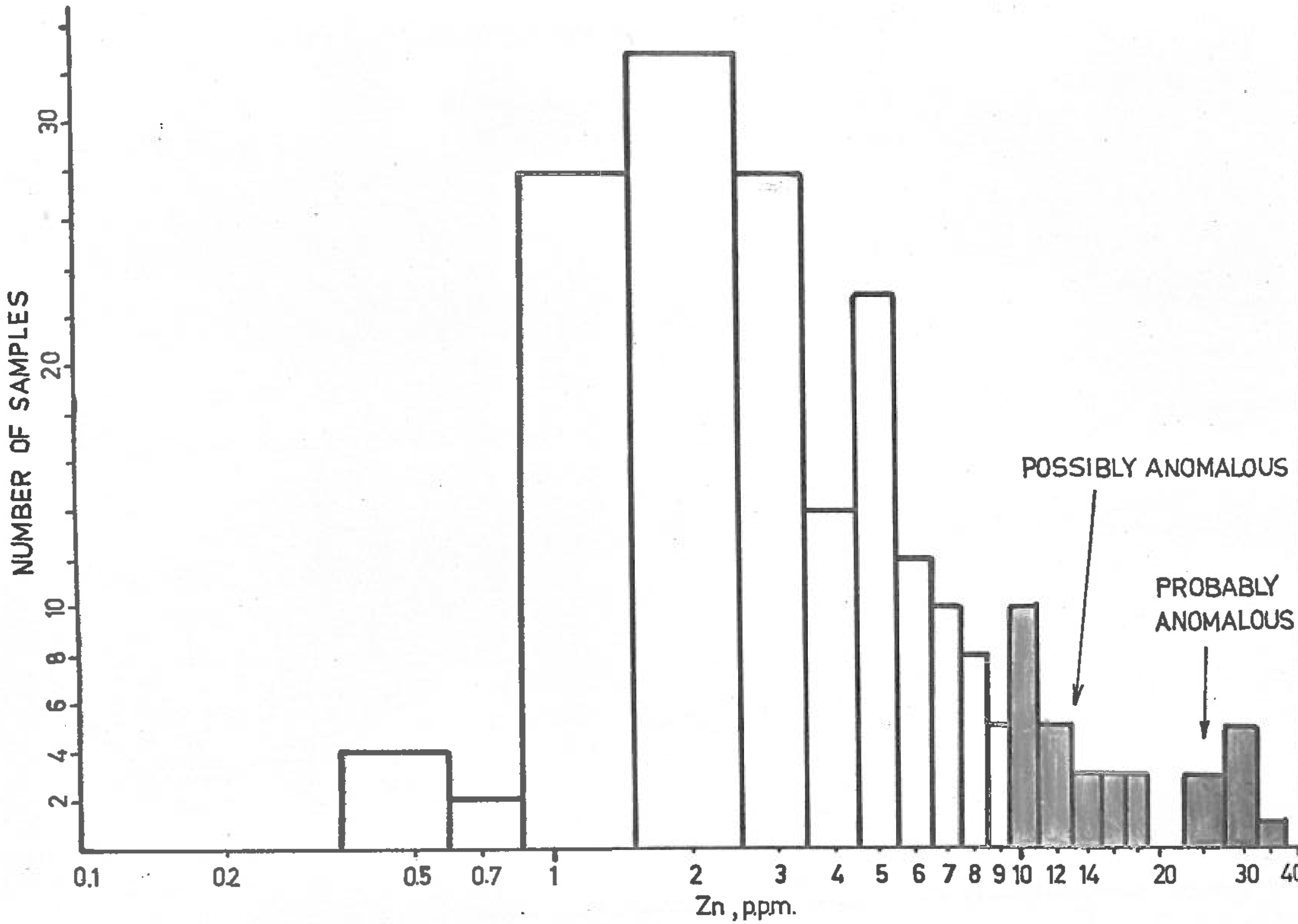

FIG.14 FREQUENCY DISTRIBUTION OF Zn OF 200 SAMPLES COLD 1M HNO_3 EXTRACTION

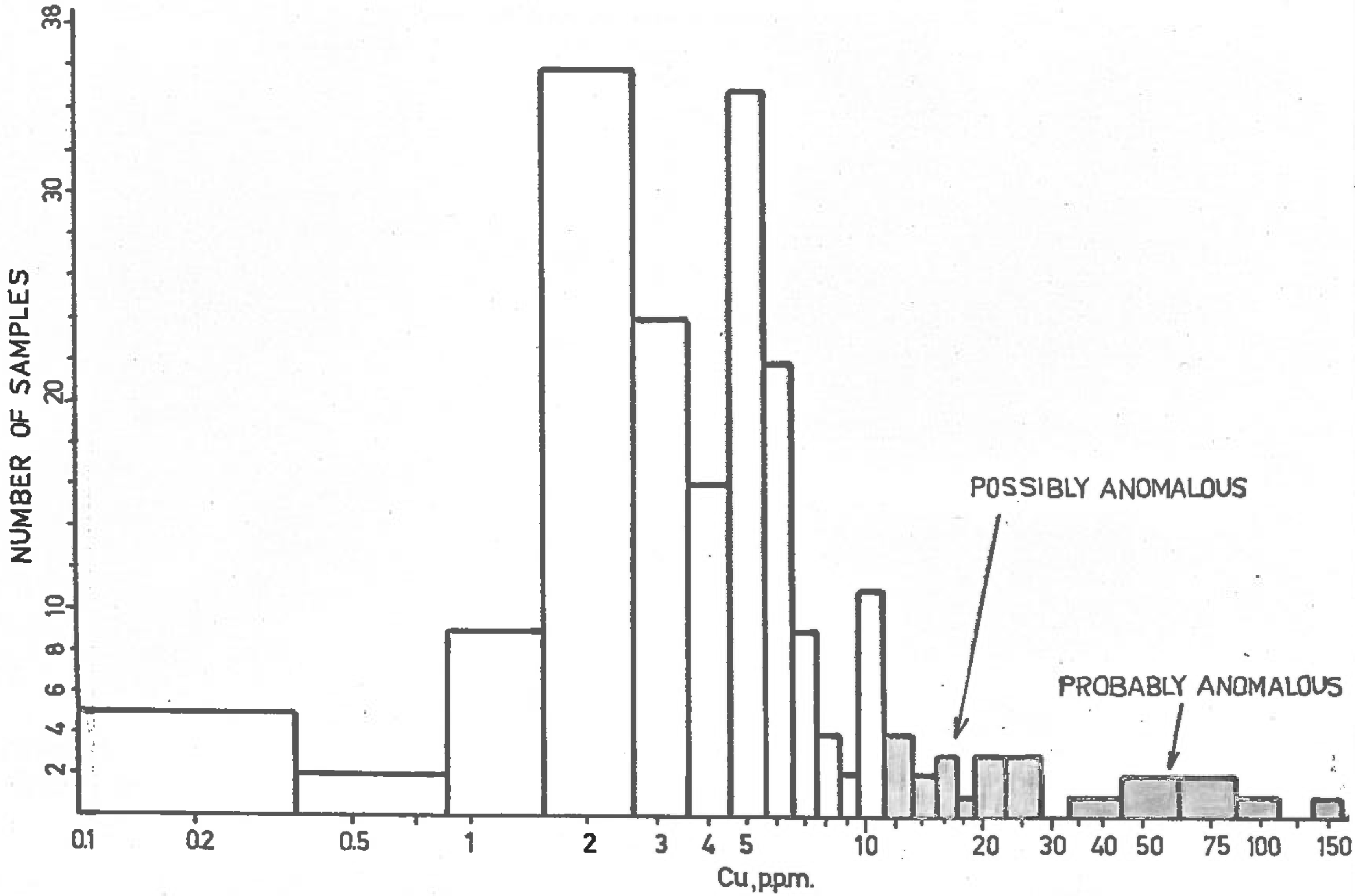

FIG.15 FREQUENCY DISTRIBUTION OF Cu OF 200 SAMPLES COLD 1M HNO_3 EXTRACTION

used in the orientation survey for copper. The recurrent anomalies are possibly due to several copper bearing rock units crossing or occurring near the creek. These may be a single folded unit and/or distinct units. An old shallow prospect shaft in azurite and malachite-stained schist occurs near sample location 41.

Sample locations 159 and 160 are down-drainage from the Wheal Harmony mines, which have azurite and malachite stained andalusite schist scattered at the surface. (Here also the zinc spinel, gahnite, occurs in quartz veins outcropping at the surface.)

Except for sample number 122 which is near a copper propect shaft, the other possible anomalies have unknown causes and therefore need further investigation.

Zn Anomalous values lie along Mount Barker Creek upstream of the Aclare Mine. These are probably due to the Nairne pyrite horizons upstream, but this needs verification. Possibly-anomalous values recur along the creek draining South Hill. These roughly correlate with the recurrent copper anomalies. Several other scattered possibly anomalous values have unknown causes. The most significant anomaly, however, lies to the east around sample localities 79-82. This anomaly is coincident with the lead anomaly described below.

Pb Several isolated anomalous values are scattered over the area. These are uninvestigated.

A large anomalous zone lies to the east. This was of sufficient scope to warrant further investigation, so samples 79 to 84, where there is a coincident Zn anomaly, were resampled and analysed. (See sketch, fig. 16). The re-samples were still anomalous, though of lesser values quantitatively. There is a clear association of anomalies with pyritic schist layers which are common in this area. Therefore in several places these pyritic schists were chip sampled across their width (usually 5 to 10 feet) and analysed for total metal by hot 60% perchloric acid extraction. Values are shown on figs. 8, 9 and 10 and Appendix 4. They range from 50 to 1250 p.p.m. Pb. PS 3 (1250 p.p.m.) is a chip sample from the full exposed width in an exploratory pit and PS 10 and PS 11

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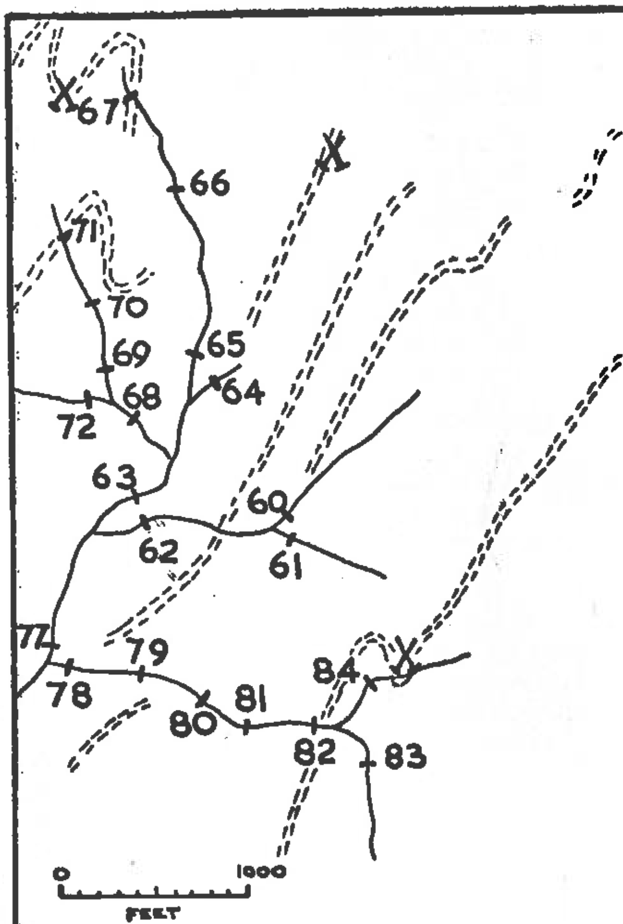
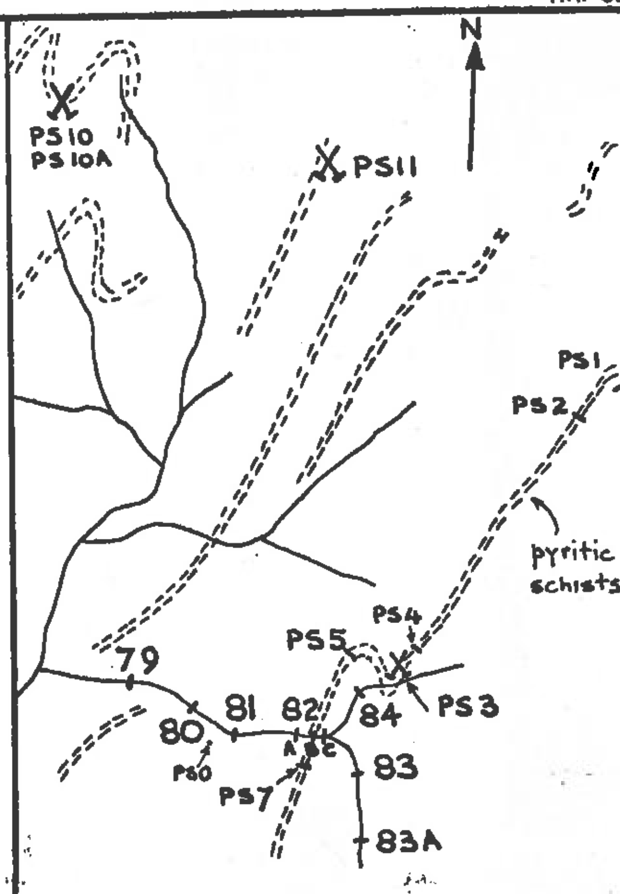


ORIGINAL SAMPLES

Sample Number	Pb ppm	Zn ppm	Cu ppm
79	8(10)	12(9)	12(8)
80	6(4)	14(12)	9(9)
81	75(50)	18(16)	10(9)
82	20(10)	30(30)	16(10)
83	35(25)	5(7)	6(5)
84	10	9	6

Figures in brackets are repeat analyses.



SUBSEQUENT SAMPLES

Sample Number	Pb ppm	Zn ppm	Cu ppm
79	4	9	6
80	10	16	10
81	14	30	12
82A	16	16	10
82B	75	14	18
82C	20	10	5
83	12	7	3
83A	14	3	6
84	5	12	4

(Metal contents of pyritic schists in Appendix 4.)

FIG.16 ANOMALOUS AREA ASSOCIATED WITH PYRITIC SCHISTS.

(fig. 17) are gossanous specimens from dump material of two old prospect shafts. These Pb contents of schist and gossan are not high but could be expected to be low because of the intense surface leaching which the pyritic schists have undergone.

.4 <u>Discussion of anomalous zone</u>: The pyritic schists are most probably the source of metals detected in the stream sediments. The anomalies are probably hydromorphic in origin, i.e. metal dissolved and transported in ground water and then deposited by precipitation and adsorption on stream sediment. There is evidence that a spring exists around location 82 (see Local Geography page 5).

Trace element contents of fresh pyritic layers at the Nairne Pyrite deposit at Brukunga are quoted by Mirams, 1965:-

Unit Sampled	No. of Samples	Pb p.p.m.	Zn p.p.m.	Cu p.p.m.	Ag p.p.m.
Wallrock (hangingwall)	3	15	160	50	1
'Orebed 1'	14	540	4250	530	2
'Waste bed A'	5	40	530	620	1
'Orebed 2'	8	700	6200	700	4
'Waste bed B'	7	120	2600	760	2
'Orebed 3' (at Hangingwall)	10	600	3600	450	3
Wallrock (footwall)	4	60	100	15	1

The minerals containing these metals are mainly galena, sphalerite, and chalcopyrite.

It is perhaps significant that metal contents of the schists and gossans are approximately equal to or even greater than the content in fresh pyritic layers at Nairne. If in fact the schists and gossans are leached of Pb, Zn and Cu, then the original rock must have a higher content of these metals than do the Nairne pyrite horizons. Clearly, therefore, this area is a likely area for ore search, by more detailed geological mapping, and then possibly geochemical exploration by patterned soil auger sampling, geophysical

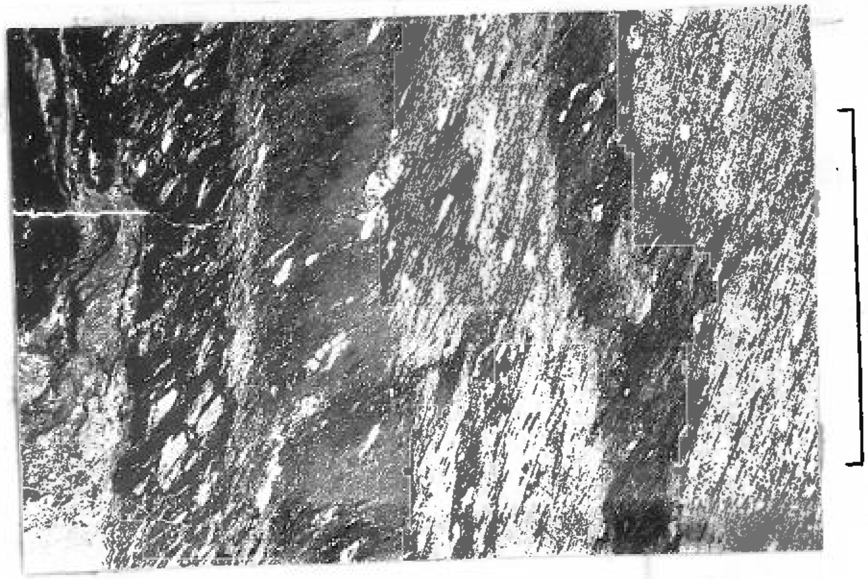
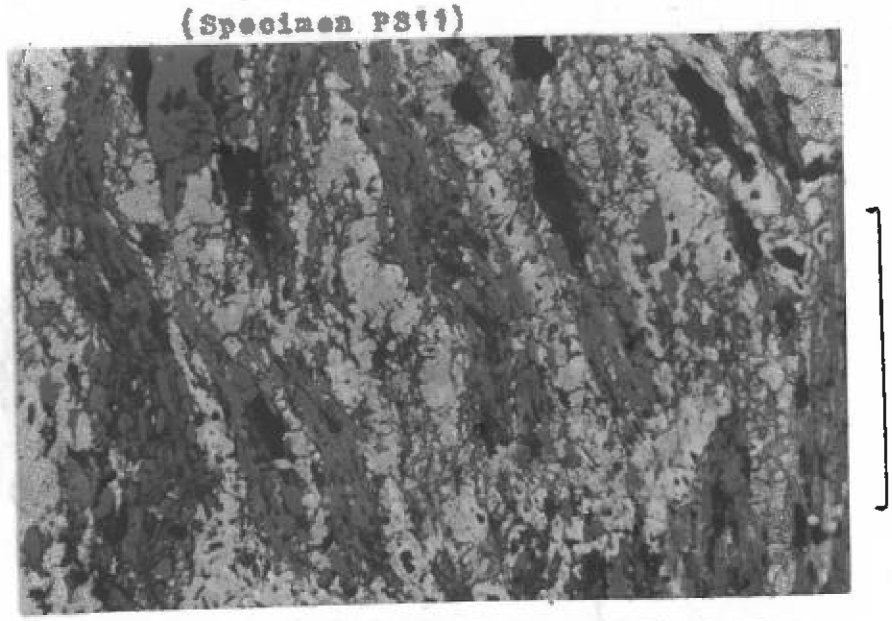


FIG 17. Pyritic schist with gossanous layers (?possibly parallel to bedding, S_0) trending across schistosity, S_1. The darker layers are richer in goethite, the lighter ones richer in alunite + jarosite. Ordinary, transmitted light.

(Specimen PS11)



Closer view of part of the central gossan layer. The lightest coloured material is goethite, remainder is quartz and mica. Ordinary, reflected light.

investigations such as I.P. and electromagnetic methods, and diamond drilling.

5. Conclusions

This geochemical drainage survey was capable of detecting anomalous zones in this environment. Sample interval, mesh fractions and analytical techniques used were found to be successful and should be directly applicable in a more extensive survey of the region.

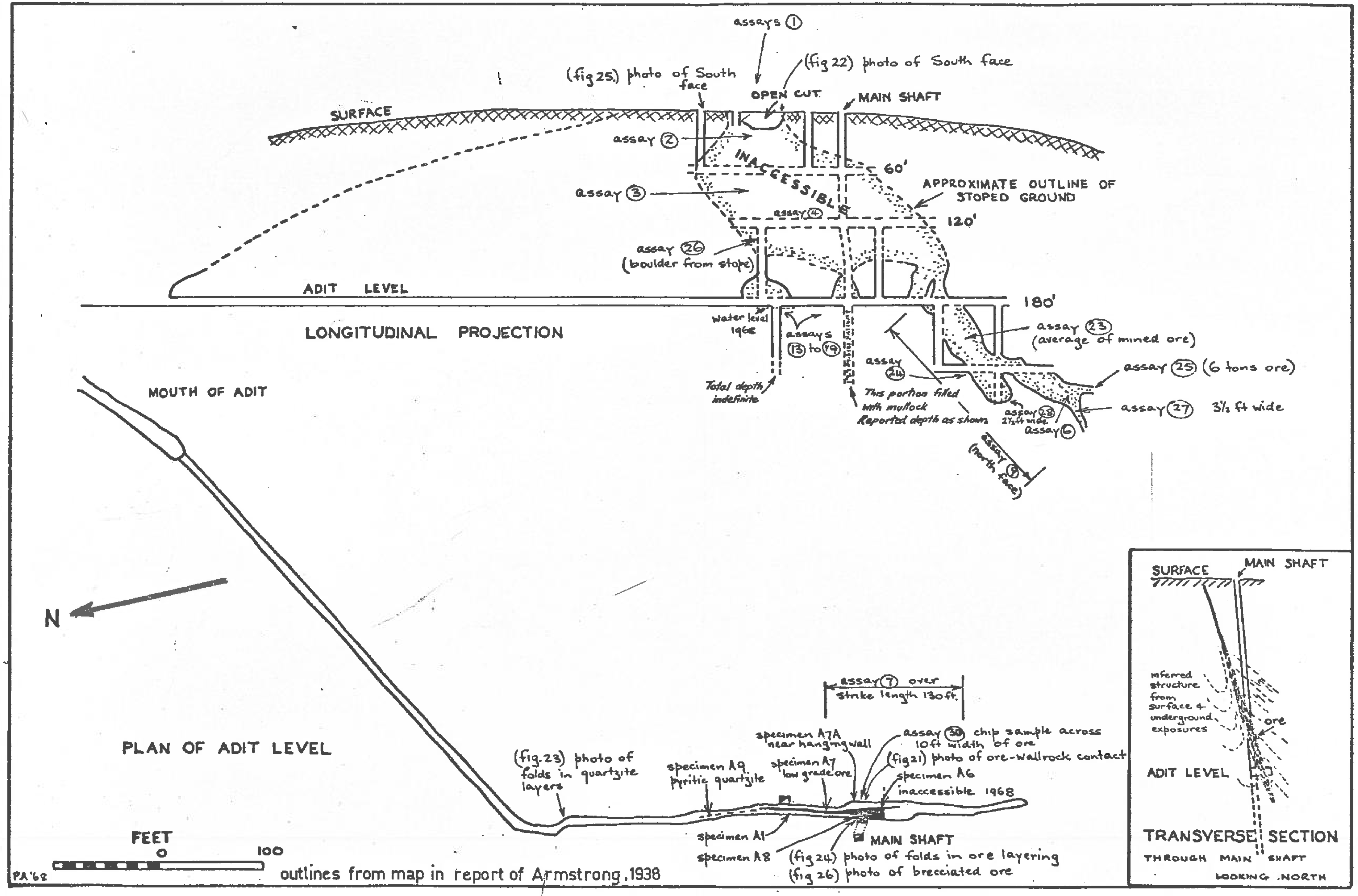


FIG. 18 ACLARE MINE, SHOWING LOCALITY OF SAMPLES, ASSAYS, & PHOTOGRAPHS

Figure 19

Ore from dump, Aclare Mine. Folded sulphide rich layers, possibly bedding. At right, a sulphide veinlet transgressive to the folded layers , and sub-parallel to the axial plane of folds. The location of thin section A10 and polished sections A10, A11, A12 is shown. Specimen cut at right angles to fold axes. Scale in inches.

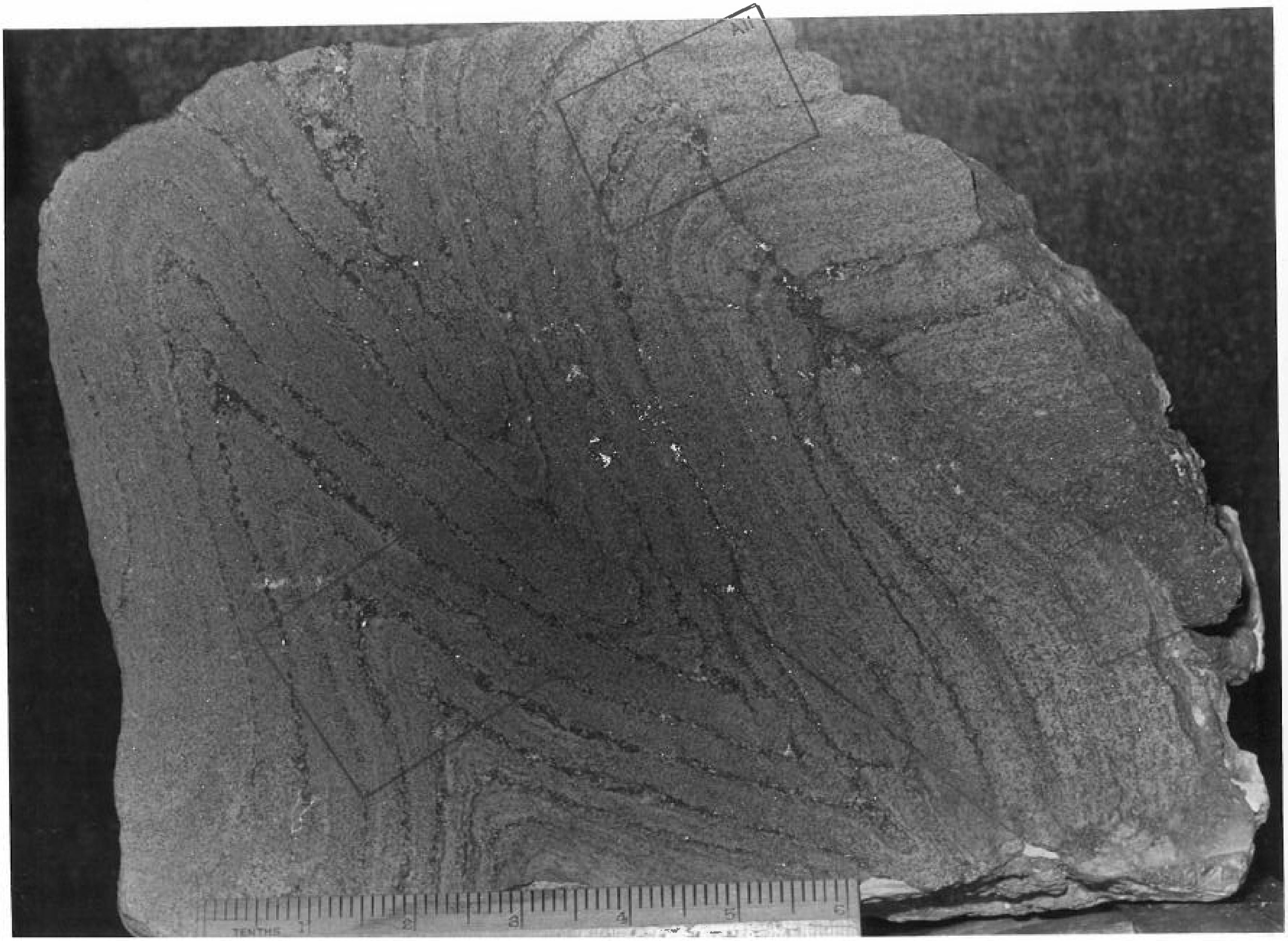


FIG.19

VI MINERAL DEPOSITS

Mineral deposits in the region include concentrations of metallic sulphides, chiefly of

1. Copper
2. Lead-Zinc
3. Iron
4. Arsenic.

1. Copper Deposits include the Kanmantoo orebodies and scattered deposits around Callington. These have been described by Dickinson (1942), and more recently the Kanmantoo orebody, proved by Mines Exploration Pty. Ltd., was described by Lindqvist (1967).[1966?]

2. Lead-Zinc-Silver deposits include the Aclare Mine, Scott's Creek Mine, Wheal Ellen, Old Strathalbyn Mine, and Glenalbyn Mine, (fig. 1). These are described in more detail below.

3. Arsenic. An arsenopyrite rich deposit occurs near Callington. This has not been investigated.

4. Iron. Pyritic layers are common throughout the region. The widest and most persistent layers are those of the Nairne Pyrite horizon, which is presently mined at Brukunga. The structure and texture of the ore here was described by George (1967).

The present investigation centred around the Aclare Mine, however for comparison aspects of other Pb-Zn deposits of the region (Scott's Creek, Wheal Ellen, Strathalbyn) were investigated.

1. ACLARE MINE

(a) History

It is not recorded when the Aclare Mine opened. A Mr. F. C. Singleton owned the mine until 1890, when it was bought by the Kangarilla Company (incorporated in England). Mining ceased in 1891 apparently because manual labour of hauling the ore up to the adit(haulage) level was too expensive. The ore at depth was richest in Zn and relatively poor in Pb and Ag: and at that time there were heavy smelting deductions for Zn. In 1937 the openings

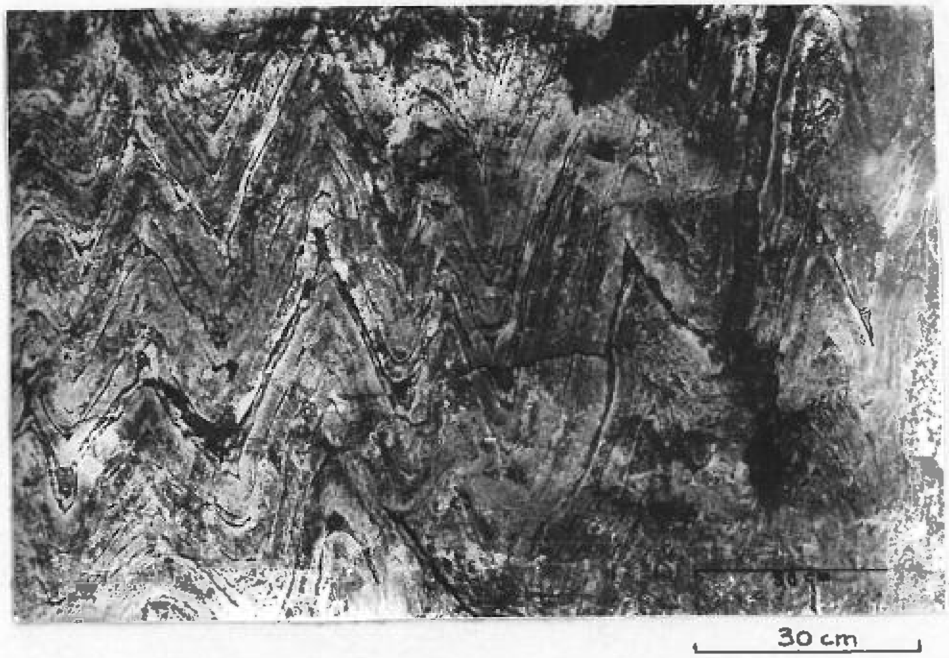


Fig.20 Folds in pyrite rich layering, probably bedding, in the Meirne pyrite ore. Note the triangular shaped sulphide enrichments at the crests of folds.
Compare with Aclare ore, fig.19
(From George, 1967, fig.12.)

were cleaned up and made accessible by the Department of Mines so that samples for assay and beneficiation tests could be taken. J. K. Gustafson and A. Blatchford of the Zinc Corporation Ltd. briefly examined the mine in 1937-8. H. F. King and E. Cottrell of Enterprise Exploration Co. Pty. Ltd. appraised the mine and considered that it held little promise of redevelopment chiefly because of its size. In 1961 Mines Exploration Pty. Ltd. took out an Authority to Enter of the area including the Aclare Mine. The immediate mine area was relinquished in 1964 to the S.A. Institute of Technology, for the use of students especially of the Mineral Engineering Course. Students rehabilitated the mine's adit for 516 feet in November 1965 - January 1966.

Presently the adit is open to a few feet south of the main shaft. At this point it is blocked by silt and rubble presumably originating from the stopes above. Other workings, excepting shafts to shallow depths from the surface, are inaccessible.

The old workings in plan and section are shown in fig. 18.

(b) Macroscopic texture and composition

Macroscopically the ore is an aggregate of numerous, folded layers of sulphide rich and sulphide poor quartzite and quartz-muscovite-biotite schist, of the order of one inch wide. The main sulphides are sphalerite (black, presumably with high iron content) and galena. Arsenopyrite crystals up to 4mm across are visible in many ore specimens from the surface dumps.

A quartz vein, about 1 foot across, transgressive to the ore layering, was seen in the adit near the main shaft. It contains a little galena and sphalerite. Galena and sphalerite-bearing quartz is fairly common in the surface dumps, hence many quartz veins must exist within the ore.

Coarse sulphide veinlets transgress the layering in many places. Fig. 19 shows a veinlet transgressive to folded layers and sub-parallel to the axial plane of folds. R. George (1967) found many sulphide veinlets parallel to fold axial planes and also at right angles to fold axes in the Nairne Pyrite orebody at

Brukunga. A study of the attitude of veinlets was not attempted for the Aclare ore, but this could be a useful study for some insights into sulphide mobilities during metamorphism.

(c) Wallrocks

The wallrocks are mica schists, which show no apparent difference in composition, texture and structural elements from schists not associated with ore elsewhere in the area.

(d) External Morphology

The orebody overall is tabular (fig. 18). Its horizontal extent is about 250 feet, its vertical extent over 300 feet and its width from $2\frac{1}{2}$ to about 15 feet. It dips about 70° towards 280° (true) and plunges about 30° south. It parallels schistosity of the enclosing rocks and apparently lies on the ~~west~~ east limb of a southerly plunging anticline in S_0 (figs. 22, 23). The cutoff to almost barren schist is sharp where it was seen in the adit (fig. 21). Longitudinally however the sulphide rich quartzite and schist layers, where observed southwards from the mined orebody in the adit, become thinner and less numerous until at locality A9 on fig. 18 there are only a few, approximately 4-inch wide, pyrite bearing quartzite layers.

(e) Size of Orebody

Past production from the mine is reported as 4,200 tons and ore reserves are estimated at from 8,000 to 15,000 tons to a depth of 300 feet (120 feet below the adit level) (Cottrell, 1951). It is not known whether the ore continues, enlarges or pinches out below this depth. Therefore the orebody (using 1 ton equals 10 ft^3) is at least 120,000 ft^3 and possibly much larger.

(f) Grade of orebody

All recorded assays of the Aclare Mine are grouped together in Appendix 5. It must be remembered that the mined ore would have been the highest grade parts. Overall the grade of the ore is possibly about 6% Pb, 9% Zn, 9oz/ton Ag, 1.5 dwt/ton Au.

The surface (to 30 feet) oxidized carbonate rich ore was richest in Pb and Ag and poor in Zn. Below this level in the

Fig.21. Ore - wallrock contact,
Aclare Mine, looking south
in adit at main shaft.
Ore is the stained, layered
material to the right,
wallrock is unstained mica
schist.

primary ore Zn grades usually exceeded Pb, and Ag in ozs/ton usually exceeded twice the value of Pb percentage. The available assays show a trend of decreasing Pb (assays of 2-3%) at the lowest mined depths.

(g) Internal morphology

The detailed internal structure of the ore is more complex than the external shape. It has been considerably deformed by folding and brecciation. Tightly appressed asymmetrical folds in the ore layering (figs. 24, 25) and folded and brecciated layers (fig. 26) exist nearly everywhere in underground and surface exposures.

Except at fold hinges the layering in the exposed parts of the ore parallels the schistosity of the enclosing schists. The axial plane of folds parallels schistosity. Measured fold axes of folded ore layers underground and at the surface plunge from 30° to 45° south.

The style of deformation of the ore is similar to, and the geometry of schistosity, lineations, and folded layering in the ore is identical to that of the surrounding rocks (fig 4a). It seems therefore that the ore and surrounding rocks have responded to the same deformation episode, and furthermore that the layering of the ore is equivalent to the first recognizable layering of the surrounding rocks, that is, it is possibly bedding.

(h) Mineralogy and Texture

The following opaque minerals, listed in approximate order of decreasing abundance, were recognized in polished sections under the microscope:

Sphalerite	$(Zn,Fe)S$
Galena	PbS
Pyrrhotite (locally replaced by Marcasite)	$Fe_{1-x}S$
Tetrahedrite	$(Cu,Fe,Zn,Ag)_{12}(Sb,As)_4S_{13}$
Meneghinite	$CuPb_{13}Sb_7S_{24}$
Pyrite	FeS_2
Arsenopyrite	$FeAsS$
Chalcopyrite	$CuFeS_2$

Gangue minerals, identified in thin sections were:

Quartz

Muscovite

Biotite

A little calcite

Accessory sphene, zircon.

A list of thin and polished sections is in Appendix 10.

Most ore specimens show granoblastic or lepidoblastic textures. Sulphides, especially galena and sphalerite are mostly present as lenticles of varying length and continuity. Lenticles grade into definite but somewhat ragged layers. Sphalerite and galena may be present in these lenticles together, or separately. In schistose specimens these lenticles and bands parallel schistosity (figs. 28, 32

Ore specimens of folded sulphide rich and sulphide poor layers have micas aligned parallel to the axial plane of folds. In places there is a definite tendency for sphalerite and galena lenticles to be aligned parallel to the axial plane (fig. 29).

Layers or streaks rich in sulphides are coarser grained than the surrounding sulphide deficient 'matrix'. This is clearly visible in figs. 28, 31, and 32. Coarse sulphide and quartz grains are about 0.25mm but up to 1mm across, and micas are up to 0.25mm long; whereas the finer grained matrix grains average about 0.05mm.

Specimen A3, fig. 29, shows coarse muscovite grains within the folded sulphide rich layer. The possible significance of this is discussed below.

The coarse sulphide grains are generally free of inclusions of all minerals, whereas the fine sulphide grains disseminated in the matrix usually have fine inclusions. In some coarse grained layers, sphalerite and galena show curved mutual grain boundaries, (fig. 33). Elsewhere sulphides tend to be polygonal grains aggregating into elongate lenticles. The disseminated fine grained sphalerite and galena often have a cuspoid shape interstitial between the quartz and mica grains which have a polygonal texture.

Arsenopyrite is present in many specimens as euhedral grains

Fig.22 Looking south into the open pit, Aclare Mine. Two politic layers on the left (east) trend up into the ore, which has a schistose wall on either side. The ore has internal isoclinal folds, (not quite visible). It apparently lies on the western limb of an anticline, which is parallel to the schistosity. A southerly plunging syncline is clearly visible on the right. For scale depth is about 95 feet.

Fig.23 Looking south at east wall in adit, Aclare Mine. Isoclinal asymmetric folds in quartzite, with schistosity of surrounding mica schists as axial plane. The sense of asymmetry of these folds suggests an anticline in so to the ~~east~~ west (right), where the orebody lies in projection along strike.

Fig.24 Looking north in adit at main shaft Aclare Mine. Folds in ore. Lighter layers are quartzite; sulphide rich layers are stained.

2 ft.

Fig.25
Surface outcrop of the ore, Aclare Mine, at the northern shaft, looking south. Isoclinal folds in ore layering

up to 2mm across.

Pyrite was seen in only one ore specimen; it was ragged and totally enclosed by (apparently partially replaced by) pyrrhotite.

Pyrrhotite is present in small amount both as euhedral laths about 0.3mm long, of variable orientation, within the quartz gangue (fig. 34), and as anhedral irregular shaped grains when surrounded by other sulphide minerals. Some sections show the pyrrhotite partially replaced by marcasite. Tiny rounded pyrrhotite blebs are present often as trails (exsolution texture?) in the sphalerite of some specimens. Usually some chalcopyrite blebs with the same habit are also present.

Chalcopyrite is also present in some specimens as scattered larger anhedral grains, which are often but not always associated with sphalerite.

Tetrahedrite is present usually as wispy inclusions within galena or at the edges of galena grains. There is a tendency for tetrahedrite to be present as inclusions in the finer grained galena disseminated through the 'matrix' and to be at grain edges of coarse galena in the relatively coarse grained layers or lenticles or in the cross cutting veinlets. Tetrahedrite was also observed within patches of coarser grained meneghinite.

Meneghinite (see X-ray identification, Appendix 8) has a similar association and habit to tetrahedrite but was also observed (rarely) within sphalerite. The galena of specimen A4 has meneghinite* as tiny (5μ) rounded blebs, some oriented in trains. The cross cutting veinlets have the coarsest meneghinite (fig. 35). Individual grains are up to $\frac{1}{4}$mm across, but they are aggregated in places to patches a few cm long and a few mm wide. Flame-like texture exists in some places. Some inclusions in galena are needle-like, (0.02mm long).

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*The identification of meneghinite is based on one X-ray determination from specimen A11. It is possible that boulangerite and jamesonite also occur, but these are not readily distinguishable from meneghinite in polished section.

One brecciated ore type (A6) was examined under the microscope. It has an exploded appearance; the sulphide deficient schist layers appear broken apart and folded. Sulphides, chiefly sphalerite and galena fill all the fractures and "pull-aparts", and together occupy over 50% of the volume. Sphalerite also appears brecciated and galena is interstitial (fig. 36).

Specimen A7-A from near the hangingwall of the ore in the adit at the main shaft, is rich in a fine grained (<0.02mm) intergranular mixture of pyrite and angular marcasite. Larger euhedral arsenopyrite is also present, (fig. 37).

Specimen A9 is a thin quartzite layer from the north of the main ore zone in the adit. Only one grain of sphalerite was seen in the section; but euhedral arsenopyrite grains up to 0.1mm and subhedral pyrite grains up to 0.2mm are concentrated in trails parallel to the schistosity (which may be parallel to bedding) (fig. 38). Quartz grains are usually smaller than the pyrite and arsenopyrite, and have a lepidoblastic texture.

A little calcite (less than 1% of rock) is present in specimen A10. It exists between quartz grains and as coarse grains in the hinge of the folded layer, (fig. 30).

Discussion of texture.

The folded ore layers possibly are of most use in interpreting the ore textures. These layers are possibly bedding (discussed above), but in their present form have the same metamorphic texture as the enclosing silicate mineral assemblage. Sulphide rich layers are coarsest, and layers of disseminated sulphides are finest grained. The same relationship was found for the Nairne Pyrite ores at Brukunga by R. George (1967).

This coarse and fine layering is apparently an effect caused by metamorphic processes. If the layering is preserved bedding, perhaps initial sulphide rich and sulphide poor layers provided the necessary anisotropism such that during metamorphism a 'chemical potential' was set up between them, resulting in the observed coarsening of the sulphide rich layers.

Fig.26 Brecciated and folded quartzite layers. Sulphides (stained), are interstitial. Aclare Mine, in adit at main shaft, looking north.

Possible evidence that the layering was a metamorphic layering prior to being folded exists in specimen A3. The folded sulphide rich layer contains coarse grained muscovite parallel to the layering. This can be interpreted as a folded metamorphic layering, which may not necessarily have been parallel to bedding, but may have been, for example, axial plane to folds in pre-existing bedding. However the coarse muscovite can also be interpreted to have grown in place in the softer sulphide layer (bed?) during the same metamorphic and fold episode. This latter interpretation is possibly more viable because, as can be seen in fig. 29(b), the muscovite grains tend to grow in variable directions where the sphalerite is coarsest. Certainly more detailed structural and textural investigation of the ore and the surrounding rocks is necessary to resolve this problem.

A feature which supports the conclusion that the sulphide minerals have been deformed and metamorphosed is the tendency towards elongation of sphalerite, galena and meneghinite lenticles parallel to the axial plane of folds (fig. 29). The sulphides clearly define an axial plane schistosity.

Measurement of triple point mineral interface angles, initiated by Stanton (1964), and petrofabric studies (orientation of grains) would help in a detailed understanding of the ore textures and history.

Cross cutting veinlets are usually coarser grained than the remainder of the ore. Only sulphide minerals are present and these are free of inclusions. Presumably the sulphides of these veinlets were derived from the adjacent ore by some process involving grain boundary migration, creep, or diffusion. The only minerals present in these veinlets are galena, sphalerite, meneghinite and tetrahedrite. Meneghinite is present in much greater proportion than it is the ore, so apparently its 'mobility' is greater than the other sulphides.

Arsenopyrite, pyrite and pyrrhotite have euhedral outlines.

Fig.27 Distinct layering of Aclare ore, specimen A4 from dump. Layering is probably metamorphic.

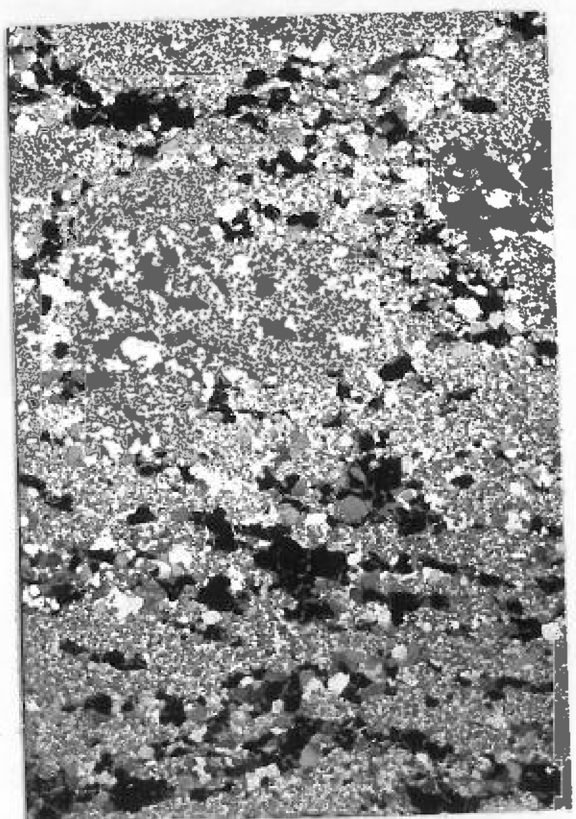


Fig.28
Closer view of part of ore of fig.27.
Lenticles of coarse sulphides and quartz, parallel to one another (and to the schistosity defined by the preferred orientation of small micas), separated by a 'matrix' of granoblastic quartzite.
Ordinary transmitted light.

This is interpreted to be an effect of their high surface free energies compared with the other sulphides and gangue minerals, so that during metamorphism they grew with crystal form. Pyrrhotite, however, when present with other sulphides (galena, sphalerite, chalcopyrite) is anhedral, which presumably means that in that association its surface free energy is the same order as that of the other sulphides.

(i) Surface expression and mineralogy

The lode outcrop consists of quartzite, up to 15 feet wide. The sulphide rich layers are represented as porous and cellular layers with coatings of pale green earthy beudantite(?). (See X-ray determination, Appendix 9).

The quartzite is more resistant than the surrounding rocks and so stands a few feet above the general surface.

(j) Age of the ore

This has not been determined, though if the ore is syngenetic then it would have the same age as the enclosing rocks. Their age is as yet unknown but is assumed to be Cambrian.

2. SCOTT'S CREEK MINE (Wheal Margaret and Wheal Rose).

This mine is located 1½ miles north of the Aclare Mine.

The only recorded data for this mine is in the Record of Mines, 1908. It was leased from the Paringa Mining Company in 1848 and was apparently worked up to the outbreak of the Victorian goldfields, in 1851. There is no record of the amount of ore raised, and scant records of ore grades. (All known assays are presented in Appendix 6).

Three shafts, the deepest being 90 feet, were sunk to the water level and the drives and levels extend about 200 feet. Most ore was removed from between the 40 and 90 feet levels.

At the present time workings are inaccessible except for some near surface exposures in the shafts.

The old records describe the ore as 3 tabular bodies dipping about 70° towards 280° (true) with widths from 2 to 12 feet. They

? see fig 4b (PTO. 115)

are therefore parallel to schistosity and possibly also to bedding (fig. 4b).

The country rocks are finely layered andalusite schists, and more massive quartzite layers. The first recognizable layering in the schists, probably bedding, is folded into often tightly appressed asymmetrical folds of hand specimen size. Measured structural elements are shown in fig. 4b. Exposure in the shafts was not clear enough to establish certainly whether folds in the ore exist, however folded sulphide rich (now leached and weathered) layers were observed in some specimens from the dump.

Six polished and thin sections of material from the dumps were examined. All specimens, excepting one of massive quartz with disseminated grains of sphalerite, galena and chalcopyrite (vein quartz?), are distinctly layered. The layering is defined by relative proportions and differences in grain size chiefly of quartz and pale buff garnet. Several of the specimens have a schistosity defined by muscovite, biotite and elongate quartz grains, but in SC5 the layering (fig. 39), interpreted to be bedding, is at 20^{o} to the schistosity. Grain sizes are approximately 0.04-0.06mm. The texture is granoblastic. Some sections have very fine grained chlorite pseudomorphing mica.

Sulphide minerals are present as lenticles or ragged layers parallel to the schistosity or bedding (figs. 40, 41, 42). Individual grains vary in size up to 0.2mm, and all except some pyrite grains are anhedral. The observed sulphides are sphalerite, galena, chalcopyrite, pyrite and a little tetrahedrite. Sphalerite often has included blebs of chalcopyrite. Non-opaque very fine dusty inclusions are particularly common in sphalerite. Tetrahedrite is present as isolated grains and also associated with galena.

<u>Discussion</u>: Compared to the Aclare ore the grain size of all minerals is small. Where sulphide-sulphide grain boundaries could be seen they are polygonal, indicating that the sulphide texture is probably metamorphic. Specimen SC5, showing an angular relationship between the layering (bedding?) and schistosity, is nearly devoid

of sulphides. Other specimens have sulphide layers, schistosity and layering parallel. Therefore, without further information, it cannot be said with any confidence that the sulphide rich layers are distributed parallel to the layering (or bedding?) rather than to the schistosity.

3. <u>OLD STRATHALBYN MINE</u>

This mine is located near Strathalbyn, fig. 1. A summary of the known information and list of other references concerning the mine is given by Cochrane, (1952).

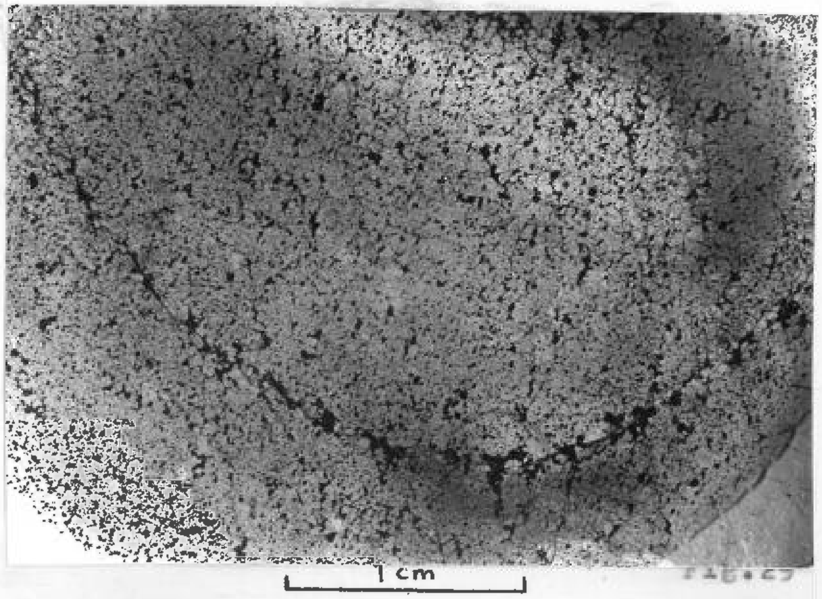
The northern part of the mine is believed to have been opened in 1848, when some copper ore was mined. Later activity was concentrated on the Pb-Zn ores at the southern end of the lode. Mining ceased about 1858, but was later recommenced for several years around 1907. The workings have been filled in to the surface and are therefore now inaccessible.

In 1952 the South Australian Department of Mines investigated the possible continuity of the ore in depth with two diamond drill holes (Cochrane 1954) and self potential and applied potential geophysical methods (McPharlin and Seedsman, 1953). Geophysical results did not indicate any substantial sulphide bodies, but the drill holes intersected a sulphide bearing schist zone (see assays Appendix 7). The sulphides in this zone are mainly pyrite with lesser pyrrhotite and chalcopyrite, and traces of arsenopyrite and sphalerite.

? see fig 43

Judging by the available descriptions the orebody was well defined, tabular, dipping at 70° towards 270° and varying in width from a few inches to 14 feet. Fig. 43 summarizes much of the old data. In Appendix 7 all available ore assays are compiled.

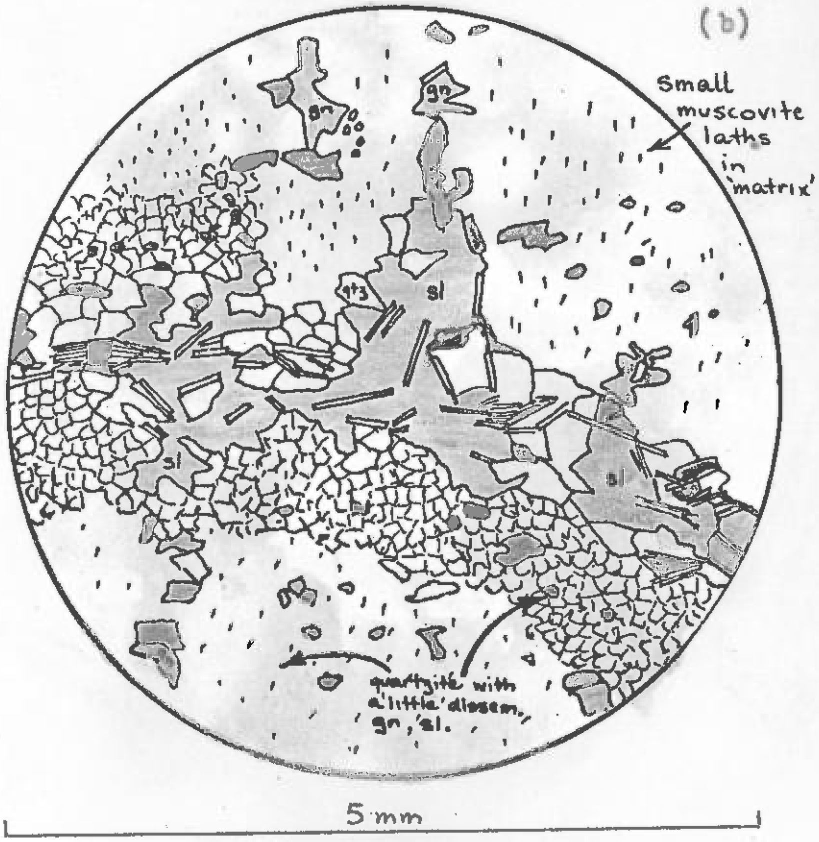
Four specimens from the remnant dumps were sectioned. They are quartzite or quartz-mica schists with sulphides disseminated though commonly concentrated in coarse layers. The texture is similar to those of the Aclare ore, (fig. 44). Coarse grains are up to 0.5mm across, whilst the finer grained minerals are 0.25-0.1mm



(a)

Fig.29

(b)



Folded sulphide rich layer in ore, Aclare Mine. Specimen A3 from dump.
Sulphide lenticles are elongate parallel to the axial plane of the fold and parallel to small muscovite grains in the fine graindd 'matrix'.
The enlargement shows coarse muscovite laths within the sulphide rich layer.

Ordinary transmitted light.

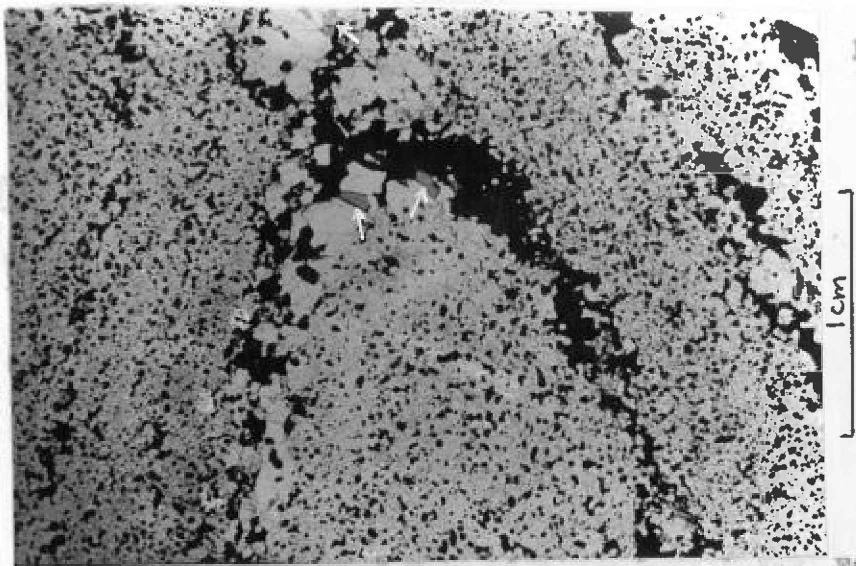


Fig.30

Folded layering in ore, Aclare Mine. Part of specimen shown in fig.19. Sulphide rich layers are coarse grained, but coarsest at hinges. Sulphides are black, remainder , except for arrowed calcite, is quartz. Ordinary transmitted light.

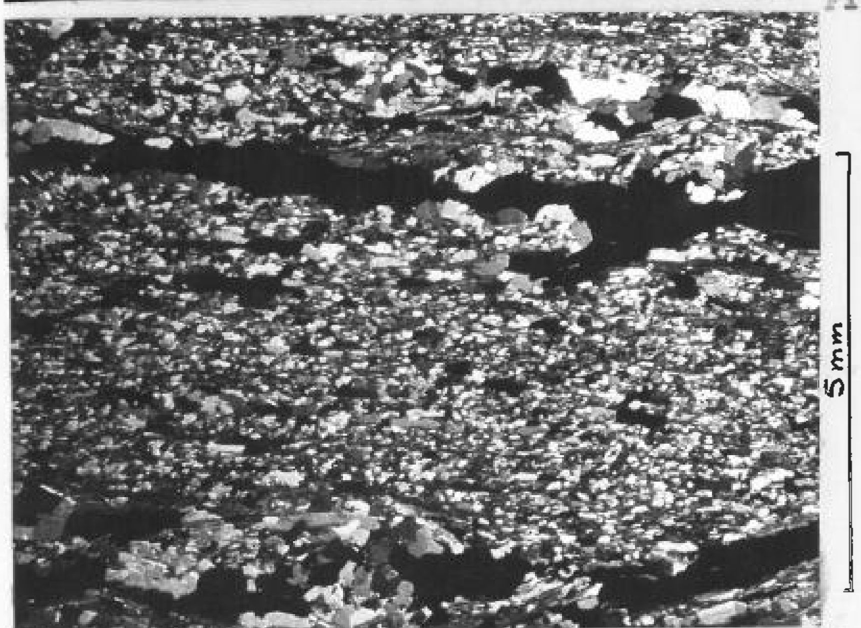


Fig.31

Schistose ore, Aclare Mine. Lepidoblastic texture, and typical finer grained matrix with coarse sulphide rich layers, which here are parallel to schistosity. Specimen A1a, cut parallel to lineation and normal to schistosity. Crossed nicols.

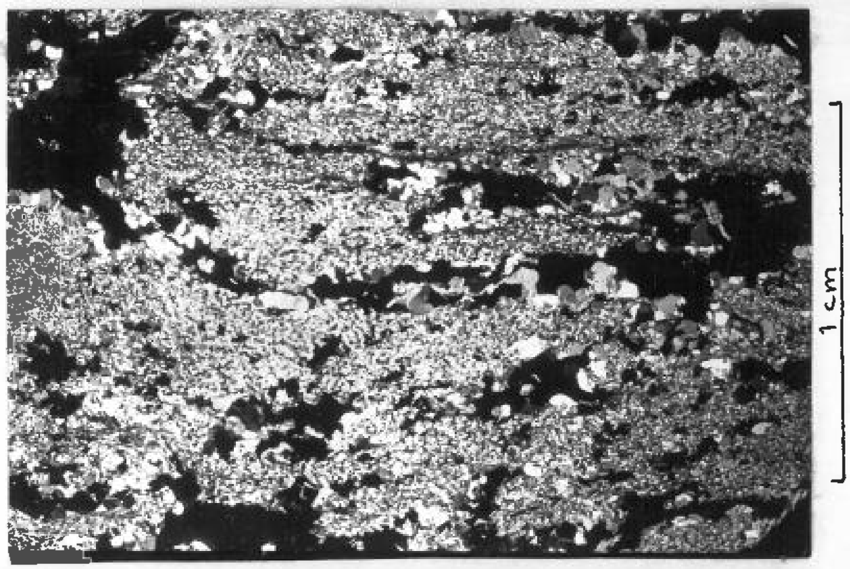


Fig.32

As above, but cut normal to lineation. Specimen A1b or smaller. Sulphides present are chiefly pyrite, sphalerite, and pyrrhotite (largely replaced by marcasite). Galena, and a little associated tetrahedrite, are less common.

Arsenopyrite and pyrite are euhedral, whereas other sulphides are anhedral and ragged, excepting a few tabular euhedral pyrrhotite grains. The sphalerite commonly contains many fine inclusions, presumably of silicate minerals. It also commonly contains small rounded blebs of pyrrhotite (exsolved?).

One specimen is of folded schistosity. Sulphides, chiefly arsenopyrite, are in trails parallel to the folded schistosity. Without etching the sulphides appear texturally identical to those of other specimens.

Discussion: Texturally, the ore is distinctly similar to the Aclare ore. In all specimens however the ore layering parallels schistosity and the textures are probably metamorphic, so they do not help to resolve the problem of the nature and disposition of sulphides prior to the metamorphism.

4. GLENALBYN MINE

This mine is located near Strathalbyn (fig. 1).

The only record of this mine is in the Record of Mines, 1908.

It opened in 1850, closed in 1863. A shaft was sunk about 180 feet. The ore is described as galena impregnated with yellow copper ore, assaying 18½% Pb and 16½ oz/ton Ag.

Judging from the geological map of Mirams (see fig. 1) the orebody lies in a pyritic layer. It may therefore be useful to study in an attempt to assess the likelihood of Pb-Zn deposits associated with pyritic schist layers.

5. THE WHEAL ELLEN. (Commonwealth Mine).

This mine is located about 5 miles north of Strathalbyn, (fig. 1).

A comprehensive review and report of the mine is presented by Wade & Cochrane, (1952).

It was worked from 1857-1865 and later but unprofitably from

1906-1911. To explore the ore in depth the South Australian Department of Mines placed two diamond drill holes in 1920 and four in 1953. These helped to clarify the shape and size of the orebody. It is tabular, varying in width from 1 to 14 feet, and dipping about 50°-70° towards 280°. Its lowermost limit and the highest grade sections plunge 30° south. It is over 970 feet long, 130 feet deep in the north, and 360 feet deep in the south where it lenses out. Judging by the published descriptions the orebody parallels both bedding and schistosity. The overall grade of mined primary ore approximates 20% Pb, 25% Zn, 12oz/ton Ag, 3dwt/ton Au. A substantial amount of Au was recovered from the deep oxidized ore, reaching 120 feet deep. The chief sulphide minerals are pyrite, galena and sphalerite. Gahnite, a zinc spinel, is present.

The nature of the ore was not described in the report by Wade & Cochrane, though specimens from the dumps are rather massive, consisting almost entirely of pyrite and sphalerite.

The external morphology of the orebody is similar to other Pb-Zn bodies in the region, but details of the structure and internal nature of the ore are not known. These are necessary towards an understanding of the genesis of the ore and its possible relationship with other ores of the region.

VII SOME NOTES ON GENESIS OF THE ORES

Evidence that the ore types have been metamorphosed has been discussed in the previous section. The Aclare ore layering is possibly equivalent to bedding, and since there is no evidence for favourable layers, such as carbonate layers, to accommodate a replacement origin prior to or during metamorphism, the ore may be syngenetic. The other Pb-Zn ores in the region have similar morphologies, texture, composition and occurrence, hence they possibly originated in the same way.

The nature and geometry of the fabric elements and texture of the Nairne pyrite are identical to those of the Aclare ore. The folded sulphide rich layering of each is of similar style (figs. 19 and 20), and there appear to be similarities of texture and orientation of the transgressive veinlets. Both ores have therefore probably been deformed during the same metamorphic episode. There is good evidence for a syngenetic origin of the Nairne Pyrite ore (e.g. Skinner, 1958), so this lends support to a syngenetic origin for the Aclare ore.

The copper ores at Kanmantoo were investigated by Lindqvist (1967 He concluded that the ore, (disseminated and lenticular aggregates of chalcopyrite, pyrrhotite and magnetite in quartz-garnet-chlorite-schists) seemed to be tabular and generally conformable with the bedding and schistosity of the surrounding andalusite-staurolite schists. Hence this ore is possibly also syngenetic.

The Kanmantoo group rocks of the region therefore contain scattered possibly syngenetic pyritic layers, Pb-Zn bodies/and Cu bodies, all lying within peletic or psammitic rocks. Most Cu deposits are in andalusite schists, i.e. originally Al rich peletic rocks.

There is a possibility that the Pb-Zn bodies represent particular facies of the pyritic layers. This may be so for the Glenalbyn Mine, as discussed above, and for the Wheal Ellen which according to published descriptions is more pyritic at its

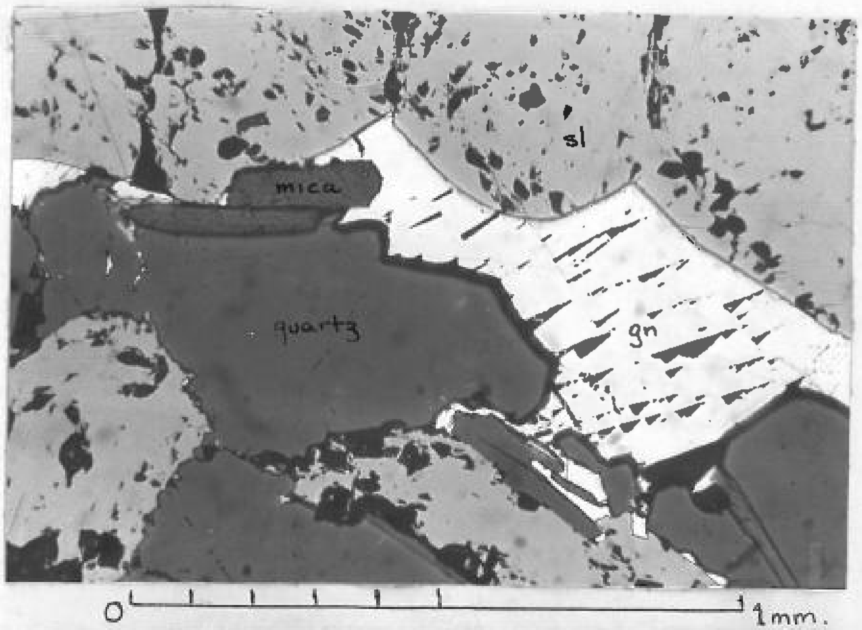


Fig.33

Part of coarse sulphide layer showing curved grain boundaries between galena and sphalerite Specimen A7. Aclare Mine Ordinary reflected light.

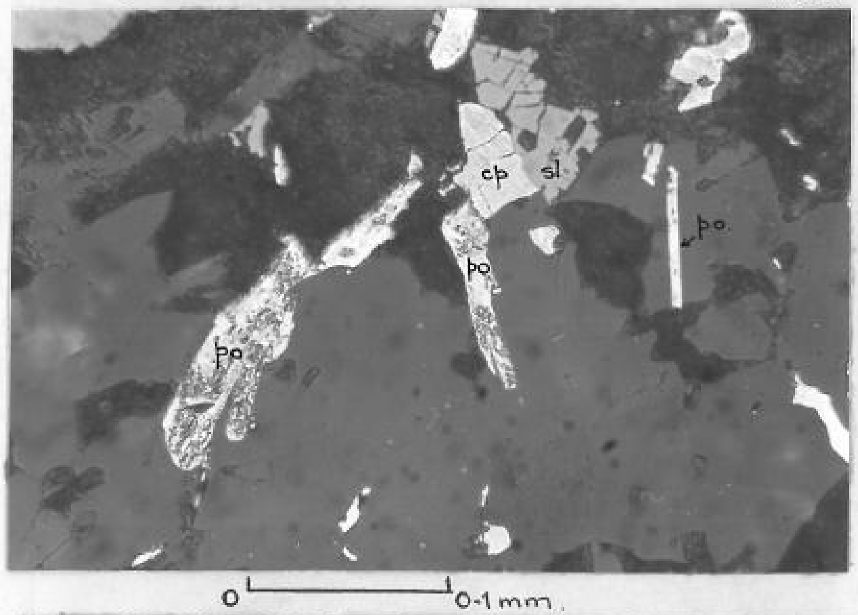


Fig.34

Pyrrhotite laths in quartz.
Specimen KM3(b) Aclare Mine.
Ordinary reflected light.

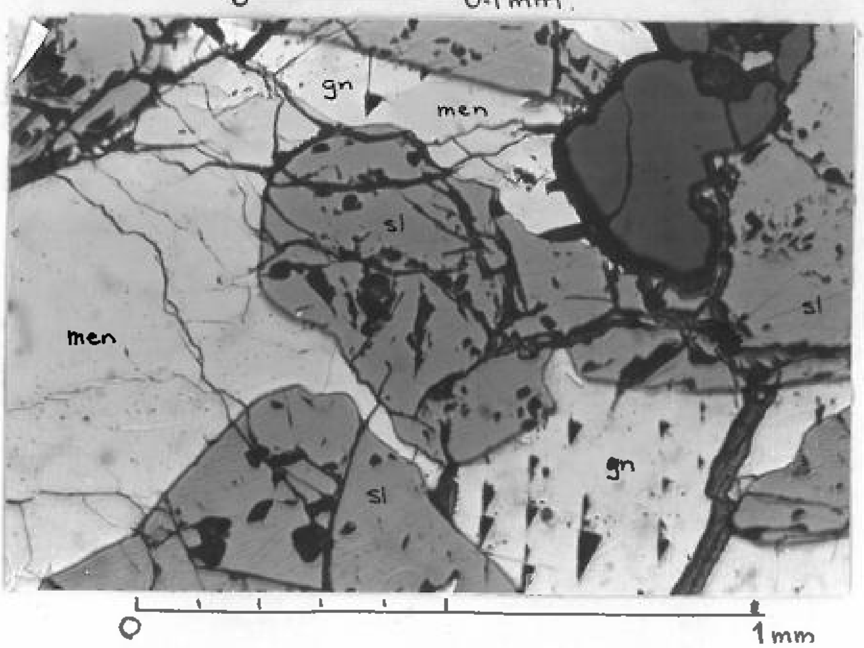


Fig.35

Part of coarse sulphide veinlet containing coarse meneghinite(men). Specimen A12 Aclare Mine. (Part of specimen shown in fig.19) Ordinary reflected light.

extremities. Diamond drilling shows the Old Strathalbyn orebody to be a pyritic schist at its bottom extremity. The Aclare ore was observed to lens out to a pyritic quartzite in the adit. This possible facies control is perhaps significant as a guide to ore search - Pb-Zn anomalies such as those found associated with pyritic schists may therefore be worthy of further testing.

At this stage there is insufficient data compiled to advance any hypotheses regarding the source of the sulphides and their environment and mechanism of deposition.

Comparison with other regions.

Many areas of the world have what are regarded as syngenetic sulphide ores in rocks of, or associated with, carbonates or acid volcanics and pyroclastics. These rock types do not exist in the Kanmantoo group, except for a few thin dolomitic interlayers recognized by George, (1967) in the Nairne Pyrite ore. In the literature there are relatively few stratiform, and possibly syngenetic, Pb-Zn bodies and Cu bodies associated with only pelitic and psammitic rocks, or their metamorphosed equivalents. No references to a limited area containing stratiform pyritic, Pb-Zn and Cu bodies could be found.

Two examples of comparable stratiform, possibly syngenetic, Pb-Zn ores are the Sullivan orebody, B.C., Canada and the Rammelsberg deposit, Germany. Both have similar composition and lie in similar rocks to the Pb-Zn ores in the Kanmantoo group, though they are, of course, vastly larger than those in the Kanmantoo group.

The Sullivan orebody, of Precambrian age, is stratiform and "most of the ore in the outer zone .... is distinctly banded and much of it is intimately interbanded with layers of sediment (argillite). ..... Even in areas of strong folding, the individual layers and/or laminae of sulphides or sediment may be preserved to a remarkable degree" (Freeze, 1966) (fig. 45). Fig. 46 shows a cross section of the orebody. The sedimentary rocks in the region include pyrite or pyrrhotite bearing pelites, which are possibly analogous to the pyritic schists of the Kanmantoo group.

The Rammelsberg deposit consists of several folded, lens shaped ore bodies which lie conformably in the 'Wissenbacher Schiefer', a Middle Devonian slate horizon. In parts it consists of finely interlayered sulphide rich and sulphide poor layers, regarded as bedding.

The Pb-Zn ores of the Kanmantoo group lie in rocks of higher metamorphic grade than the Sullivan or Rammelsberg ores, (and also of the McArthur deposit, N.T., and Mount Isa ores), but of lower metamorphic grade than the Broken Hill ores, N.S.W. Therefore they should be a valuable link in the study of the effects of progressively higher metamorphic grade on sulphide mineral assemblages.

VIII CONCLUSION

The ores of the Kanmantoo group in the Nairne-Callington-Strathalbyn area are a variety of sulphide deposits of possible syngenetic origin. They provide many problems of academic interest such as the effect of metamorphism and deformation on sulphide assemblages and their disposition within the rock - also problems of both exploration and academic interest such as the relationship between ores, structure and stratigraphy.

Drainage sediment geochemical surveys should be a useful exploration tool for these deposits.

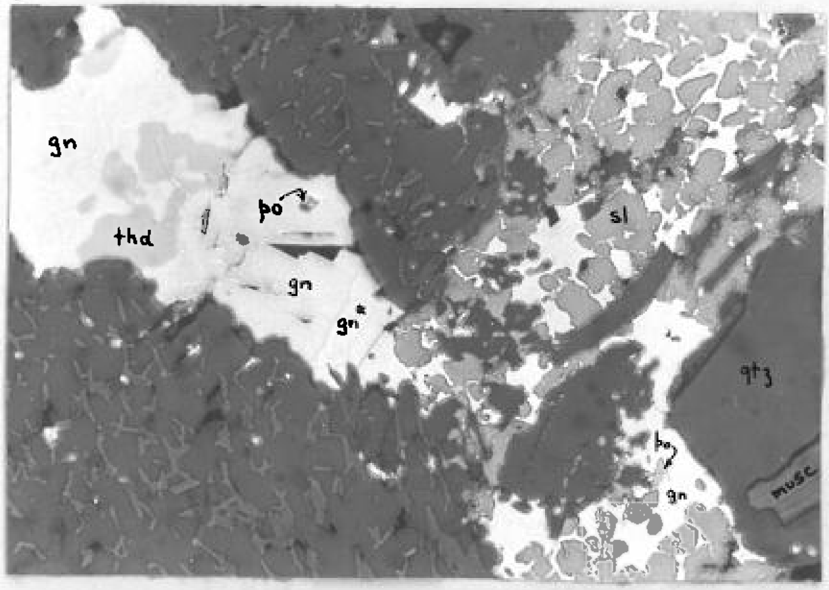


Fig.36

Brecciated ore; gangue and sphalerite appear broken apart. Tetrahedrite (thd) is shown in its typical association with galena.
*This grain is lighter and softer than the rest of the galena - it may be altaite, PbTe.
Specimen A6, Aclare Mine
Ordinary reflected light.

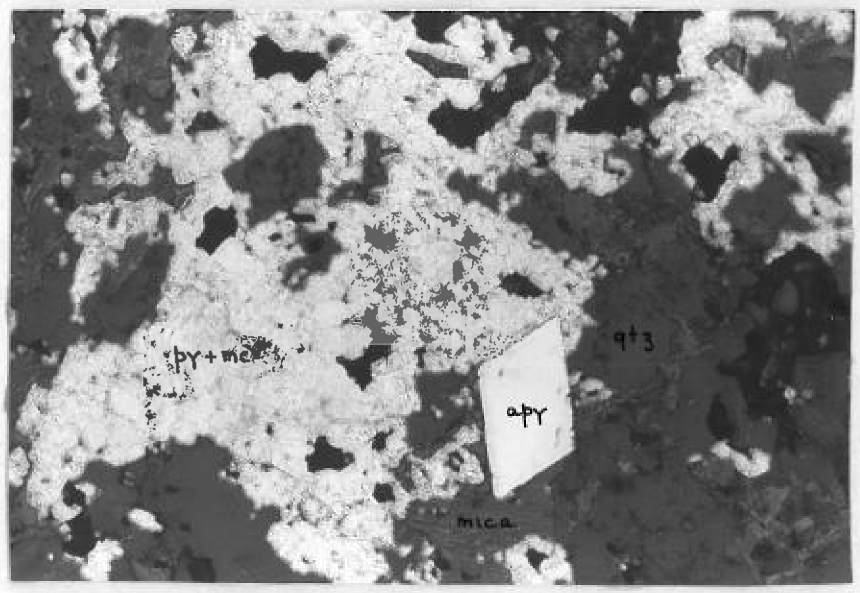


Fig. 37

Euhedral arsenopyrite and fine grained pyrite with marcasite.
Specimen A7A from near hangingwall of orebody, Aclare Mine.
Ordinary reflected light.

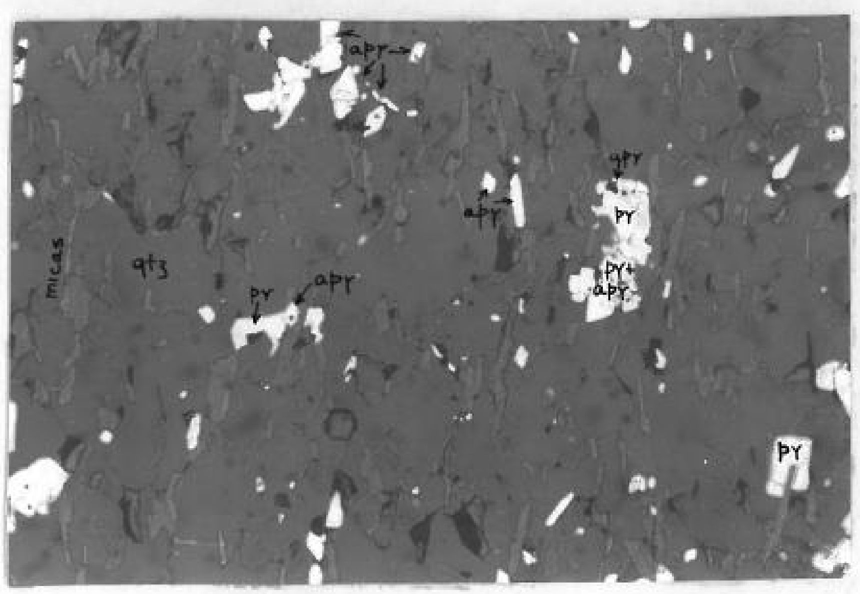


Fig.38

Pyritic quartzite - pyrite grains elongate parallel to schistosity.
Specimen A9, north of Aclare ore, along strike.
Ordinary reflected light.

0 1mm

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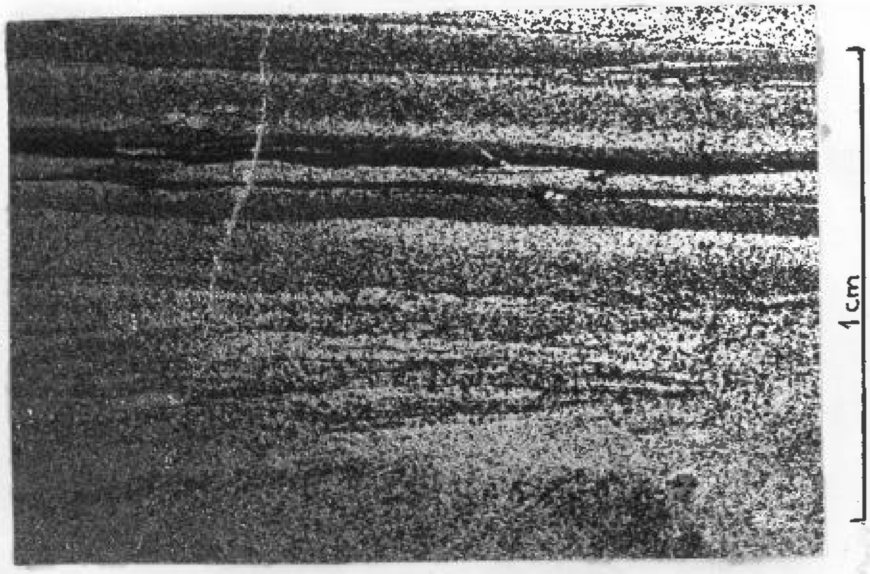

Fig.39 Scott's Creek Mine. Specimen SC5
Layering in lode rock, probably bedding, defined by relative proportions of garnet (dark) and quartz. Schistosity, defined by the preferred orientation of micas, lies at 20° to the layering, but is not visible in this photograph. Ordinary transmitted light.

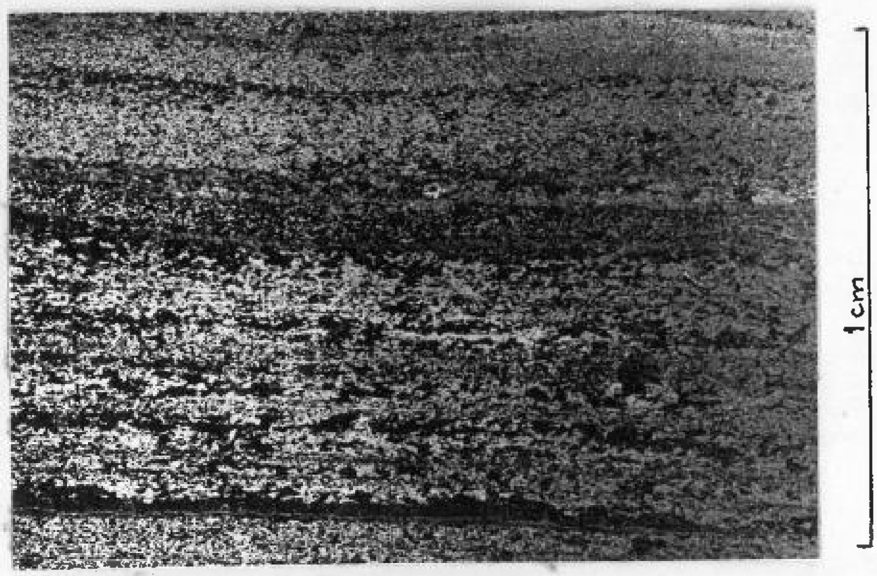

Fig.40 Scott's Creek Mine. Specimen SC3
Distinctly layered ore. Layering defined by differences in grain size and ratios of quartz, garnet and sulphides. The schistosity is parallel to the layering. Quartz and sulphides (black) are elongate. Ordinary transmitted light.

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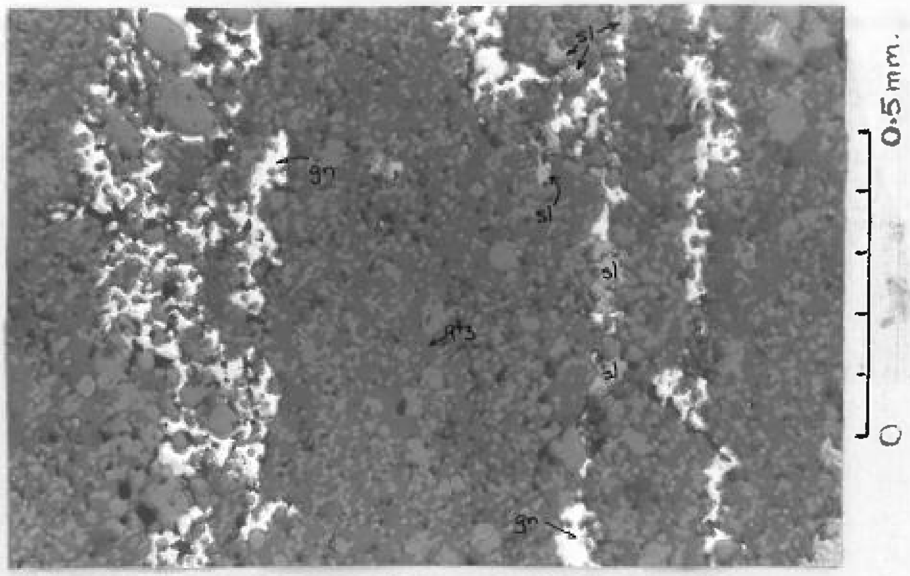


Fig.41 Scott's Creek Mine . Specimen SC2

Typical distribution of sulphides in ragged layers.
Ordinary reflected light.

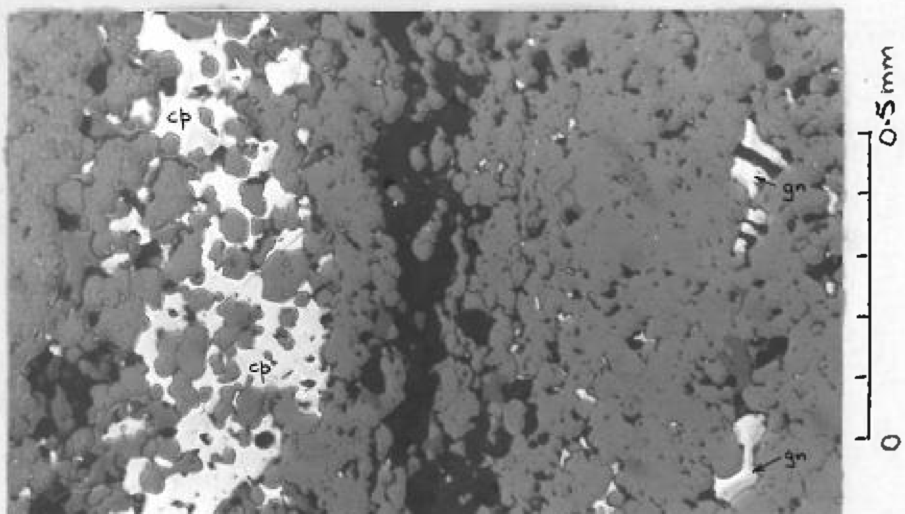
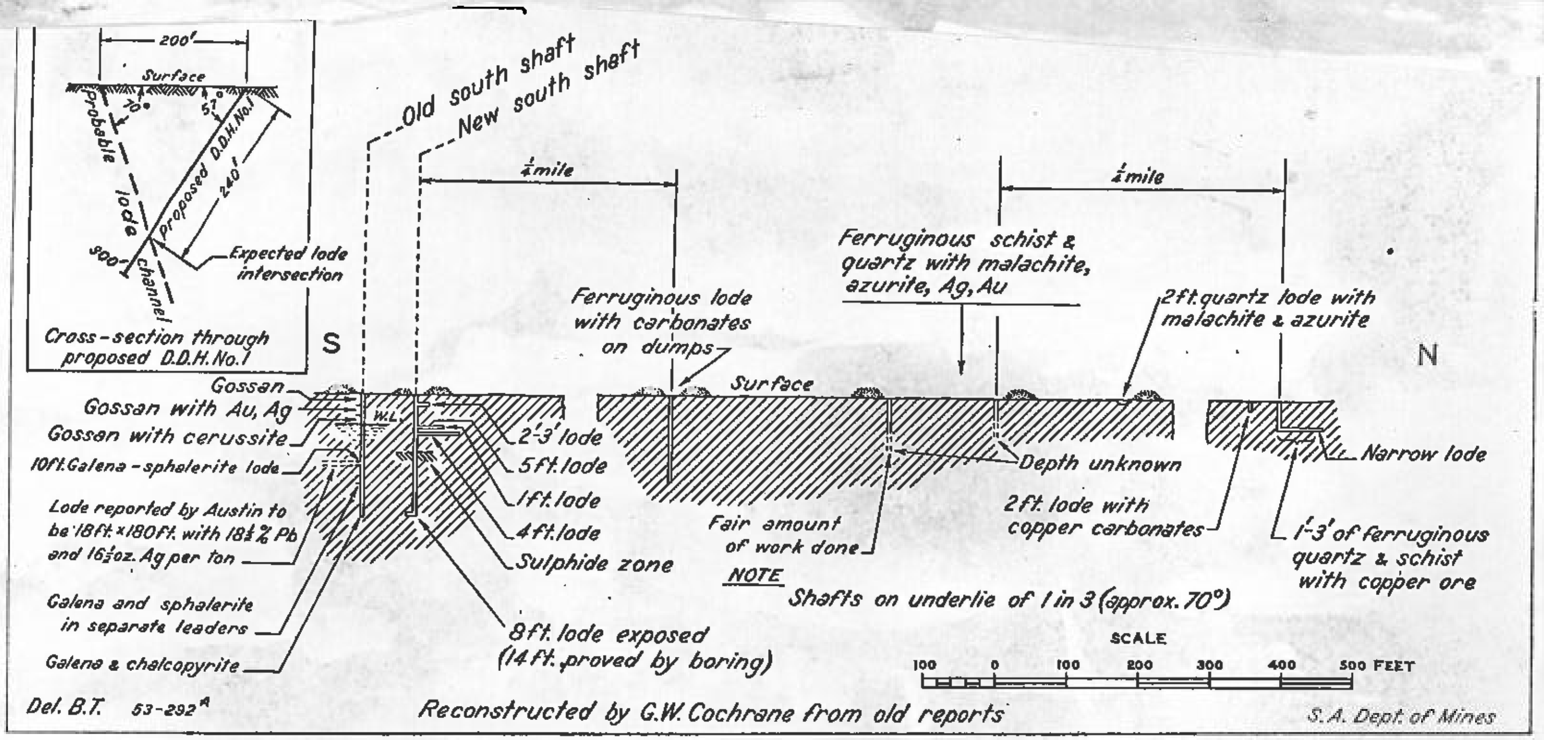


Fig.42 Scott's Creek Mine. Specimen SC1

Similar to fig.41. Black layer in centre is a weathered void, probably originally a sulphide layer.
Ordinary reflected light.

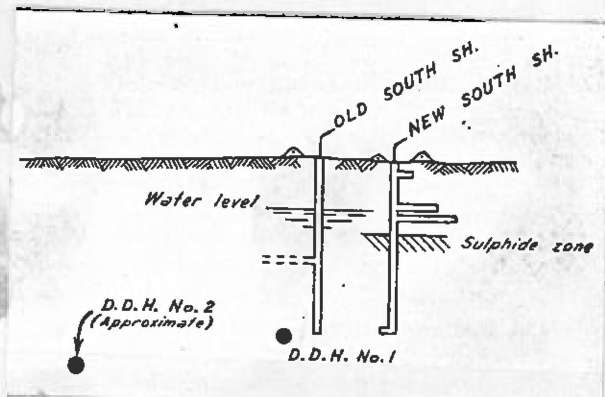
3

FIG.43

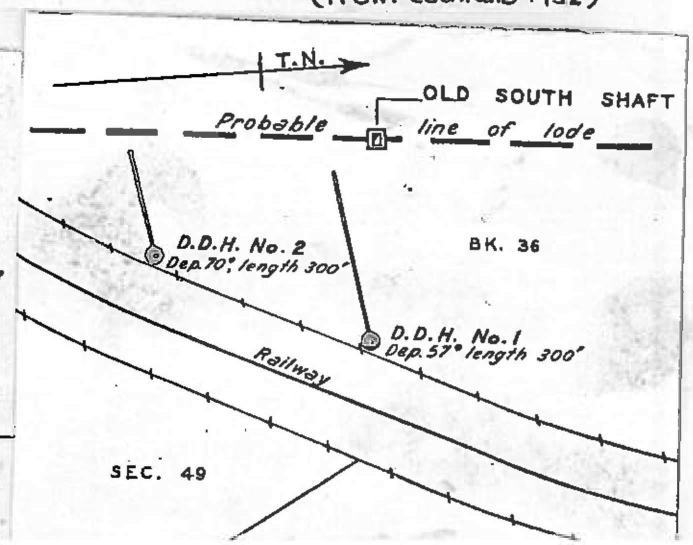


STRATHALBYN MINE
Vertical projection of underground workings and cross-section through proposed borehole

(from Cochrane 1952)



PLAN AND SECTIONS OF THE SOUTH END OF THE STRATHALBYN MINE
Showing boreholes (from Cochrane 1952)



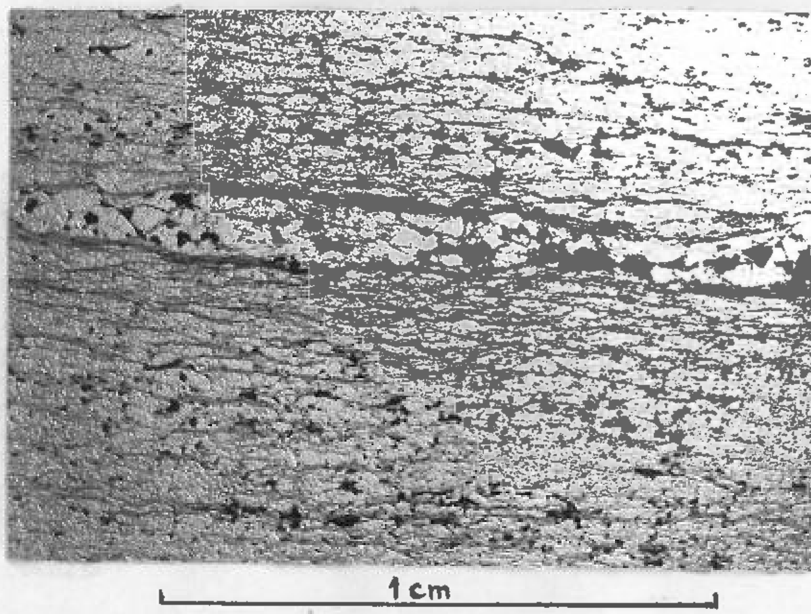


Fig.44 Old Strathalbyn Mine, Specimen ST4.

Schistose ore with lepidoblastic texture. Coarse sphalerite rich layer is parallel to schistosity. Sulphides are black - remainder is quartz and muscovite.

FIG. 45

Drag folds in interbedded sulphides and argillite. The light coloured material is pyrite. Sphalerite is present in some of the darker beds. Massive argillite occurs above and below the banded sequence.

(from Freeze 1966)

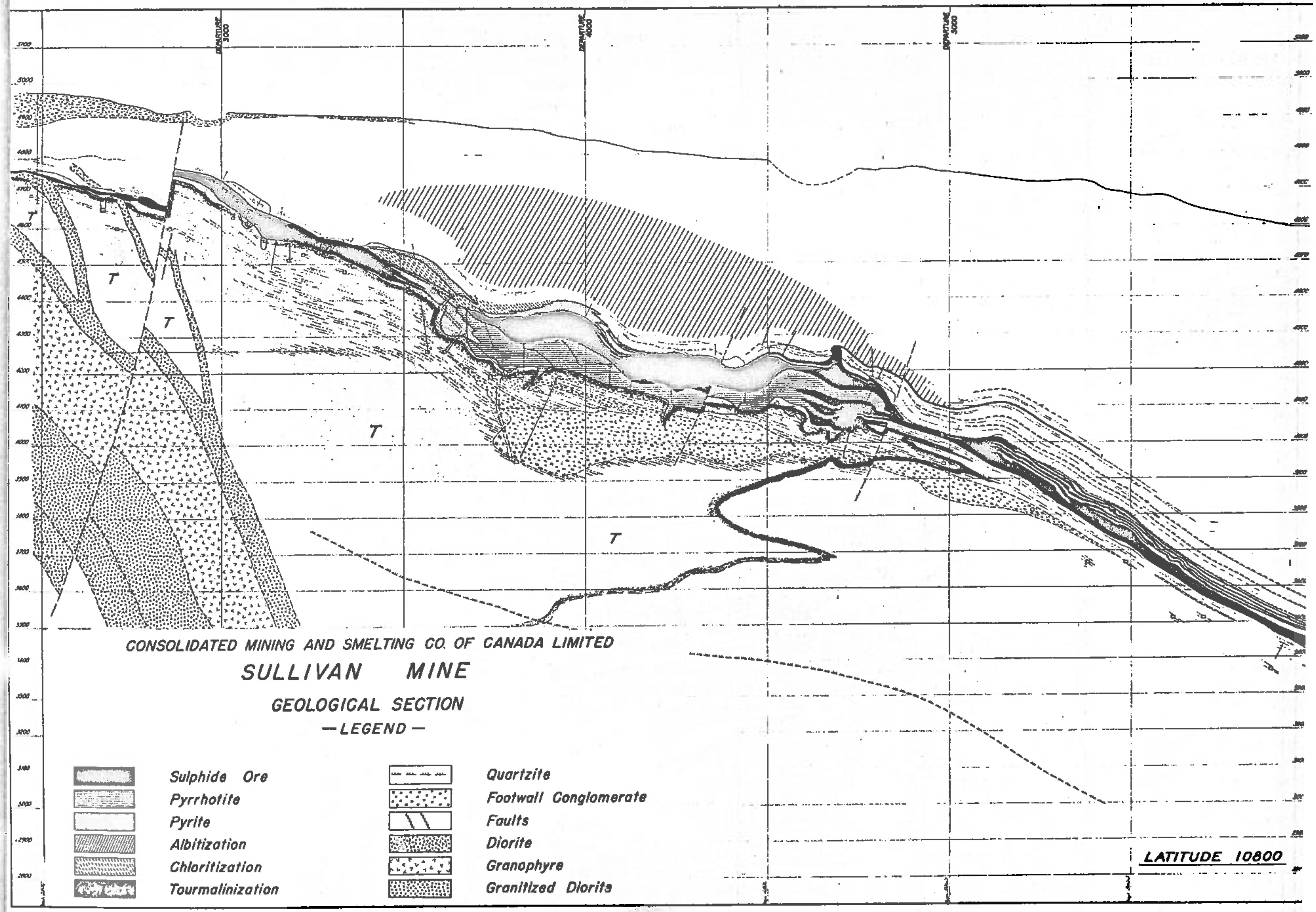

DEPARTURE 3000
DEPARTURE 4000
DEPARTURE 5000
T
CONSOLIDATED MINING AND SMELTING CO. OF CANADA LIMITED
SULLIVAN MINE
GEOLOGICAL SECTION
—LEGEND—
Sulphide Ore
Pyrrhotite
Pyrite
Albitization
Chloritization
Tourmalinization
Quartzite
Footwall Conglomerate
Faults
Diorite
Granophyre
Granitized Diorite
LATITUDE 10800

FIG 46

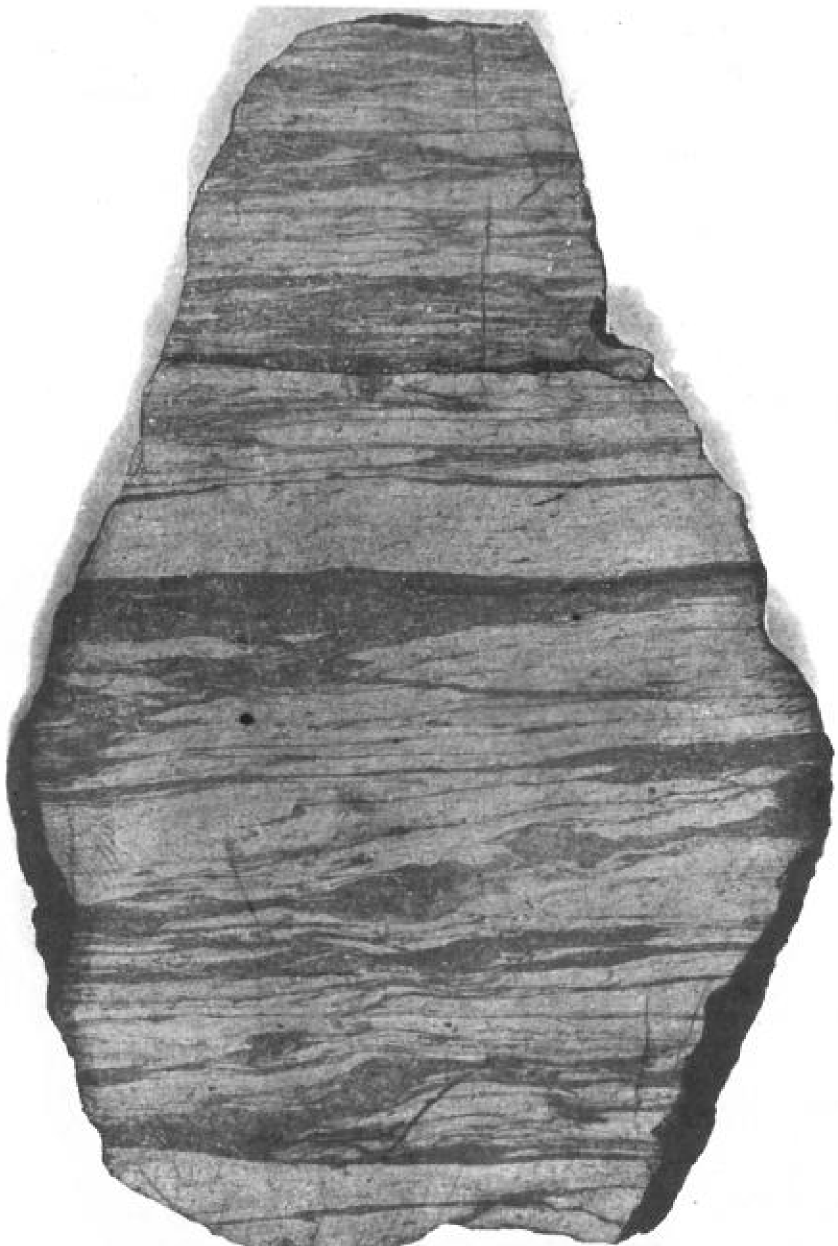


FIG.47 *Photograph of banded sulfide ore from the Rammelsberg district, Germany. Natural size.* (from Park & MacDiarmid 1964)

APPENDIX 1

ANALYSES, STREAM SEDIMENTS - ORIENTATION SURVEY

SAMPLE NUMBER	MESH FRACTION	WEIGHT g.	Pb p.p.m. Cx	Pb p.p.m. Hx	Zn p.p.m. Cx	Zn p.p.m. Hx	Cu p.p.m. Cx	Cu p.p.m. Hx	Ag p.p.m. Cx	Ag p.p.m. Hx
19	- 14+ 44	28.5	600	1500	1000	1500	30	75	0	2
	- 44+ 75	12.5	500	1750	600	1000	18	50	0	2
	- 75+140	54.8	400	1500	400	700	18	50	0	2
	-140+220	30.2	400	1500	400	700	14	50	0	2
	-220	24.1	500	2000(2000)	500	700(800)	14	50(75)	0	2
20	- 14+ 44	24.5	10	14	16	30	0.5	2	0.5	0.5
	- 44+ 75	11.5	7	14	18	35	3	6	0	0
	- 75+140	11.3	10	16(20)	20	35(30)	3	6(6)	0	0
	-140+220	3.9	20	30	30	50	6	6	0	0
	-220	6.2	20	35	40	75	7	8	0	0
21	- 14+ 44	67.7	500		500		14			
	- 44+ 75	30.0	500		500		14			
	- 75+140	14.0	700		800		18			
	-140+220	6.3	800		800		25			
	-220	8.6	1000		1000		30			
22	- 14+ 44	10.2	700		600		40			
	- 44+ 75	31.7	400		350		16			
	- 75+140	30.3	500		400		20			
	-140+220	26.5	500		400		20			
	-220	18.0	600		350		20			
23	- 14+ 44	43.7	75		250		3			
	- 44+ 75	26.0	125		300		3			
	- 75+140	21.3	150		400		5			
	-140+220	12.8	250		700(800)		6			
	-220	14.4	300		1250(1000)		10			
24	- 14+ 44	71.0	30	35	75	100	2	5	0	0
	- 44+ 75	50.2	40	50(40)	75	125(100)	3	7(8)	0	0
	- 75+140	33.9	50	70	125	175	6	12	0	0
	-140+220	14.8	50	75(75)	150	250(200)	5	14(12)	0	0
	-220	22.4	75	150	200	350	4	18	0	0
25	-14+ 44	11.6	50		100		4			
	- 44+ 75	6.5	125		175		6			
	- 75+140	4.5	100		150		8			
	-140+220	3.6	125		200(175)		7			
	-220	4.7	125		175(175)		9			

SAMPLE NUMBER	MESH FRACTION	WEIGHT g.	Pb p.p.m. cx	Pb p.p.m. hx	Zn p.p.m. cx	Zn p.p.m. hx	Cu p.p.m. cx	Cu p.p.m. hx
26	- 14+ 44	56.6	20		40		3	
	- 44+ 75	38.9	20		75		5	
	- 75+140	23.3	35		100		5	
	-140+220	7.5	16		75		5	
	-220	12.6	50		125		7	
27	- 14+ 44	130.4	10		14		2	
	- 44+ 75	23.3	12		25		3	
	- 75+140	19.0	16		50		3	
	-140+220	9.6	20		50		5	
	-220	10.1	22		50		4	
28	- 14+ 44		0		2		1	
	- 44+ 75		0		2		1	
	- 75+140		5		2		1	
	-140+220		0		3		2	
	-220		0		2		2	
29	- 14+ 44	41.0	18	30	200(150)	100(110)	6	12
	- 44+ 75	27.9	16	25	50	75	6	10
	- 75+140	27.2	18	25	60	75	5	10
	-140+220	13.6	18	35	60	100	6	16
	-220	20.1	25	60	80	150	18	20
30	- 14+ 44	62.1	7	50	60	100	6	20
	- 44+ 75	19.1	12	35	60	100	12	35
	- 75+140	27.4	10	25	30	100	10	40
	-140+220	25.4	10	25	30	100	10	40
	-220	17.4	10	25	35	100	12	40
32	- 14+ 44	75.2	5	18	2	35	2	30
	- 44+ 75	30.1	5	14	2	25	4	20
	- 75+140	23.9	5	12	3	25	6	18
	-140+220	24.9	6	18	4	50	10	35
	-220	11.9	7	30	6	70	12	40
41	- 14+ 44	30.0	7	35	10	70	10	35
	- 44+ 75	68.4	6	18	9	60	12	30
	-75 +140	17.8	5	12	9	50	12	25
	-140+220	62.5	5	16	6	80	10	40
	-220	31.3	5	25	12	100	16	50
48	- 14+44	37.5	2	10	14	35	250	350
	- 44+ 75	46.6	4	10	12	20	200	250
	- 75+140	60.7	5	14	14	20	125	175
	-140+220	16.6	5	25	16	40	150	250
	-220	12.7	10	27	30	60	300	350

APPENDIX 1 cont.

NOTES: (a) Figures in brackets are repeat analyses.

(b) cx indicates extraction with cold 1M HNO_3.
hx indicates extraction with hot 25% HNO_3.

(c) Because repeat analyses as outlined in Appendix 2 involve errors up to 23%, all analyses are quoted to the following significant figures;-

0.5	10	20	100	500	1000
1	12	25	125	600	1250
2	14	30	150	700	1500
3	16	35	175	800	1750
4	18	40	200		2000
5		50	250		
6		75	300		
7			350		
8			400		
9					

APPENDIX 2

Random Repeat Analyses, Hot 25% HNO_3 Extraction

Sample Number	Fraction	Pb p.p.m.			Zn p.p.m.			Cu p.p.m.		
		orig	repeat	Error	orig	repeat	Error	orig	repeat	Error
19	-220	2100	2400	+12.5%	680	774	+12 %	61	66	+ 7.6%
20	- 75+140	17	20	+15 %	34	32	- 5.9%	6.5	6.5	0.0%
24	- 44+ 75	49	38	-23 %	113	98	-13 %	7	8.5	+17.5%
24	-140+220	77	75	- 2.6%	230	200	-13 %	13.5	12.5	- 7.4%

APPENDIX 3

GEOCHEMICAL STREAM SEDIMENT SURVEY, -75 MESH FRACTION

COLD 1M HNO_3 EXTRACTION

SAMPLE NUMBER	Pb p.p.m.	Zn p.p.m.	Cu p.p.m.	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
1				-	W	floor of adit Aclare Mine
2				-	D	tailings near Smelter
3				-	D	" " "
4				-	D	gully 5ft wide, 3ft deep
5	500	800	18	-	D	"
6				+	D	"
7				-	D	tailings
8				-	D	from gully
9				-	D	tailings
10	400	800	12	-	D	Scott's Ck top few inches near right bank
11	300	800	9	-	D	" "
12	350	700	12	+	W	" from full width
13	100	150	10	++	W	" " "
14	7	25	5	-	W	" near left bank
15	5	50	5	-	W	" " "
16				-	D	steep slope draining Aclare
17				-	D	" " "
18				-	D	" " "
19	200	200	8	-	D	" just before Mt Barker C
20	14	25	5	-	W	Mt Barker Ck active sedimen
21	800	900	25	-	W	" " "
22	500	400	20	++	W	semi-active sediment
23	200	700	7	-	W	active sediment
24	50	150	5	+	W	" "
25	100	175	8	+	W	some bank material
26	40	100	6	++	W	semi-active sediment
27	18	50	4	-	W	active sediment
28	2	2	2	-	D	active sandy sediment
29	20	75	9	++	W	" ; live & dead shells
30	10	30	10	-	D	active sediment

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
31	5	8	18	++	D	probably much bank material
32	6	4	9	+	D	
33	5	2	3	++	D	
34	7(10)	12(14)	25(25)	++	D	
35	7	2	7	+++	D	
36	5	8	14	+	W	
37	2	1	7	++	D	some bank material
38	5(7)	5(4)	50(30)	+	D	
39	5	6	20	+	W	near outcrop with Cu stainin
40	5(4)	10(14)	50(40)	++	W	
41	5	8	12	+	D	
42	2(4)	14(18)	40(30)	+	W	
43	0	6	20	+	D	
44	0	2	2	+	D	
45	1	3	3	+	D	
46	2(4)	14(12)	75(50)	++	W	
47	2(4)	8(9)	25(20)	+	D	possible contam by galvanize iron wire fence
48	6	16	150	+	D	adjacent to house
49	0	7	100	+	D	" " Cu prospect
50	0	5	5	+	D	
51	0	1	6	+	D	
52	2	10	5	+	W	many shells
53	1(7)	12(16)	1(3)	+	W	
54	0	3	2	+	D	
55	0	2	4	+	D	
56	0	3	4	+	D	
57	0	1	10	++	D	
58	0	5	8	+	D	
59				–	D	clayey calc. material; vein in schist adjacent to fault.
60	8	7	6	–	W	
61	10	10	9	–	W	
62	9	8	10	–	W	
63	8	4	4	+	W	
64	6	3	6	+	W	

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
65	14(10)	5(7)	10(6)	++	W	
66	14(10)	2(2)	6(5)	+	W	
67	10	2	4	+	W	from edge stream;rabbit burr...
68	10	2	4	+	W	
69	8	2	6	+	W	
70	7	2	6	++	W	
71	9	6	3	+++	W	
72	7	7	8	+	W	
73	8	8	6	+	W	
74	10	10	8	+	W	
75	4	2	5	+	W	
76	7	4	5	+	W	
77	10	10	6	++	W	
78	10	8	6	+	W	
79	8(10)	12(9)	12(8)	+	W	
80	6(4)	14(12)	9(9)	+	W	
81	75(50)	18(16)	10(9)	+	W	
82	20(10)	30(30)	16(10)	-	W	
83	35(25)	5(7)	6(5)	-	W	
84	10	9	6	+	W	
85	2	3	4	+	W	
86	0	2	4	+	W	
87	0	4	4	+	W	
88	0	10	10	++	W	colluvium opp bank to Cu prospect
89	0	2	4	+	W	
90	2	30(20)	14(8)	++	W	Mt Barker Ck semi-active se...
91	5	25(16)	5(6)	++	W	" " "
92	0	6	2	+	W	" " "
93	5	16(14)	4(9)	++	W	" " "
94	0	25(18)	6(8)	++	W	" " "
95	0	18(14)	5(10)	++	W	" " "
96	0	3	1	+	W	
97	0	3	2	+	W	
98	0	1	4	+	W	
99	0	3	7	+	W	

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
100	0	5	6	+	W	
101	0	2	7	+	W	
102	0	3	12	++	W	
103	0	7	16	++	W	
104	0	3	3	++	W	
105	0	1	0	-	W	
106	0	1	1	+	W	
107	0	6	7	+	W	
108	0	3	6	++	W	
109	0	7	5	+	W	
110	0	4	5	+	W	
111	0	3	7	+	W	
112	2	9	3	+	W	bank material
113	5	10	4	+	W	
114	0	2	2	+	W	
115	2	3	0	++	W	
116	20(20)	2(1)	4(9)	+	W	
117	0	4	3	-	W	
118	5	3	3	-	W	
119	0	3	5	+	W	
120	0	5	7	++	W	
121	0	4	5	+	W	
122	0	1	12	++	W	
123	0	6	7	+	W	
124	0	4	4	+	W	
125	0	5	5	++	W	
126	0	2	7	++	W	
127	0	1	1	-	D	colluvium
128	0	1	3	+	D	
129	0	1	2	-	D	colluvium across gully, 10ft deep
130	0	1	3	-	D	" "
131	0	1	0	-	D	" "
132	0	1	3	-	D	" "
133	0	1	4	-	D	" "

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
134	0	1	4	-	D	
135	10(14)	18(14)	10(6)	+	W	
136	7	5	5	+	W	
137	7	9	5	++	W	
138	16	30(25)	6(7)	+	W	
139	20(35)	30(25)	2(5)	+	W	
140	6	7	2	-	W	
141	5	2	0.5	-	W	
142	10	9	0.5	-	W	
143	10	6	5	+	W	
144	5	6	2	+	W	colluvium + some A horizon
145	10	7	10	+	W	
146	10(14)	12(9)	10(9)	-	W	
147	14(14)	25(16)	16(12)	+	W	
148	5	2	10	++	W	
149	5	3	2	+	W	colluvium + A horizon; rabbit burrows
150	7	8	10	+++	W	
151	7	6	8	+	W	
152	5	2	3	+	W	
153	2	3	2	-	W	
154	2	2	1	+	W	
155	5	0.7	6	+	W	
156	5	1	2	-	W	
157	5	5	2	-	W	
158	6	5	6	+	W	
159	16(14)	16(10)	35(25)	+	W	
160	14(20)	3(3)	75(75)	-	W	
161	5	2	2	-	W	gully 11ft. high in colluviu
162	5	2	5	-	W	
163	5	1	5	-	W	
164	5	1	6	-	W	gully 3ft. high in colluvium
165	6	1	2	-	W	" "
166	6	3	2	-	W	
167	7	5	5	-	W	
168	6	2	5	-	W	
169	7	5	6	+	W	

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
170 (&)	5	1	3	-	W	
171	3	1	6	-	W	
172	5	2	5	+	W	
173	5	2	2	-	W	
174	3	3	3	+	W	
175	5	3	3	-	W	
176	5	1	5	-	W	gully 3ft. high in colluvium
177	7	1	5	-	W	gully 10ft high 10ft wide in colluvium
178	5	0.5	5	-	W	
179	5	0.5	20	-	W	gully 4 ft high in colluvium
180	2	0.7	2	-	W	
181	7	3	5	-	W	gully 4 ft high in colluvium
182	5	2	2	-	W	" "
183	10	10	5	+ +	W	
184	7	3	5	+ +	W	
185	5	9	5	+	W	
186	10(10)	35(40)	6(7)	+	W	
187	7	10	5	+	W	
188	7	5	5	+	W	
189	5	2	2	+	W	from rabbit burrow, mid gully.
190	2	3	1	-	W	
191	2	1	0	-	W	
192	10	4	2	-	W	
193	2	4	1	+	W	
194	5	5	2	-	W	
195	5	5	2	+	W	
196	7	6	2	-	W	
197	5	5(5)	*25(2)	+	W	
198	5	7	5	-	W	
199	5	5	3	-	W	soil greenish, rich in mica.
200	5	4	5	+ +	W	
201	5	12(10)	3(5)	+	W	
202	6	10	1	+	W	
203	6	4	2	+	W	
204	5	3	5	+	W	

SAMPLE NUMBER	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
205	2	2	2	+	W	
206	5	3	5	−	W	colluvium
207	5	5	2	−	W	
208	7	7	2	+	W	
209	2	3	3	−	W	
210	5	6	5	−	W	
211	6	7	3	++	W	
212	2	1	0	+	W	
213	5	5	3	+	W	
214	2	1	2	+	W	reworked colluvium
215	5	2	2	+	W	" "
216	7	6	6	+	W	white clay present
217	5	4	5	−	W	
218	2	0.5	2	−	W	downstream from galvanised wire fence
219	2	3	2	−	W	
220	2	2	2	−	W	
221	2	2	2	−	W	
222	5	2	3	−	W	
223	1	1	3	−	W	
224	2	4	3	−	W	
225	5	5	3	−	W	
226	2	0.5	3	+	W	colluvium
227	5	1	5	+	W	mostly colluvium
228	5	5	2	+	W	
229	7	2	2	+	W	

SAMPLE NUMBER (resampled)	p.p.m. Pb	Zn	Cu	PRESENCE ORGANIC MATTER	WET OR DRY	OTHER NOTES
79	4	9	6	+	W	
80	10	16	10	+	W	
81	14	30	12	+	W	
82a	16	16	10	-	W	just below pyritic schist
82b	75	14	18	-	W	decomposed pyritic schist
82c	20	10	5	+	W	above pyritic schist
83	12	7	3	-	D	
83a	14	3	6	+	D	
84	5	12	4	++	W	

NOTES: (a) * This analysis was proved incorrect by repeat analysis.

(b) Figures in brackets are repeat analyses.

(c) Figures are quoted within the significant figures listed in Appendix 1.

APPENDIX 4

Metal Contents of Pyritic Schists, p.p.m.

Sample No.	Pb	Zn	Cu	Notes
PS 0	25	100	8	See below (a)
PS 1	300	250	250	Surface outcrop, chips across.
PS 2	40	40	16	" " " "
PS 3	1250	30	75	chip sample across width of exploratory pit.
PS 4	250	150	175	surface outcrop, chips across.
PS 5	250	40	20	" " " "
PS 7	125	100	30	" " " "
PS 10	40	100	20	gossanous pyritic schist on dump of exploratory shaft
PS 10A	125	150	30	" " " " " " " "
PS 11	600	600	30	" " " " " " " "

Notes:

(a) P.S. 0 is a sample of quartzite from near stream sediment sample locality 80. This was analysed to give some idea of metal content in the surrounding rocks.

(b) Location of samples is shown on Fig. 16.

(c) Metal extraction from powdered rock by 60% $HClO_4$ at fuming point for one hour.

APPENDIX 5

ASSAYS - ACLARE MINE

	Locality	Source	Pb %	Zn %	Cu %	Ag oz/ton	Au dwt/ton	Width
1.	Lode outcrop	Jones (1912)	5.8	0		26.75	1	
			0	0		4.7	1	
2.	Surface to 30ft. (oxid.. ore)	Singleton (1887)	50			90		
3.	30 to 140ft.	"	some	40		60-302		
4.	120ft. level	Rosewarne (1889)	6	35		32		
5.	120ft. level hangingwall	"	10	trace		58	33	8ft
6.	ore parcel 120ft. below adit.	Mathews (1900)	10	25		30		7ft
7.	adit level, strike length 130ft.	Stockdale (1906)	10.0	12.4		29.4		
8.	below adit level	"	31	20		112		18-24ins
9.	N face from 300ft to 180ft level	"	12.6	33.5		48.8		
10.	362 tons, Dry Ck. smelters	"	10	24		48		
11.	1650 tons, E. & A. Copper Co.	"	12.6	not kept		39		
12.	1200 tons, Block 14 Co.	"	11.9	25-30		36.35		
13.	Lode along adit	Jones (1912)	0	1.1		trace	0	5ft
14.	" " "	"	6.7	8.9		2.5	0	5ft
15.	" " "	"	8.5	12.3		2.2	trace	5ft
16.	" " "	"	0	4.4		2.8	2	5ft
17.	" " "	"	0	12.9		1.5	trace	5ft
18.	" " "	"	9.8	12.2		18.2	1	5ft
19.	" " "	"	8.1	14.8		14.7	2	5ft
20.	S face below adit level	"	28.1	16.4		47.0	3	
21.	S face below adit level	"	0	trace		trace	trace	veins 4 to 8 ins
22.	S face below adit level	"	35.2	8.8		3.1	1	
23.	Approx average mined ore below adit level	McDonald (1937)	12	12		32		4ft

	Locality	Source	Pb %	Zn %	Cu %	Ag oz/ton	Au dwt/ton	Width
24.	footwall side, N face 66ft below adit level	McDonald (1937)	22.7	34.2		47.2	4	
25.	6 tons ore from drive below adit level	"				58	3	
26.	boulder from stope above adit level	"	42	21.6		39.4	1	
27.	100ft below adit & 200ft S of shaft	Armstrong (1938)	2.9	10.9		12.3	trace	3½ft
28.	90ft below adit & 150ft S of shaft	"	2.3	16.2		14.0	trace	2½ft
29.	ore parcel	Abell & Gartrell (1938)	5.87 (other: Fe 5.38%, As 1.01%, $SO_4^=$ 0.19%, $S^=$ 8.35%, gangue 64.5%)	9.36		8.5	1.4	
30.	N face at main shaft adit level	Askins (1968)	1.5	3.0	0.05	2.1		10ft
31.	specimen A3, from dump	"	5.0	9.5	0.09	20.0		
32.	specimen A4, from dump	"	10.5	11.0	0.02	21.2		
33.	specimen A5, from dump	"	10.0	17.5	0.15	20.0		
34.	Tailings near old plant.	Jones (1912)	trace 0	6.1 2.6		11.25 7.25	1 1	

APPENDIX 6

ASSAYS - SCOTT'S CREEK MINE

Locality	Source	Pb %	Zn %	Cu %	Ag oz/ton
1. Dressed ore, 35 tons	Record Mines, (1908)	50-60			45-55
2. Specimen SC 1, from dump	Askins (1968)	4.5	1.5	0.22	10.9
3. " SC 2, " "		1.6	1.2	0.05	1.9
4. " SC 3, " "		3.5	3.0	0.09	8.8

APPENDIX 7

ASSAYS - OLD STRATHALBYN MINE

	Locality	Source	Pb %	Zn %	Cu %	Ag oz/ton	Au dwt/ton	S %	Width
	A. SOUTH END								
1	dressed ore	Austin (1863)	18.5			16.5			
2	bottom drive, vein on hangingwall side	Mathews (1907)	8	20.4		8			18-24 ins
3	bottom drive, bulk sample hangingwall side	"	0.5	7.9		0			4ft
4	ditto footwall side	"	0	1.6		0			
5	ore parcel, Send shaft	"	8	12		7			
6	bulk sample ore dumps from sinking of shaft	"	3	5.7		1.6			
7	hang'wall side of lode	"	0.8	1.8		0.7			
8	drive at 50ft level	Jones (1913)	0.7			16			12ins
9	ditto	"	0.6			16			12ins
10	schistose ore, h'wall side	"	15.4		0.3	9.9	trace		1ft
11	schistose ore, centre	"	4.9			7.1			2ft
12	schistose ore, f'wall side	"	1.7			16	1		2ft
13	schistose ore, 15ft level drive	"	0.5	2.0		6.5	1		2ft
14	ore on dump from newer shaft	"	6.7	25.0		4.9			
15	ore on dump from older shaft	"	1.2	0.75	0.2	1			
16	ditto	"	1.5	0	0.3	6	1		
17	dump		0	4.9	0.1	0.1	2		
18	gossan, dump	Cochrane (1952)	1.7	1.2	0.1	2.5	5.5		

No.	Locality	Source	Pb %	Zn %	Cu %	Ag oz/ton	Au dwt/ton	S %	Width
19	gossan, dump	Cochrane	0.5	0.3	0.3	0.5	1		
20	gossan in rail cutting near S end of lode	(1952) "	2.3	1.0	0.7	0.1	0		2ft
21	Bore 1 204-206¾	Cochrane (1954)	0	0.9	0.1	0	1	10.1	
22	" -210¼	"	0	3.2	0.1	0	3	24.6	
23	" -218¾	"	0	1.0	0.1	0	1	6.4	
24	" -226	"	0	0.7	0.2	0	0.5	9.6	
25	" 234-238	"	0	4.3	0	0	0	16.1	
26	Specimen ST2 from dump	Askins (1968)	0.2	1.5	0.01	0.2			
27	Specimen ST3 from dump		4.0	17.0	0.01	4.6			
28	Specimen ST4 from dump		3.5	4.0	0.01	1.5			
	B. <u>NORTH END</u>								
29	dump	Cochrane (1952)	0	0.5	12.1	1.5	0.5		
30	Cu carb. ore at 8ft depth	Jones (1913)			13.2	0.8			2ft
31	ditto	"			5.1	0.5			
32	dump	"			5.0	0.4	1		

APPENDIX 8

X-RAY DETERMINATION - MENEGHINITE FROM SPECIMEN A11. Cu Kα radiation

measured 2θ	Intensity	d, Å	Meneghinite ASTM 8-7 d, Å	Meneghinite ASTM 8-7 Intensity	Galena ASTM 5-0592 d, Å	Galena ASTM 5-0592 Intensity
21.5	M	4.13	4.10	30		
22.9	W	3.88				
23.8	S	3.74	3.70	90		
24.1	W	3.69				
24.7	W	3.60				
25.5	S	3.49	3.52	10		
26.1	M	3.41			3.429	84
27.2	S	3.28	3.29	100		
29.0	M	3.08	3.07	10		
30.2	W	2.96			2.969	100
30.65	S	2.92	2.91	80		
32.3	M	2.77				
32.7	W	2.74	2.74	40		
33.7	M	2.66	2.64	30		
37.1	VW	2.42	2.41	10		
37.9	M	2.37				
39.3	M	2.29	2.30	10		
40.2	M	2.24	2.24	30		
41.4	M	2.18	2.19	30		
42.5	VW	2.13	2.12	10		
43.8	S	2.07	2.07	50	2.099	57
44.8	VW	2.02	2.02	5		
46.0	S	1.97	1.967	40		
47.0	M	1.93	1.935	10		
48.2	S	1.89	1.875	40		
49.3	M	1.85	1.846	10		
50.5	M	1.81	1.799	20	1.790	35
51.5	M	1.77	1.779	10		
52.4	M	1.75	1.735	5		
53.2	S	1.72	1.717	40	1.714	16
54.4	W	1.68	1.687	5		
56.4	W	1.63				
57.3	VW	1.61				
59.8	VW	1.55	1.537	10		
62.0	VW	1.50	1.497	5		
62.8	W	1.48	1.480	10	1.484	10
63.2	W	1.47				
64.5	W	1.44	1.438	10		
65.5	M	1.42	1.423	10		
67.0	S	1.40	1.396	30		
71.0	W	1.33	1.327	10	1.362	10
71.9	VW	1.31			1.327	17
73.4	VW	1.29				
75.6	VW	1.26				
77.1	W	1.24	1.240	20		
78.5	VW	1.22			1.212	10
80.0	S	1.20	1.196	50		
84.6	W	1.14	1.140	10		
87.5	W	1.11	1.119	10		

Note: (a) One of the likely contaminants from the polished section is galena; this checks well for some of the extra lines.

(b) VW very weak: W weak: M medium: S strong.

APPENDIX 9

(A) X-RAY DETERMINATION - (?)BEUDANTITE FROM SPECIMEN A13, ACLARE MINE

Cu Kα radiation

Measured 2θ	d, Å	Intensity	Jarosite ASTM (10-443) d, Å	Jarosite Intensity	Alunite ASTM (2-0703) d, Å	Alunite Intensity	Beudantite ASTM (11-147 d, Å	Beudantite Intensit
			5.94	30				
15.3	5.79	S	5.74	20	5.70	20	5.89	70
16.0	5.54	VW						
17.9	4.95	W	5.09	40	4.92	40		
24.8	3.59	M	3.65	10	3.50	20	3.63	40
25.6	3.48	W					3.46	10
29.1	3.07	VW	3.11	60				
29.4	3.04	S	3.08	100			3.05	100
30.5	2.93	M	2.97	10	2.96	100	2.95	40
31.8	2.81	M	2.870	20	2.85	5	2.79	40
35.7	2.51	M	2.547	30	2.47	3	2.52	30
38.3	2.35	W					2.35	10
39.4	2.29	VW	2.292	50			2.29	10
39.9	2.26	M			2.24	50	2.25	70
40.4	2.23	W						
46.2	1.96	S	1.978	50			1.96	40
			1.941	20				
			1.913	10				
50.3	1.81	S	1.823	50	1.89	50	1.82	40
52.1	1.75	VW			1.74	50	1.74	40
54.0	1.70	W	several				1.68	10
55.0	1.67	W	weak		1.65	5	1.66	30
56.2	1.64	VW	lines					
59.6	1.55	W			1.56	3		
60.5	1.53	M	1.539	30				
			1.512	30				
62.1	1.49	M	1.484	10	1.48	60		
62.9	1.477	W						
65.8	1.419	W			1.44	3		
66.5	1.406	W						
67.8	1.382	VW			1.37	20		
70.5	1.335	M			1.32	3		
74.1	1.279	VW			1.29	20		
76.7	1.242	M						
78.4	1.219	W			1.20	20		
80.8	1.189	W						
83.5	1.158	W			1.16	5		
84.6	1.145	M			1.13	20		
					1.07	10		
					0.95	10		

Note: There is possibly a continuous series between alunite and jarosite, and an unknown degree of substitution to form minerals like beudantite. Hence there are probably many variations in d-spacings and intensities. The published figures for beudantite agree best with the specimen (which may be a mixture of several similar minerals). The d-spacings for natroalunite and hidalgoite do not correspond to those of the specimen.

Compositions of these minerals are:

Alunite	$K\ Al_3(SO_4)_2(OH)_6$
Natroalunite	$(Na,K)Al_3(SO_4)_2(OH)_6$
Jarosite	$K\ Fe_3(SO_4)_2(OH)_6$
Beudantite	$Pb\ Fe_3(AsO_4)(SO_4)(OH)_6$
Hidalgoite	$Pb\ Al_3\ (AsO_4)(SO_4)(OH)_6$

(B) X-RAY DETERMINATION:- ALUNITE-JAROSITE-BEUDANDITE SPECIMEN PS 3, EXPLORATORY PIT

Several photographs of this mineral were taken on the small (57mm dia.) camera. These were compared with photographs of jarosite, alunite and beudantite, which are available in the Department. There were several lines of each of these minerals in the specimen, some of them coincident. Therefore the specimen is probably a mixture of these minerals, or a species intermediate between the three.

APPENDIX 10

LIST OF THIN SECTIONS, POLISHED SECTIONS, etc.

Specimen Number	Polished Section	Thin Section	Assayed	X-ray Determination	Locality
1(a)	x	x			Underground Aclare Mine
1(b)		x			" " "
2	x				Aclare Mine dump
3	x	x	x		" " "
4	x	x	x		" " "
5			x		" " "
6	x				" " "
7	x				" " "
7A	x				" " "
8	x				" " "
8A	x				" " "
9	x				" " "
A10	x				From folded ore specimen Aclare Mine dump
A11	x	x			From folded ore specimen Aclare Mine dump
A12	x				From folded ore specimen Aclare Mine dump
A13				x	Aclare ore outcrop
*KM 3(a)	x				Aclare Mine dump
*KM 3(b)	x				" " "
*KM 4	x				" " "
SC 1	x	x	x		Scott's Creek Mine dump
SC 2	x	x			" " " "
SC 3	x	x	x		" " " "
SC 4	x		x		" " " "
SC 5	x	x	x		" " " "
*KM 6	x	x			Scott's Creek Mine dump
ST 1	x	x			Old Strathalbyn Mine dump
ST 2	x	x	x		" " " "
ST 3	x	x	x		" " " "
ST 4		x	x		" " " "
PS 3				x	From pyritic schist, exploratory pit
PS10	x	x			From dumps beside exploratory shafts
PS10A	x				From dumps beside exploratory shafts
PS11	x	x			From dumps beside exploratory shafts

Note: *These specimens are catalogued and are housed in the Department's collection. All others were collected during this study.