



PROGRESS

REPORT

NOVEMBER 1986

**CONTROLS ON GOLD AND SILVER
GRADES IN VOLCANOGENIC
SULPHIDE DEPOSITS
(84/P210)**

**GEOLOGY DEPARTMENT
UNIVERSITY OF TASMANIA**



Australian Mineral Industries Research Association Limited

11th Floor, 63 Exhibition Street
Melbourne, 3000 Australia
Telephone (03) 654 8844 Telex AA 38530
Fax (03) 654 8661

DT

17th November, 1986

CONTROLS ON GOLD AND SILVER GRADES IN VOLCANOGENIC SULPHIDE DEPOSITS
(84/P210)

TOWN HOUSE
139 WILSON STREET
BURNIE TAS 7320

MONDAY 17TH NOVEMBER, 1986, AT 8.00 P.M. AT THE TOWN HOUSE
TUESDAY 18TH & WEDNESDAY 19TH NOVEMBER, 1986 ON WEST COAST TASMANIA

ATTENDANCE LIST

Aberfoyle Limited	R. Paterson D. Wallace G. Mcarthur D. Jack
Balcooma Joint Venture	B. Stainforth K. Harvey
The Broken Hill Proprietary Co. Ltd.	P. Gregory A. Clarke D. Windrim D
Billiton Australia Limited	D. Hall
BP Minerals Australia	C. Laughton
CSR Limited	R. Fountain R. Williams
Department of Mines, TAS	A. McNeil R. Bottrill G. Green
Electrolytic Zinc Company of A/Asia Limited, C/- North Broken Hill Holdings Limited	S. Taylor I. Mathison
Pancontinental Mining Limited	K. Airas
Gold Fields Exploration Pty. Limited	P. Roberts L. Newnham
	F. Fitzgerald T. Cartwright
University of Tasmania	R. Large P. McGoldrick P. Ruxton S. Adrichem Kihn Zaw D. Huston S. Huns I. Gordon R. Wedekind
AMIRA	J. D. Bailey



CONFIDENTIAL

AMIRA REPORT

NOVEMBER 1986

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INTRODUCTION

Restatement of Aims:

To investigate the geological and geochemical controls on the distribution of precious metals within volcanic hosted massive sulphide deposits, with the objective of developing exploration models useful for the discovery of further precious metal-rich deposits.

Background:

Due to the high concentration of gold and silver in the Western Tasmanian volcanogenic deposits, the project has initially concentrated on the documentation and study of gold-silver accumulation along the Mt. Read Volcanic Arc. A four pronged approach has been adopted on the Tasmanian deposits.

- 1) Detailed studies of precious metal geology and geochemistry at Rosebery and Que River, the two richest deposits.
- 2) Geology and geochemistry of a barren sulphide system, Lake Selina, to evaluate why some volcanic hydrothermal systems are devoid of precious and base metals.
- 3) A study of gold mineralisation along the Henty Fault Zone, a major structure which dislocates the Mt. Read Volcanic Arc and has been the focus of hydrothermal activity.
- 4) Research into the chemistry of the Mt. Read Volcanics to determine whether there is a relationship between gold mineralisation and volcanic rock chemistry (either primary or alteration chemistry).

To compliment the Tasmanian studies, three Western Australian Archean volcanogenic deposits (Gossan Hill, Scuddles, and Teutonic Bore), and a Queensland deposit (Balcooma) have been included in the project for comparative purposes.

This Report:

This second major report marks 15 months of research since commencement of the project in August 1985. The first report (April 1986), dealt mainly with research on;

- geology, structure, and metal distribution of the PQ lens and P-north lens at Que River.
- a chemical data base for the Mt. Read Volcanics.

This report covers further research developments on the Tasmanian deposits plus a comprehensive section on the Archean massive sulphides. Progress this year has been excellent and I would like to give special thanks to all the AMIRA team members at the University of Tasmania for their dedication, support, and fine standard of research.

Ross Large
Project Leader

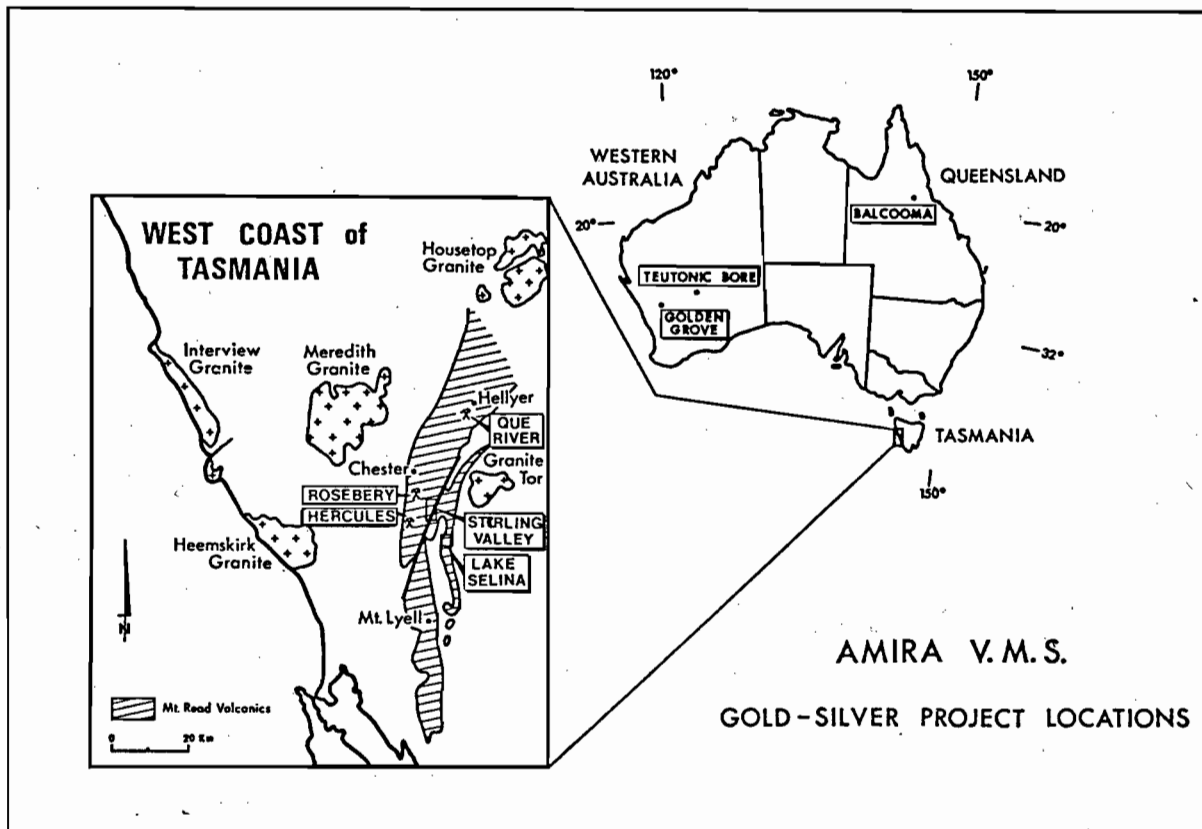


TABLE 1 : Tonnage-grade data for Australian VMS deposits included in this study.

DEPOSITS	TONNES	CU	PB	ZN	AG	AU	AG/AU
	MT.	%	%	%	ppm	ppm	
W. TASMANIA							
ROSEBERRY	19.4	0.74	5	16.2	155	2.9	53.4
HERCULES	2.6	0.42	5.2	16.7	159	2.7	58.9
QUE RIVER-PQ LENS	2.1	0.45	9.2	16.2	241	4.4	54.8
-P NORTH LENS	0.4	0.43	6.5	10.8	189	2.9	65.2
-S LENS	0.6	1.5	2.2	6	63	0.3	210.0
HELLYER	19	0.4	7	13	160	2.3	69.6
MT. LYELL-BLOW	5.6	1.3	-1	-1	61	2	30.5
-WEST LYELL	58.3	0.72	0.01	0.04	2	0.24	8.3
-PRINCE LYELL	17.4	1.2	0.01	0.04	3	0.38	7.9
-NORTH LYELL	4.8	5.3	-1	-1	33	0.39	84.6
W.A. ARCHEAN							
GOSSAN HILL-CU	15	3.4	0.05	0.1	14	0.1	140.0
-ZN	1.7	0.4	1.6	14	87	2.2	39.5
SCUDDLES-MS	18.6	0.81	0.68	9.5	78	1.2	65.0
-STRINGER	7.5	2.1	0.1	0.6	12	0.3	40.0
TEUTONIC BORE-MS	1.4	4.2	1.2	16.4	203	0.2	1015.0
-STRINGER	0.75	2.4	0.1	1.9	52	0.2	260.0
QUEENSLAND							
BALCOOMA-CU	3.5	3	-1	-1	-1	-1	
-ZN	0.5	0.6	5.3	11.3	64	0.4	160.0
MT. CHALMERS-M	3.2	1.8	0.1	0.7	11	1.8	6.1
-WEST LODGE	0.4	1.7	1	3.5	42	3	14.0
MT. MORGAN	50	0.72	0.05	0.1	6	4.75	1.3
* -1 means no reliable data							

SUMMARY OF PROJECTS

Footwall Precious Metal Zone at Que River

(Peter McGoldrick and Ross Large)

Que River is the richest massive sulphide deposit in Australia in terms of gold, silver, and base metals (see Table 1). In the previous AMIRA report, Large and McGoldrick demonstrated that the PQ lens is folded in a tight isoclinal structure, with gold (from 5 to 30 g/t) concentrated along the syncline axes. Anomalous levels of gold and silver (about 0.5 to 2 ppm and 10 to 80 ppm respectively) also occur in a "stringer-like" alteration zone footwall to the PQ lens in the northern, down plunge, part of the mineralising system. The precious metal zone occurs in a sequence of coarse to medium grained fragmental volcanics and is associated with a characteristic style of "white-mica" alteration which appears to post date an early phase of K-feldspar alteration. Preliminary studies suggest a link between the gold concentration and K-feldspar - white mica - sphalerite alteration. Such an association is unusual in massive sulphide systems, but common in epithermal deposits. Further work is required to determine the genesis of the zone; a number of working models are under investigation.

Rosebery F Lens

(Khin Zaw)

Huston and Large (1986) reported on gold and silver distribution in the northern Rosebery ore lens at the previous AMIRA meeting. Khin Zaw has recently commenced a Ph.D. study on the geology and geochemistry of the southern-most mineralisation in the F lens intersected in the 1985 deep drilling programme. This project will concentrate on resolving the genetic relationship between base and precious metal massive sulphide mineralisation in F lens, and the superimposed pyrrhotite - magnetite - tourmaline assemblage, which appears to be cross cutting and later.

Gold Along the Henty Fault Zone, Sterling Valley

(Ian Gordon)

Gold - arsenic vein-style mineralisation of probable Devonian age occurs in the Sterling Valley within volcanic and shale host rocks adjacent to the Henty Fault Zone. Mineralogical and geochemical studies on the basalt hosted veins drilled by E.Z. Co. suggest two distinct episodes of mineralisation. The first is pre-deformation with a high Au/As ratio and low base metals. The second is post-deformation (probably Devonian granite related) with a low Au/As ratio and enrichment of tin and base metals.

A Barren Sulphide System - Lake Selina

(Steve Hunns)

The Lake Selina prospect is a large pyrite-rich hydrothermal system on the eastern side of the Mt. Read Arc. Because of the intense hydrothermal alteration it has not been possible to map the rocks according to their primary volcanic character. However a combination of surface mapping and drill core logging has enabled the compilation of an alteration map of the prospect. Three major alteration zones have been recognised;

- K-feldspar zone
- chlorite $\pm$ magnetite $\pm$ pyrite zone
- sericite - quartz $\pm$ pyrite zone

The K-feldspar alteration appears to be early and is over printed by later chlorite and sericite/quartz alteration. The prospect lies 5 km along strike from the Murchison Granite. Granite and associated quartz porphyry intrusives have been intersected in some of the deeper drill holes at Selina. The spatial relationship of the mineralisation to granite, the K-feldspar bearing alteration zone, and the trace metal characteristics of the mineralisation (high Mo, low Au/Ag, low zinc number), indicate that it is not part of a VMS system but more likely to be a Cambrian porphyry-style system.

Primary and Alteration Chemistry of the Mt. Read Volcanics

(Ross Large, Anthony Crawford, and Sharon Adrichem)

The chemical data base for the Mt. Read Volcanics has been extended by the addition of analyses from the Que River area (David Whitford, CSIRO) and the Rosebery area (Winfried Naschwitz, Ph.D. Thesis, Univ. of Tasmania). Ti/Zr variation diagrams have been used to study magmatic differentiation trends in the volcanics, and discriminate hydrothermal trends related to mineralisation. This work suggests that rather than a continuous calc-alkaline trend (rhyolite-rhyodacite-dacite-andesite-basalt), there exists four major regional chemical groups. Two distinct groups occur in the Central Volcanic Sequence (Queenstown to Pinnacles), while another two groups occur in the Que-Hellyer volcanic sequence. The relationship between mineralisation and the eruption of these groups, in space and time, appears to have important exploration implications.

Archean Massive Sulphides in Western Australia

(Peter Ruxton)

Peter Ruxton spent two months in Western Australia between June-August working on the Scuddles and Teutonic Bore deposits.

The *Scuddles* Zn-Pb-Ag-Cu-Au massive sulphide deposit is stratabound and underlain by a blanket

stringer zone. It is a particularly high grade deposit by Australian standards (see Table 1). Footwall and host rocks consist of felsic epiclastics with hanging wall rhyodacitic lavas. The dominant mineralogy is sphalerite, pyrite, chalcopyrite, galena, magnetite, and pyrrhotite. Gold and silver are confined to the massive sulphide lens. The distribution of silver, zinc, and lead is similar. Gold is preferentially concentrated in the transition zone between massive sphalerite and massive pyrite ore types. Copper is spatially separate from the other metal zones and concentrated in the footwall.

The *Teutonic Bore* Zn-Pb-Ag-Cu deposit is gold deficient (see Table 1). The deposit consists of a massive sulphide lens underlain by a stringer sulphide pipe. Mineralisation is hosted by altered tholeiitic basalts which overlie a graben structure developed in calc-alkaline felsic volcanics. Silver distribution follows zinc and lead. Minor silver occurs with copper in the stringer zone.

The Balcooma Deposit, North Queensland

(David Huston)

Balcooma is a metamorphosed and structurally complex massive sulphide system hosted by probable Paleozoic meta-sediments and meta-volcanics, 400 km by road northwest of Townsville. Study of the deposit will enable an understanding of precious and base metal mobility in VMS systems under high metamorphic conditions. Field mapping, drill core logging and structural studies suggest the presence of multiple ore horizons deformed by a refolded recumbent fold. The lower zinc-lead horizon contains minor precious metals while the upper copper-rich horizon is devoid of precious metals (see Table 1).

Gold-Silver Relationships in Australian VMS Deposits

(Ross Large)

Preliminary investigations of base and precious metal grades in the Australian VMS deposits involved in this project indicate some important relationships. In the majority of cases the zinc-rich (and lead-rich) deposits have the best gold and silver grades with an Ag/Au ratio of about 50. At the high zinc end of the scale (>7% Zn) minor increases in the zinc grade can be accompanied by significant increases in the gold grades. Except for Mt. Morgan and Mt. Chalmers, the copper-rich VMS deposits (and stringer zones) usually contain low precious metal values and low Ag/Au ratios.

Kuroko Deposits Data Base

(Peter Ruxton)

A wealth of previous research has been published on the VMS deposits of Japan and it was considered appropriate to summarise this work as the first stage in establishing a world wide VMS data base. A separate report has been prepared on this topic.

In the Kuroko Province, gold and silver are concentrated in the lead/zinc stratabound ore relative to the copper stockwork/stringer ore types (similar to the pattern in Australian deposits). Significant gold occurs in deposits with zinc values in excess of 8%, and lead greater than 1%. Silver-rich deposits contain greater than 5% zinc and 1% lead. Individual ore clusters show characteristic Ag/Au ratios, and copper-rich groups have lower Ag/Au ratios.

PRELIMINARY REPORT ON THE FOOTWALL PRECIOUS METAL ZONE, QUE RIVER

Peter McGoldrick and Ross Large

INTRODUCTION

Initial work at Que River concentrated on elucidating the structure of the orebodies (see Large and McGoldrick in the April 1986 Progress Report). Subsequent examination of drill core from the west of and beneath the ores has revealed hydrothermally altered and/or weakly mineralised andesitic volcanoclastic rocks for some distance away from massive base metal sulphide mineralization. Stringer pyrite mineralization was intersected in QR 87, 300 meters below the massive sulphide ore, enabling an outline of the main stringer pipe zone to be interpreted (Fig. 1). This lends further support to the suggestion that the Que River mine sequence is folded in a synclinal structure (see also Young, 1980 and Komyshan, 1986).

Our recent work at Que River has concentrated on a substantial volume of hydrothermally altered and weakly base metal mineralised volcanoclastics in the footwall of the northern part of PQ lens (Figs 2 and 3). Aberfoyle geologists drew our attention to this zone because it contains anomalous levels of Au and Ag (about 0.5 to 2 ppm and 10 to 80 ppm respectively) and in places it extends more than 50 m to the west of PQ lens (eg., on 7700 N section (Fig. 2a). Hence, this "footwall precious metal zone" (PMZ) may represent a substantial resource of the metals as well as providing important information concerning the geochemistry of Au (and Ag) in massive sulphide-forming systems.

HOST ROCKS OF THE PMZ

The rocks in the immediate footwall of PQ lens are variably altered polymict and monomict volcanoclastics (Wallace, 1982, 1984). Trace elements in these rocks indicate that they are dominantly of andesitic provenience (Wallace, 1984; Whitford et al., in prep.). Although they are commonly poorly sorted and may contain decimeter size boulders the presence of some well sorted horizons suggests that they are epiclastic volcanic deposits (Wallace pers. comm., 1986).

ALTERATION

In the Que River area the Mount Read Volcanics (MRV) have been (burial?) metamorphosed to prehnite-pumpellyite grade. Textures are generally well preserved but primary mineralogies are not. For instance, fine grain and glassy rocks are now devitrified to fine felted aggregates of quartz and feldspar(?) $\pm$ sericite and carbonate. In andesitic rocks primary basic plagioclases have been albitised and/or replaced by

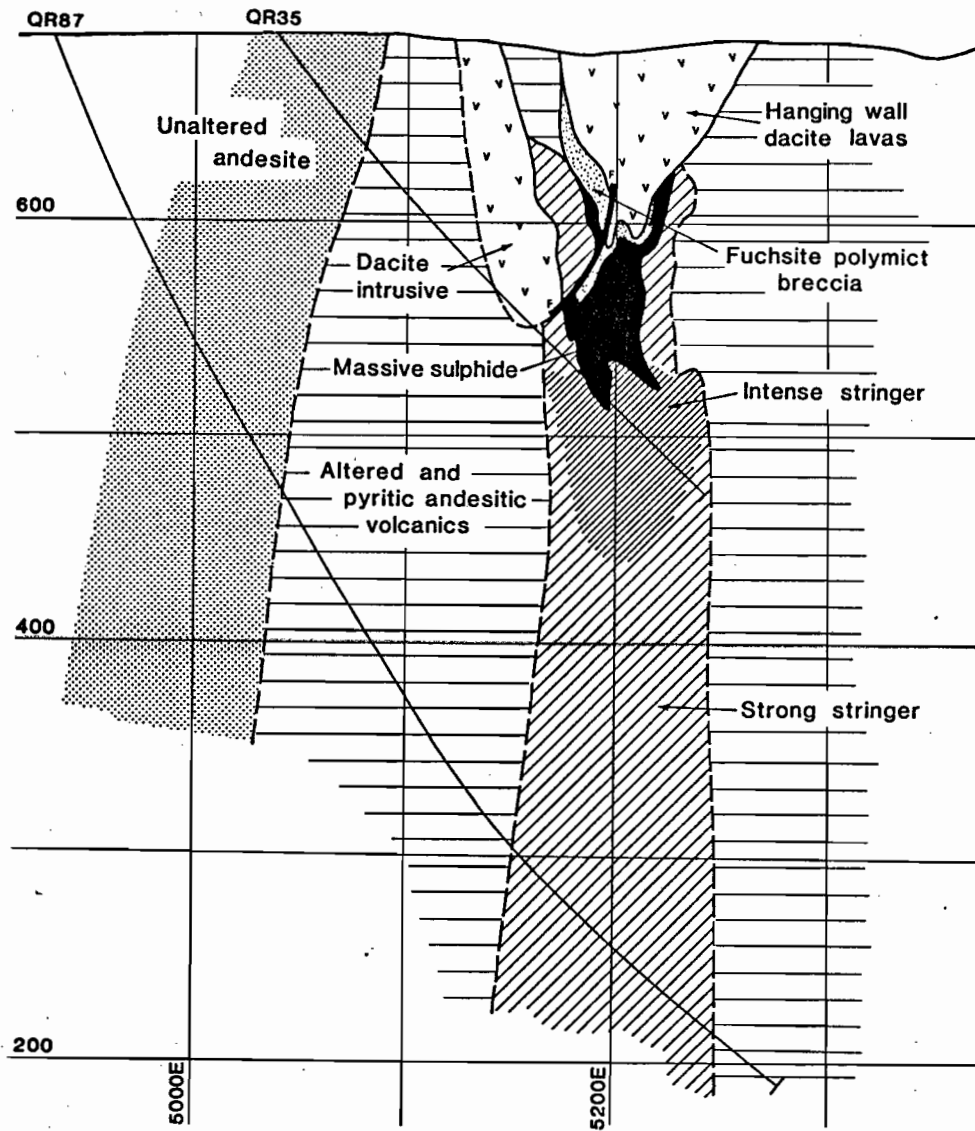
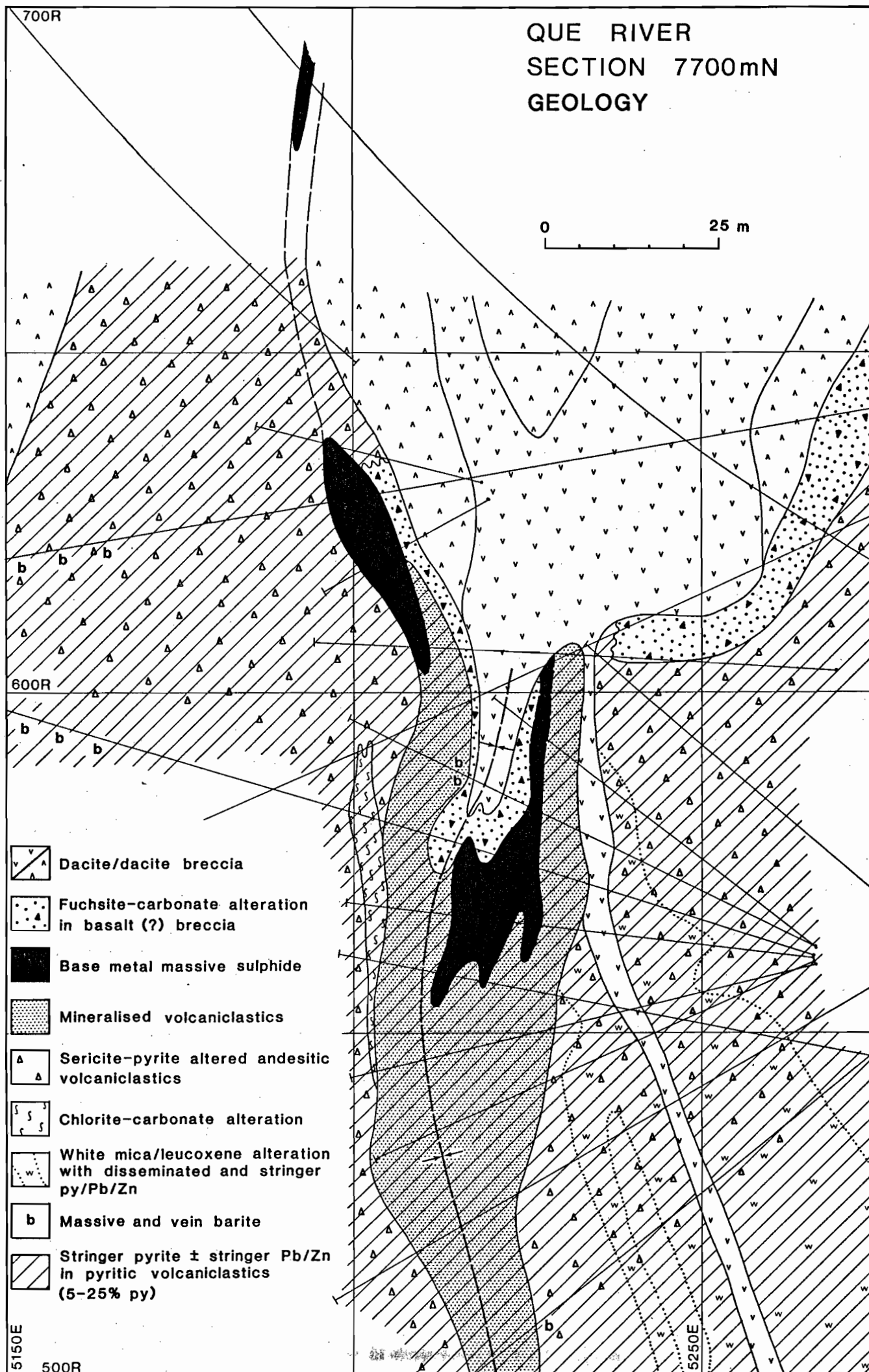
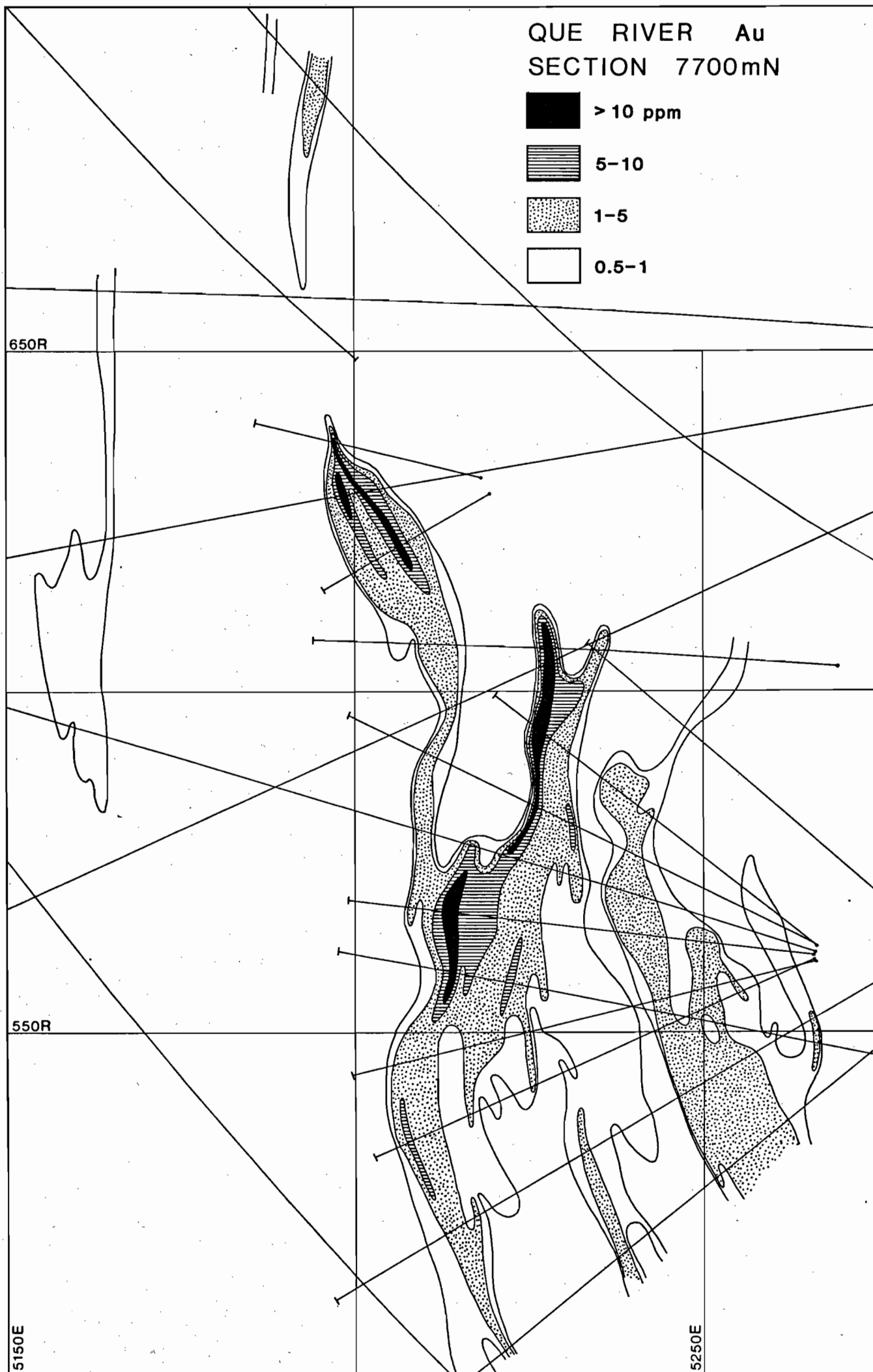


Fig.1 7550 N cross-section showing deep drill holes and the continuation of hydrothermal alteration to the west of and beneath the orebodies.

Fig. 2a





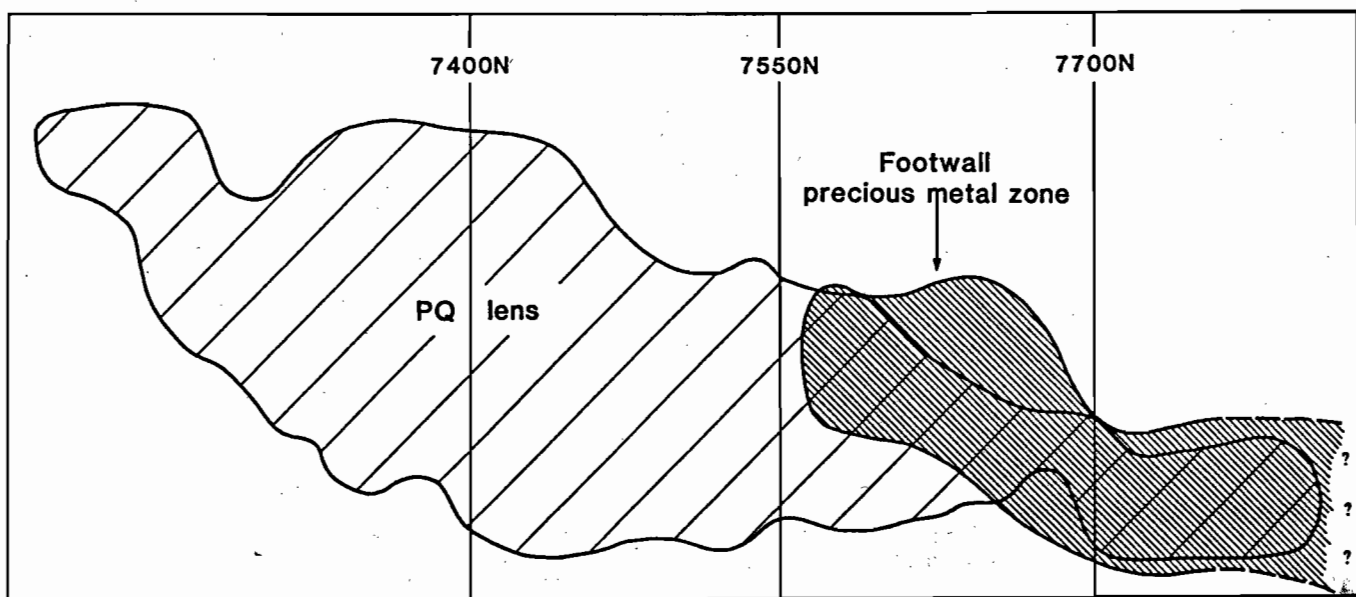


Fig.3 Long section projection of PQ lens showing the approximate position of the footwall precious metal zone.

quartz.

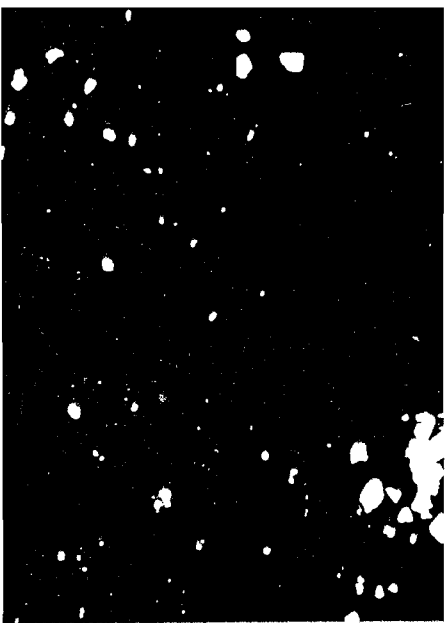
In the vicinity of Que River Mine there is a gradual transition from regionally metamorphosed volcanics to footwall host rocks that have been hydrothermally altered by the mineralizing solutions. Hydrothermal alteration has produced an assemblage sericite-silica-carbonate ($\pm$ base metal sulphides and/or pyrite), with minor but locally important chlorite (Wallace, 1984). In hydrothermally altered rocks to the east and west of the massive sulphide bodies fragmental textures are well preserved in coarser grained lithologies, and finer grained rocks may retain fragmental textures where they have been silicified. In contrast, more sericitic rock types fail to preserve original textures and often show evidence of strong shearing (especially in rocks which have a sericitic matrix to larger fragments). The pyrite and base metal sulphides are present as discrete stringers (<1mm to several centimeters wide) or as disseminations through the altered rock.

This style of alteration is common throughout the footwall rocks of all the Que River orebodies and is clearly not diagnostic of the PMZ. However, footwall rocks with anomalous Au and Ag are often characterised (in hand specimen) by the presence of irregular shaped patches of a cream-white mineral (Fig. 4a and b). The mineral occurs in the matrix and within fragments and is not normally observed elsewhere at Que River. In thin section this white "alteration" consists of an intergrowth of muscovite and poorly crystalline gray-brown semi-transparent mineral (Fig. 4c). This mineral has been identified as leucoxene (D.B. Wallace, pers. comm., 1986), however in reflected light the brown mineral appears to be sphalerite (Fig. 4d). This identification has been confirmed using the electron probe. The distribution of Zn and Ti have been mapped in several patches of "white" alteration. Significant amounts of Zn were observed, more or less evenly distributed, in all the areas that were scanned. In contrast, Ti was not always present and when present it was distributed unevenly through the white alteration. Hence, while some leucoxene may be present in the mine sequence rocks at Que River it is of minor importance in the bulk of the white alteration in the PMZ. The "cream-white" mineral patches are intergrowths of fine sphalerite and muscovite (coarse hydrothermal sericite?).

That this white mineral is a hydrothermal alteration effect is confirmed by its intimate association with some polymetallic stringers. For instance, Figure 4e show a thin stringer with a halo of white alteration extending more than a centimeter into the volcanoclastic host rock. Thin section examination indicates that the halo results from the presence of larger amounts of fine and coarse sericite closer to the sulphide vein (Fig. 4f). Further out from the vein the rock is siliceous and the fragmental texture is well preserved.

A second important characteristic of the PMZ is the presence of two types of feldspar. Electron probe analysis reveal that both types are K-rich potash feldspars (typical analysis: 0.17 wt% Na₂O, 18.70% Al₂O₃, 63.00% SiO₂, 15.50% K₂O, 0.60% CaO, 0.60% TiO₂, 0.50% BaO). This contrasts with footwall volcanic rocks from elsewhere in the mine sequence rocks at Que River and andesites remote from known

- Fig.4
- a) Coarse, poorly sorted andesitic volcanoclastics from the PMZ.
 - b) Two pieces of core from the PMZ showing characteristic creamy-white alteration of fragments in the volcanoclastic host.
 - c) Photomicrograph of a patch of "white alteration" containing coarse sericite intergrown with a dark brown to opaque, poorly crystalline mineral phase. Note the euhedral quartz grain in the lower left of the picture. Plane polarised light, field of view = 2 mm x 1.31 mm.
 - d) Same field of view as c) in reflected light. Blue mineral is sphalerite and the white mineral is pyrite. The euhedral quartz grain noted in c) can just be discerned near the center left of the photograph.
 - e) Polymetallic stringer in a piece of BQ core displaying a well developed haloe of "white alteration".
 - f) Photomicrograph of the vein in e). The vein is mainly quartz, sphalerite and pyrite. It is surrounded by a narrow zone of strong (sericite-rich) alteration, but fragmental volcanoclastic textures are well preserved on either side of the vein. Plane polarised light, field of view = 28 mm x 20 mm.
 - g) Large rectangular potash feldspar in a sample from the PMZ containing numerous opaque inclusions. Plane polarised light, field of view = 0.98 mm x 0.65 mm.
 - h) Large sericitised grain of potash feldspar from the PMZ. Crossed polars, field of view = 1.4 mm x 0.9 mm.
 - i) Same field of view as g) but reflected light. Small white grains within the feldspar are galena. Larger clusters of euhedral white grains are pyrite.



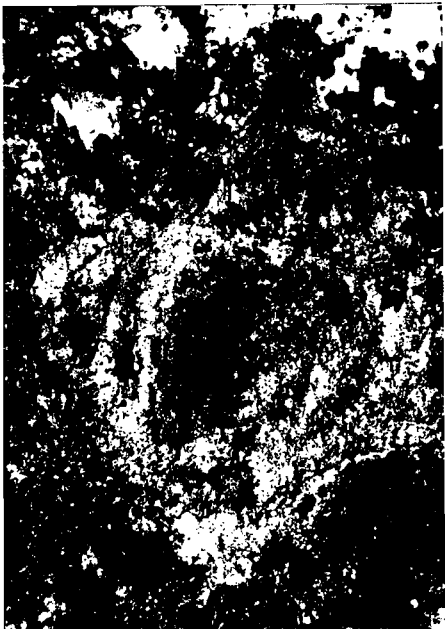
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f



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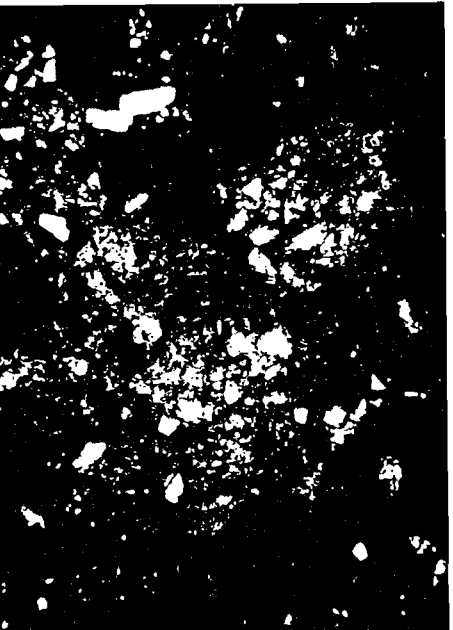
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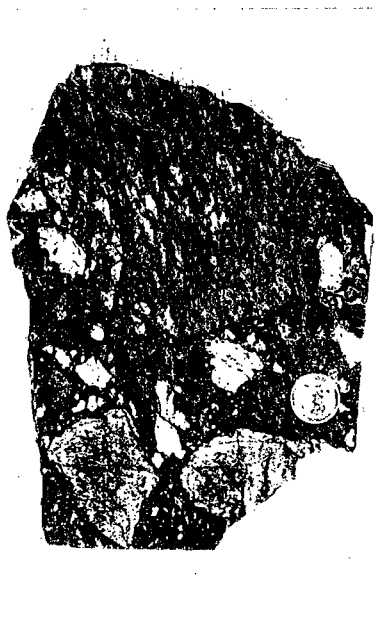
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g



p



a

mineralization in which relic feldspars have been albitised or pseudomorphed by quartz.

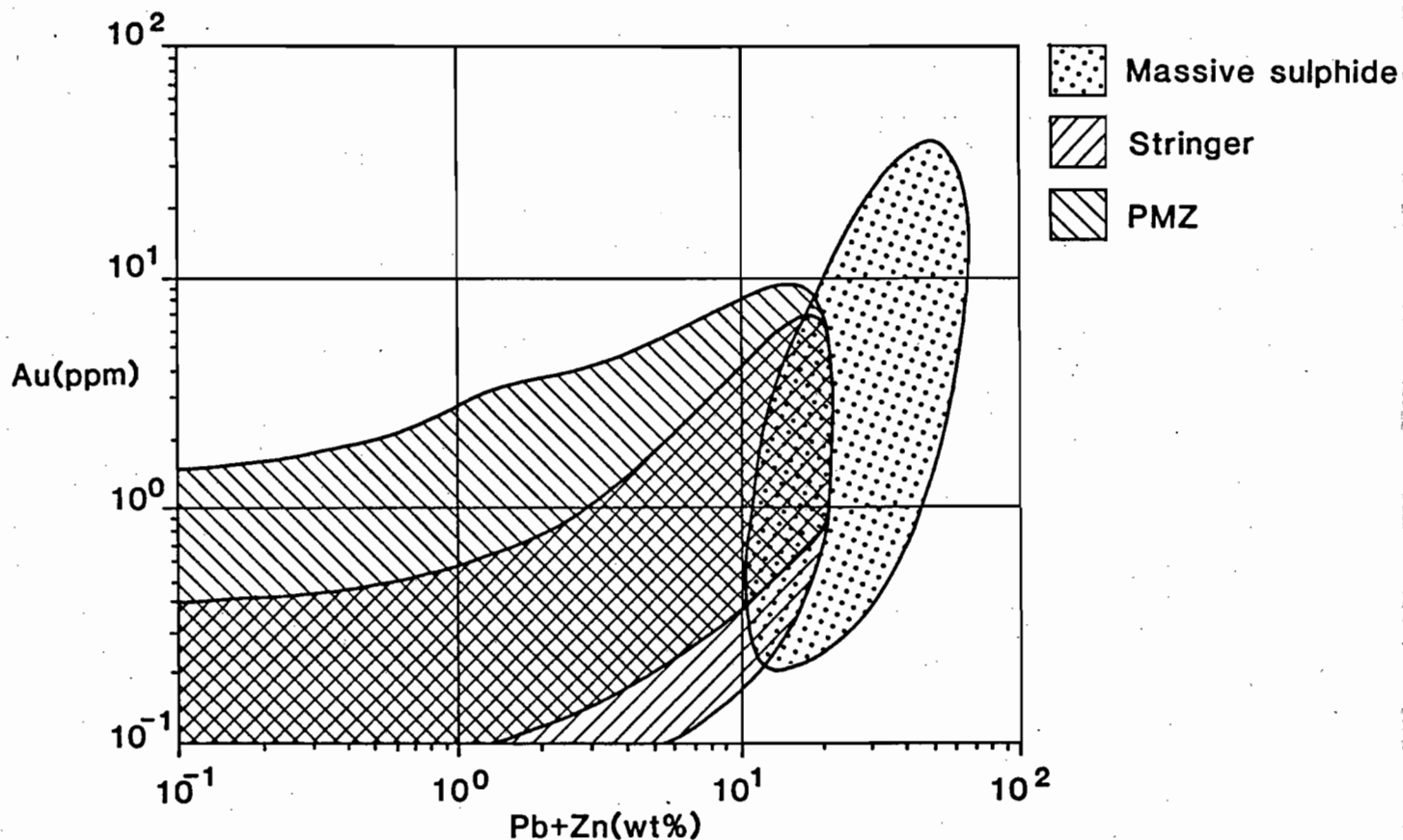
The first type occurs within the more strongly altered parts of the mineralised rocks and are coarse grained (up to several millimeters) with polysynthetic twinning and display an uneven extinction pattern (Fig. 4g and 4h). They are invariably sericite altered to a greater or lesser degree (Fig. 4h) and as a result usually have irregular shapes. Some patches of fine sericite with rectangular outlines are interpreted to have replaced euhedral potash feldspars and indicate that the feldspars were formerly a much more important constituent of these rocks. The second, less common, type of potash feldspar are simply twinned relict phenocrysts commonly observed in less altered domains of the volcaniclastics.

There are two possible explanations for the occurrence of potash feldspars in the the PMZ rocks. Either they are relict primary igneous feldspars (in which case the provenience of the PMZ rocks would have been very unusual high-K volcanics (such rocks have not been previously recognised in the MRV (A.J. Crawford, pers. comm., 1986)) or they are products of hydrothermal alteration of "normal" andesitic footwall rocks. Several observation support the latter alternative, including the close spatial association of the second type of feldspar and the "white alteration". Furthermore, the presence of numerous solid inclusions (including base metal sulphides) trapped along growth bands of the feldspar (Fig. 4i) indicate that sulphides were being deposited simultaneously with the feldspars. Finally, although only a limited number of sections have been examined to date, no potash feldspar has been observed in footwall samples away from the PMZ.

PMZ: MINERALISATION AND GEOCHEMISTRY

The same suite of ore minerals are present in the PMZ as in the massive sulphide lenses (i.e., galena, sphalerite, chalcopyrite, pyrite, arsenopyrite, native gold and tetrahedrite). No native gold has been observed to date in this study however a single grain of electrum was recorded by Creelman and Kinealy (1984). However, pyrite is by far the dominant sulphide and the base metal sulphide content of the rocks is quite variable (at least one thin (15cm) massive sulphide lens has been observed in underground exposures of the PMZ). Although mineralogically similar to "normal" stringer, the PMZ can be distinguished using available assay chemical data. For instance, Figure 5 depicts the Au content as a function of combined Pb and Zn in massive sulphides, the footwall stringer from 7550 N section and samples from the PMZ on 7700 N section. For a significant proportion of the PMZ samples their Au contents are higher (for a given amount of base metal) than the stringer samples. While Au is clearly anomalous in the PMZ it is not clear whether Ag is actually present at levels that are significantly different to those observed in normal stringer or low grade disseminated mineralization (Fig. 6). Furthermore, many PMZ samples have Ag/Au ratios that are smaller than those observed in the stringer and massive sulphides (Fig. 7). Hence, there may be a de-coupling of Au and Ag during metal sulphide precipitation in the PMZ (n.b., more work may be

Fig.5 a) Fields displaying the relationship between Au and Pb+Zn for 200 massive sulphide samples from 7550 N section, 200 footwall stringer samples from 7550 N section, and over 500 samples from the PMZ at 7700 N. Note that the PMZ field extends to significantly higher Au levels than the footwall stringer field.



b) Scattergram from which the fields in a) were derived.

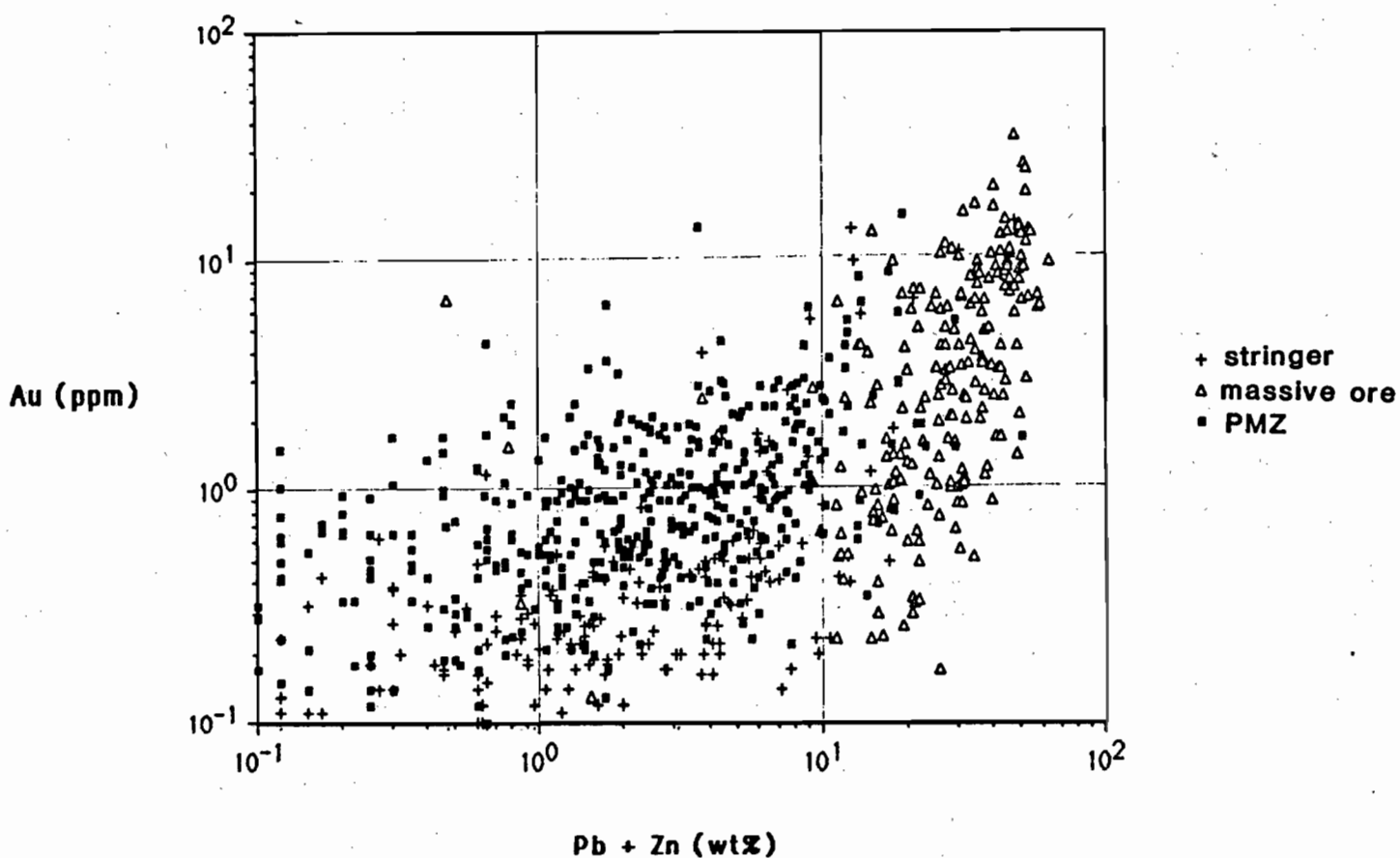
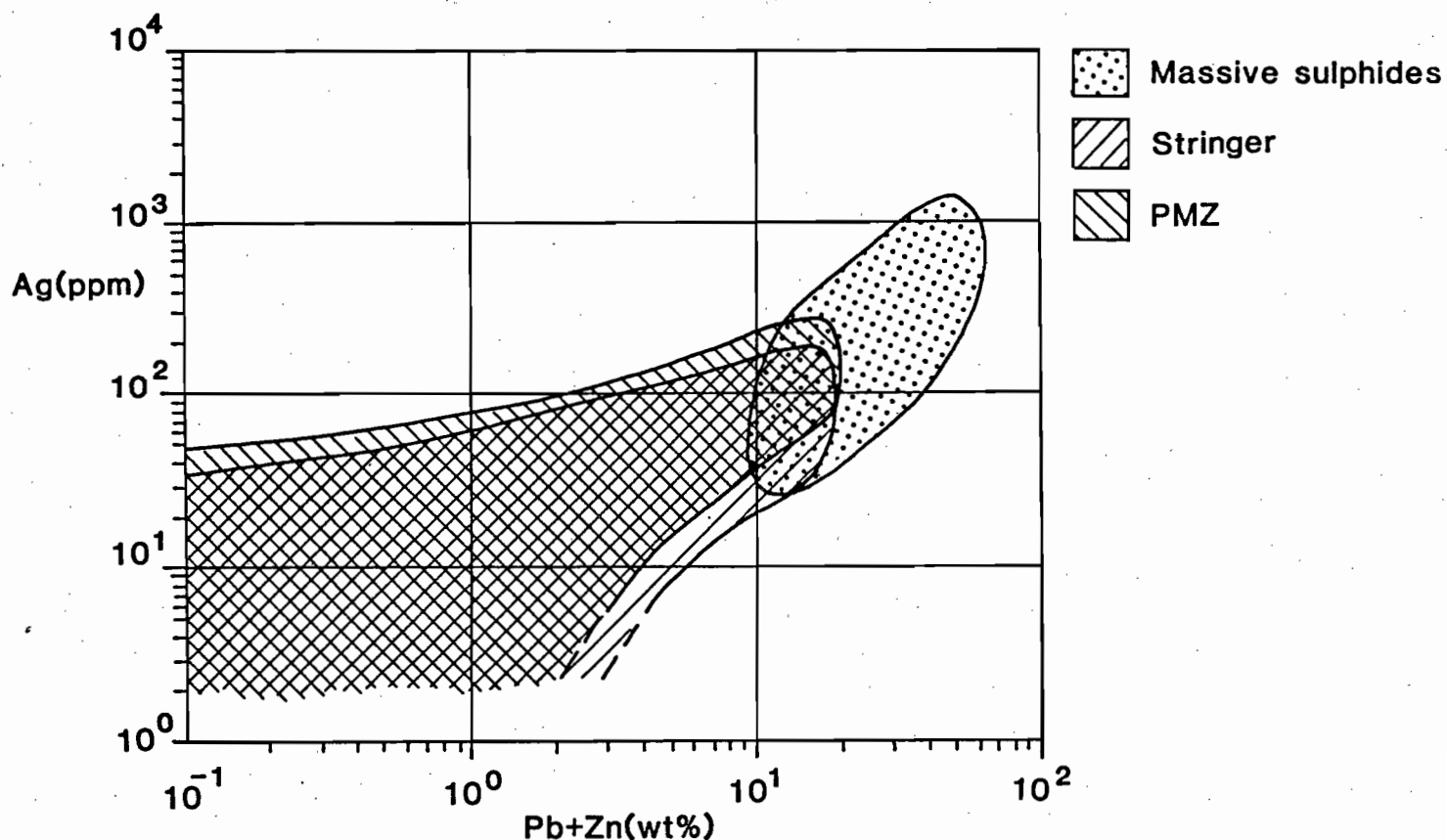


Fig.6 a) Fields displaying the relationship between Ag and Pb+Zn for the same samples as Fig. 6. Note that in this case the stringer and PMZ fields are nearly coincident.



b) Scattergram from which the fields in a) were derived.

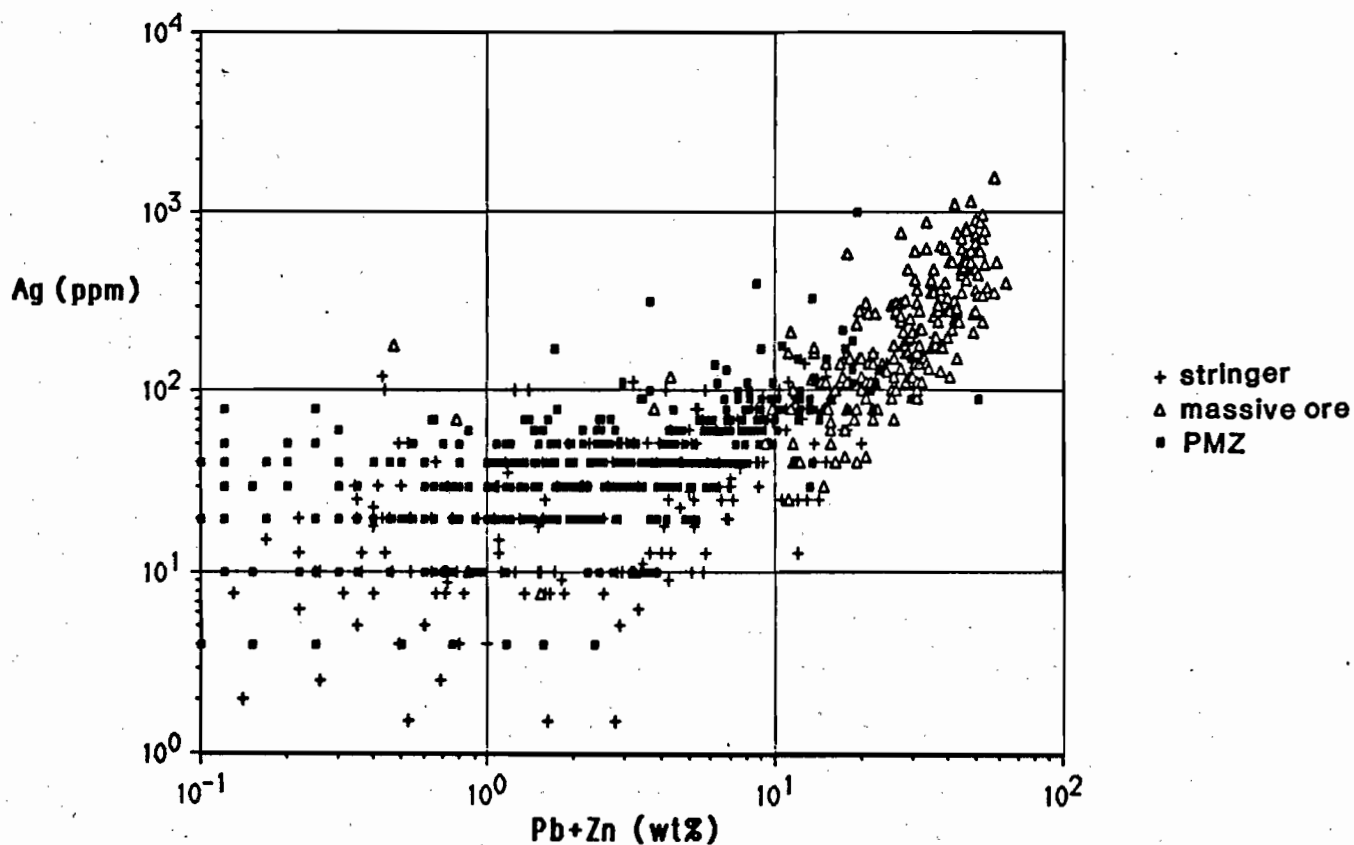
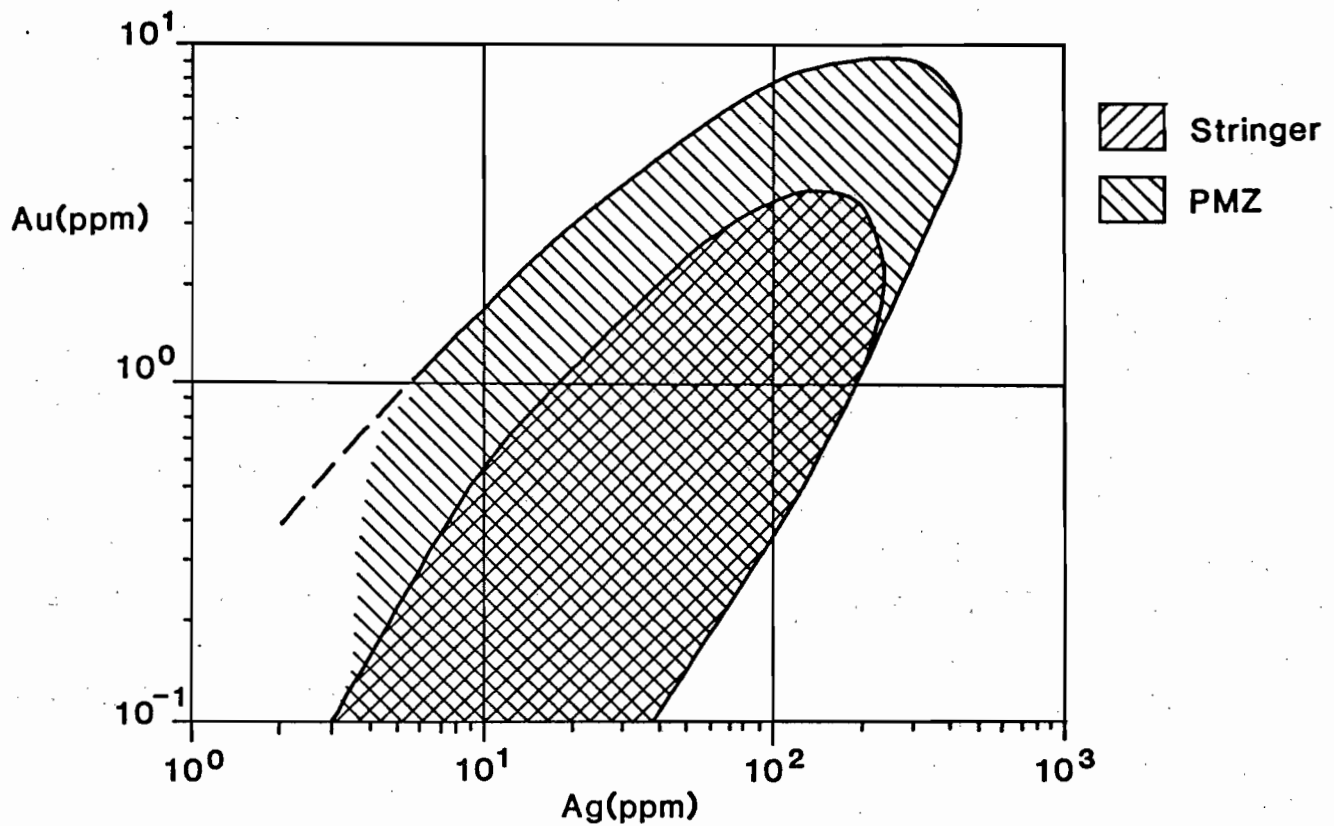
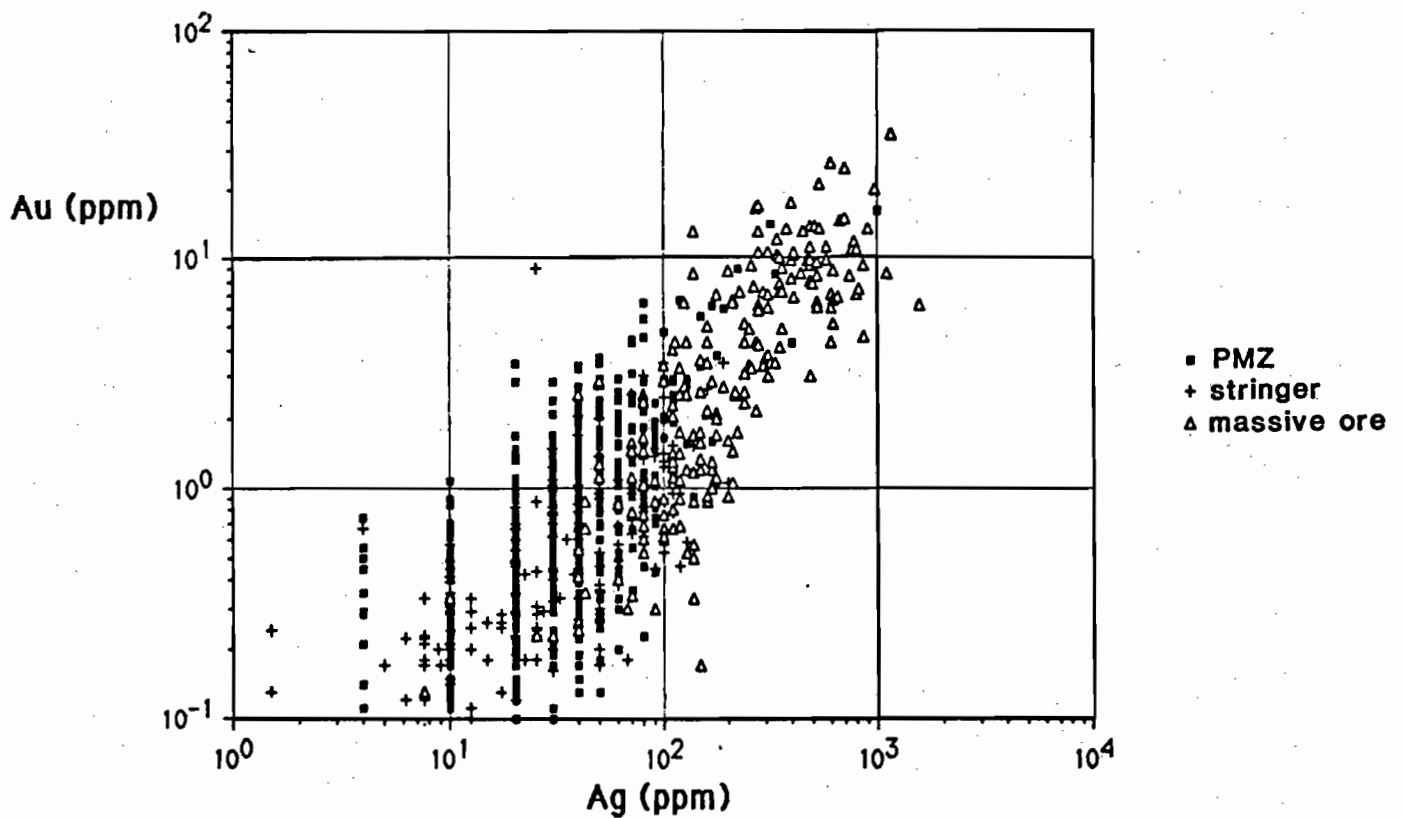


Fig.7 a) Fields displaying the relationship between Ag and Au for samples from the PMZ and the footwall stringer.



b) Scattergrams from which the fields in a) were derived (includes data for massive ores).



needed to confirm that Au has behaved differently from Ag in the PMZ):

MODELS FOR THE FORMATION OF THE PMZ

These preliminary observations make it possible to speculate on the nature and origin of the Que River PMZ and help constrain the direction that further work will take.

The truly anomalous amounts of Au (and possibly Ag) in these footwall rocks indicate that simple dilution of the massive sulphide system by clastic material to produce an extensive stringer and disseminated mineralization zone could not account for the PMZ. If the same solutions and same sulphide precipitation mechanisms as those responsible for the massive ore were involved in forming the PMZ then an overall lower grade mineralization would be expected (eg., some of the lower grade semi-massive ores from the northern part of PQ lens).

Two other general possibilities should be considered; first, the PMZ may have formed from an independent mineralizing system of different character to the massive sulphide-forming system (perhaps using the same "plumbing"). Alternatively, the same solution(s) formed both the massive sulphide and the Au-rich mineralization of the PMZ and physical or chemical changes during the evolution of the system are responsible for the Au enrichment in the PMZ.

Currently, because of similarities between the PMZ and "normal" stringer, its position in the footwall of a massive sulphide and the fact that a more complex sequence of events would be needed to produce two distinct mineralizing episodes the latter suggestion is thought to be more likely.

If the same solutions produced the massive ores, the normal footwall stringer and the PMZ mineralization, then the explanation for the Au enrichment in the PMZ must be related to the way Au was transported in the solutions. At high temperatures Au can be transported as both bisulfide and chloro complexes, but during Pb-Zn massive sulphide precipitation (temperatures of ~250° C) bisulfide complexes dominate (Huston and Large, in prep.). If the stringer mineralization forms from slightly hotter solutions than the massive ore it is possible that conditions are very close to the transition between chloro-complexed and bisulfide-complexed Au transport during sulphide precipitation. Major differences in Au grades might be expected between stringer precipitated from solutions in which Au was chloro-complexed and stringer formed from solutions in which Au bisulfide complexing was dominant.

Another suggestion is that the PMZ may have been a zone of boiling during massive sulphide formation (D.B. Wallace, pers. comm., 1986). Conventional wisdom has it that massive sulphide forming systems do not boil because they form in deep water (eg., Kuroko deposits), however, boiling is a physical process

that would help explain both the potash feldspar alteration and the anomalous Au in the PMZ. Boiling causes the solution pH to increase, hence K-feldspar alteration will be favoured over sericite (later, more acid, solutions would tend to sericitize the earlier potash feldspars). If Au was being transported as a bisulphide complex the sudden loss of H₂S from solution will drastically reduce Au solubility and although base metal solubilities will also be reduced (due to the pH increase) the effect on Au solubility is likely to be much greater. Thus sub-sea floor boiling may result in a Au-rich, potash feldspar-bearing base metal sulphide stringer system.

FURTHER WORK

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To test some of these possibilities the following work is planned for the next six months:

- 1) Complete petrographic work on PMZ samples in order to confirm the "white alteration" and potash feldspar paragenesis .
- 2) Fluid inclusion studies of PMZ samples from 7700 N section and "normal" stringer from 7400 N and 7550 N, with a view to obtaining evidence for boiling and /or hotter solutions in the PMZ.
- 3) Comparative geochemical studies of PMZ and "normal" footwall rocks:
 - a) Analysis of extra geochemical data (As, Sb, Ba, Se, Fe and S) from QR 417 and QR631;
 - b) Major and trace element investigations of "white altered" rocks from the PMZ (see also section by R.R. Large in this report).
- 4) Prepare final report on Que River.

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ROSBERY STUDY - F LENS DEEP DRILLING

(Khin Zaw)

Introduction

A distinct pyrrhotite-magnetite-tourmaline bearing replacement zone superimposed on the primary Zn-Pb-Cu-Ag-Au-Ba mineralization has been recently indicated by the deep-drilling programme at the Rosebery volcanic-hosted massive sulphide deposits, western Tasmania. The aim of this research is to describe the detailed paragenesis of the sulphide and oxide ore assemblages and the replacement mineralogy of the Rosebery south-end orebodies particularly in the F lens, and to determine and demonstrate the controls of the precious metal distribution and conditions of ore formation, together with mineralogical and geochemical characteristics of the deposits which can be applied to exploration.

Methods of study

The methods of investigation will involve the following integrated programme:

- detailed textural investigation, core logging and sample collection of DDH on the selected cross-sections;
- sample collection and examination on mesoscopic and megascopic scales of ore mineral paragenesis and host rock alteration in the accessible underground workings and exposures;
- mineralogical and petrological studies of the collected samples using thin sections, polished rock slabs, and doubly polished thin sections;
- construction of contoured assay cross-sections to understand the distribution of the precious and base metals and their inter-elemental ratios and variations;
- geochemical studies on the compositional variation of ore and gangue minerals and replacement assemblages with electron microprobe analyses;
- fluid inclusion studies with application of heating/freezing stage and possibly infra-red and Laser Raman Spectroscopy to determine -
 - (a) thermal history of the overall ore formation
 - (b) temperature of precious metal deposition
 - (c) composition and salinity of ore fluids

- (d) evidence of the boiling of ore fluids and its relation to precipitation and localization of precious metals
- (e) difference or similarity of the ore fluids characteristics in comparison with other selected VMS deposits in the Mt. Read volcanics;
- stable isotopes (O,H) investigation of the gangue minerals and the inclusion fluids in conjunction with fluid inclusion studies to evaluate the fluid rock ratios and the source and/or sources of waters in the ore fluids;
- possible radiogenic isotopic studies (Pb,Rb,Sr) for the sulphide and sulphate ore assemblages to deduce the provenance of the ore metals.

Progress Report

The writer spent nearly two months reading and understanding the regional geological and tectonic setting of the Rosebery orebodies, local mine geology and structural setting, and previously reported petrological, mineralogical and geochemical characteristics of the ore and alteration assemblages through published and unpublished literature.

The author also spent three weeks at the Rosebery mine-site and made a detailed core logging and sample collection of diamond drill holes (81R, 82R, 88R, R16525, R1651, R1840, R1770) on 200 mS, C69R, R1440, R1452, R1830) on 100 mS and (R1477, R1527) on 300 mS sections together with initial underground geological investigation and sampling along 16 level (No. 2 sub-level) and 17 level.

Preparation of thin sections and doubly polished sections of the collected samples are underway. Preliminary investigation of available doubly polished thin sections demonstrate the presence of polyphase fluid inclusions in the ores (sphalerite, barite) and gangues (quartz, calcite, fluorite) in the Rosebery deposits.

STERLING VALLEY PROJECT

Ian Gordon

Introduction

The aims of this project as stated in the previous report (84/P210 April 1986) are to examine the occurrence of mineralisation along the Henty Fault Zone (HFZ) south of Tullah, with a view to understanding the gold distribution along the belt. Mineralisation takes several forms in and around the Sterling Valley. All occurrences are structurally controlled, localised in shear-zones and cleavage. Three broad classifications are recognised in the field. The intermediate to basic volcanics west of the HFZ are host to fracture controlled sulphide rich vein type mineralisation. These veins are sub-parallel to the HFZ, and range in thickness from 1 to 20 cms. The drill-core assay data available at present is dominated by this type of mineralisation.

Two mineralisation types are recognised east of the HFZ, in the Farrell Slates. Both are hosted in relatively incompetent volcanoclastic units. The main style of mineralisation is hosted in the easternmost of two black shale units (eg. the Sterling Valley Mine). This mineralisation contains sheared galena, pyrite, arsenopyrite $\pm$ chalcopyrite. This type of mineralisation extends northward to the Farrell mineralisation around Tullah. The other style of mineralisation hosted in the Farrell Slates occurs east of the prospective black shales, in a sericitic quartz-phyric tuff unit. These occurrences are typically dominated by sulphides, characterised by significantly more sphalerite than the black shale hosted mineralisation. Examples of this type of mineralisation may be found at the Thomas Blocks prospect on the Murchison Hwy, and at the Murchison Mine.

All these styles of mineralisation are associated with weak to moderate gold grades.

Work on the area commenced in early 1986 with a program of field mapping and core-logging / sampling. Mapping has continued since then. Preparation of polished thin sections from drill core and surface samples, and examination of these is an ongoing part of the program. Recently a program of whole rock analysis and assay work has commenced on country rocks and mineralised material respectively.

Methods

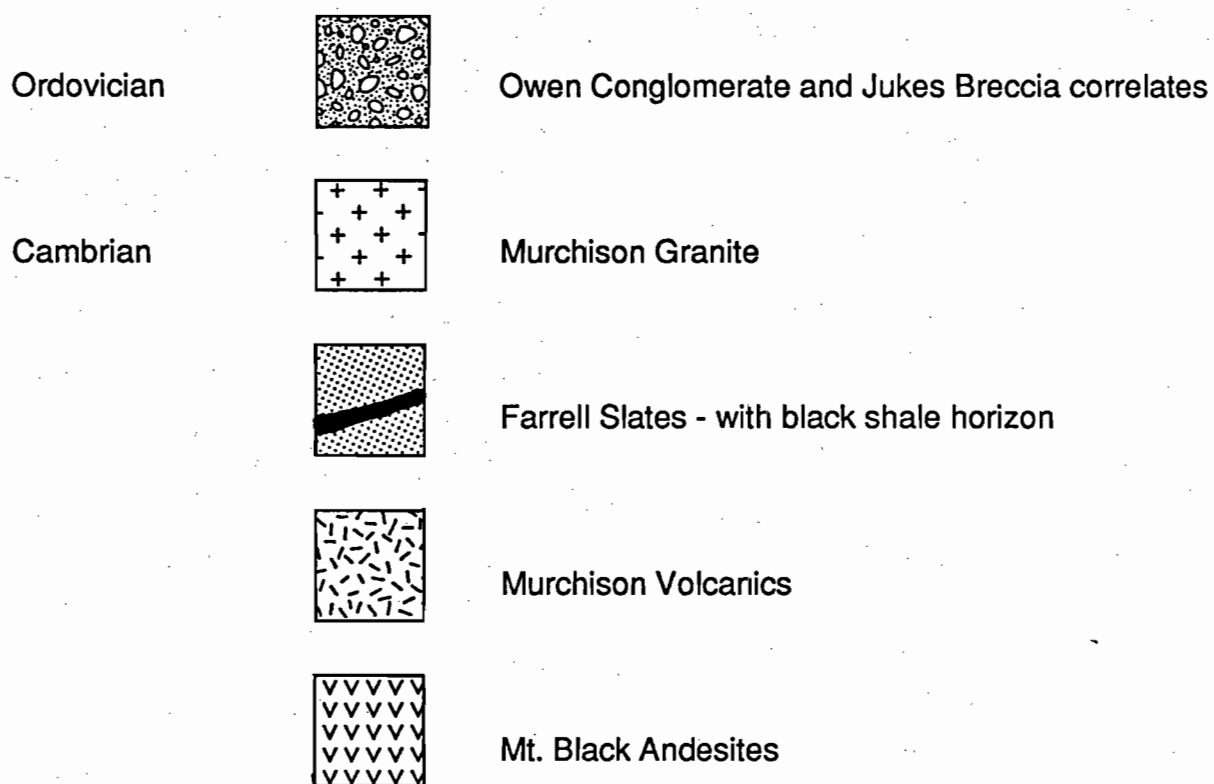
Mapping:

Surface mapping of the Sterling Valley and adjacent areas is ongoing. Creek and road sections are most useful as the original exploration grid is now largely overgrown. Various old workings have been examined

Interpreted Geology Of The Sterling Valley Area



0 1 2 km



Note: Quaternary deposits have been omitted for clarity.

 Prospects

 Drillholes

Figure 1: Interpreted Geology Of The Sterling Valley Area, Western Tasmania.
 compiled from field work by A. McNeill, D. A. Polya and I. F. Gordon.
 drawn by I. F. Gordon 1986

and sampled. These extend from the Sterling Valley Mine in the south to the New North Mt. Farrell Mine near Tullah in the north.

The northern part of the newly constructed HEC Anthony Road exposes an excellent section through the Murchison Granite, volcanics and the Farrell Slates. Parts of this section will be examined during the first day of the field excursion (see appendix for field guide).

Geochemistry:

Statistical and graphical analysis to define anomalous populations and trends in drillcore assay data has been carried out.

A program of whole rock analyses of surface material from the area has recently commenced. All the elements considered in the Mt. Read Database (A.J. Crawford, previous report 84/P210), along with a series of other trace elements will be determined. The possibility of distinguishing Devonian and Cambrian mineralisation by trace element characteristics is being considered.

Petrology:

Thin sections and polished thin sections of specimens from drillcore and surface exposures have been prepared and examined. Some electron-microprobe work has been carried out, though more is planned for the future.

Results

Mapping:

Mapping in the Sterling Valley itself proved difficult owing to the overgrown nature of most of the exploration grid. Heavy reliance has therefore been placed on the mapping of the EZ Co geologists, in particular Ian McDonald, for details of the outcrop geology. In contrast, the Anthony Road section provides good access and exposure. Several interesting points have come from the mapping program.

a) *The Murchison Volcanics.*

This sequence is dominated by quartz phyric tuffs, lavas and intrusives. Feldspar phyric tuffs do occur in places, and are more common towards the base (east) of the sequence.

Epilastic units occur intermittantly throughout the sequence, increasing in frequency towards the top (west) of the sequence, and dominating in the Farrell Slates.

b) *The Farrell Slates.*

The Farrell Slates are composed dominantly of marine deposited epiclastics. Greywacke sandstones and siltstones dominate in the Sterling Valley, with quartz and quartz / feldspar phyrlic tuffs also present.

Two black slate horizons are present in the Sterling Valley. The easternmost of these is host to the Sterling Valley Mine mineralisation, and they are correlated with the host rocks of Rivers' (1975) Farrell Lode to the north.

The boundary between the Farrell Slates and the Murchison Volcanics is gradational. No structural discontinuity across the zone of contact is recognised. On the basis of mapping and discussion with A. McNiell (Tas. Mines Dept.) the boundary here is placed at the western margin of the quartz phyrlic dominated sequence, immediately east of a feldspar / quartz tuff unit. Units similar to those in the Farrell Slates, including at least one black shale unit, do occur to the east of this boundary due to the gradational nature of the contact.

Facing evidence indicates a predominantly west facing, west dipping sequence.

c) *The Murchison Granite.*

The centre of this Cambrian granite body is a relatively pristine biotite - hornblende granodiorite, altered only by regional metamorphism. The margins are strongly altered by several phases of hydrothermal alteration. The oldest of those recognised consists of potash feldspar - hematite alteration, followed by intense chlorite - silica alteration, with late quartz - K'spar - carbonate - epidote veining. These styles of alteration will be examined as part of the field excursion.

d) *Mineralisation.*

At this stage the drill hole information from the Sterling Valley is dominated by vein style mineralisation from west of the HFZ. These veins can be divided into two groups on textural and geochemical grounds. These groups are discussed in more detail later. There is little or no wall rock alteration associated with these veins. Thin (1-3mm) zones of chloritisation occur as selvages around some of the veins.

Historically the most productive style of mineralisation in the area has been the lead/silver-rich black shale hosted type found in the Sterling Valley Mine and in the larger workings around Tullah. This style occurs as fissure filling and ?replacement bodies, sometimes up to seven metres wide, in a sheared and brecciated host rock. The ore is dominated by galena, pyrite, arsenopyrite and chalcopyrite, with a gangue of quartz, chlorite and siderite. Some Pb isotope work has been done on samples of this type of mineralisation from the Sterling Valley and New North Mt Farrell Mines (Gulson and Porritt *in press*), and a Devonian age is interpreted. It is hoped that more Pb isotope work will be possible as part of this study.

A simplified geological map of the Sterling Valley area is included (Fig 1).

Geochemistry:

Assay data from the drillholes shown in Figure 1 have been analysed using the Macintosh microcomputer. The definition of anomalous populations by cumulative relative frequency plots proved to be of little use for this data set. Anomalous populations are defined by consideration of the real data and associated geology.

Several forms of element / element plots have been produced and evaluated. Figure 2 demonstrates that the data can be broken into two groups on the basis of Au and As content. The ratio $(100 \times \text{Au})/\text{As}$ proved a good way to distinguish these two populations. The plots shown in Figure 3 (Au cutoff=0.3 g/t) show that the two groups of data have quite distinct geochemical associations. Group 1 has a relatively high Au/As ratio, and is characterised by generally low base metals, Sn and Ag, and a high Zn/Pb ratio (Zinc number from 80 to 95). The second group of data has a generally higher content of Pb, Cu, Sn, Ag and As. The Zn No. has a wide range from 10 to 92.

Petrology:

Microscopic examination of thin sections from the Sterling Valley drillcore has reinforced the identification of at least two distinct mineralisation associations. The first group defined on geochemical grounds is characterised by annealed sulphide textures. Pyrite is the dominant sulphide phase. Other phases present are listed in Table 1.

The second group has a somewhat more diverse paragenesis. The assemblage is dominated by pyrrhotite and arsenopyrite. Stannite is the dominant Sn bearing phase, though significant cassiterite was reported by previous workers.

Conclusions To Date

- The sequence to the east of the Henty Fault is composed of a pile of felsic volcanics and volcanoclastics. The sequence becomes dominated by volcanoclastics (the Farrell Slates) as volcanic activity wanes.

- The mineralisation west of the HFZ in the Sterling Valley can be divided into two main groups. The oldest of these has a higher Au / As ratio, and a simple assemblage notable for the absence of Sn bearing phases. On textural evidence it is concluded that the mineralisation formed prior to the major Tabberaberan deformation, and may be as old as the Cambrian host sequence. More work is required to define an adequate relative age for this mineralisation.

Table 1
Mineral Assemblages

	<u>Group 1</u>	<u>Group 2</u>
Major	Pyrite Sphalerite Pyrrhotite	Pyrrhotite Arsenopyrite Chalcopyrite Stannite
Minor	Chalcopyrite Arsenopyrite Bismuthinite Native Bismuth Galena	Pyrite Cassiterite Galena Sphalerite
Gangue	Quartz Chlorite Carbonate	Quartz Sericite Chlorite Tourmaline

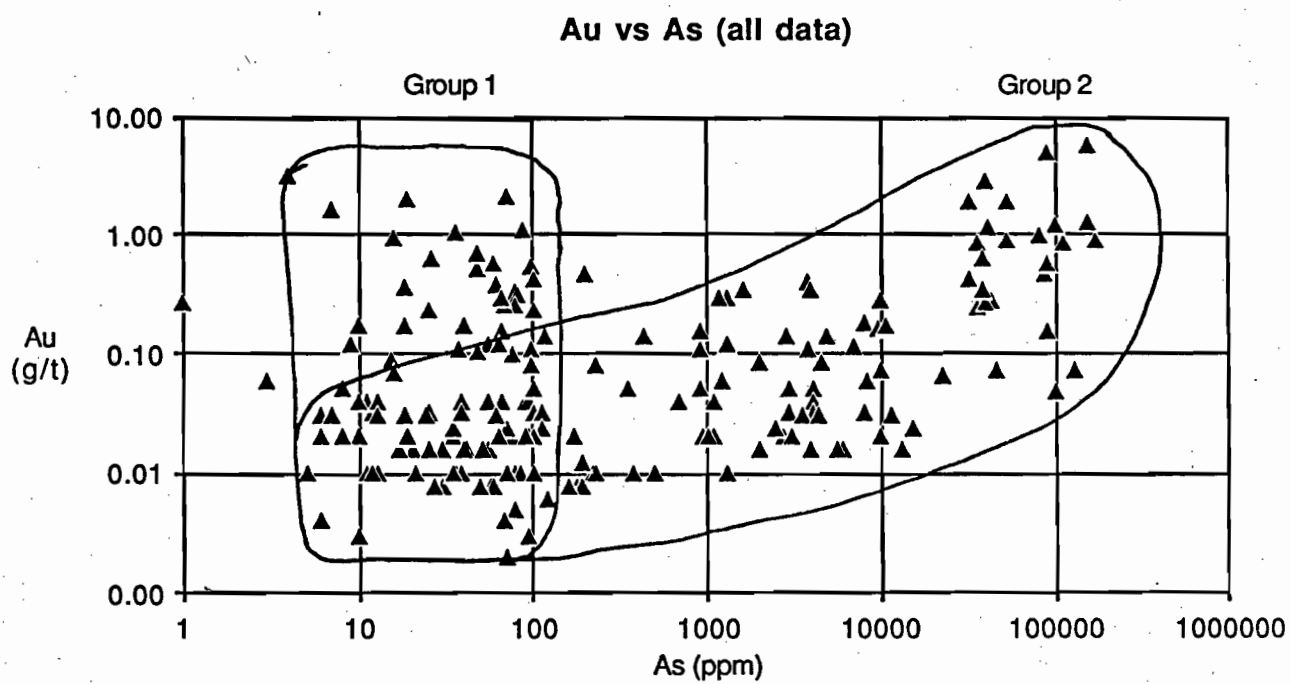


Figure 2: Gold vs. Arsenic for the Sterling Valley assay data.

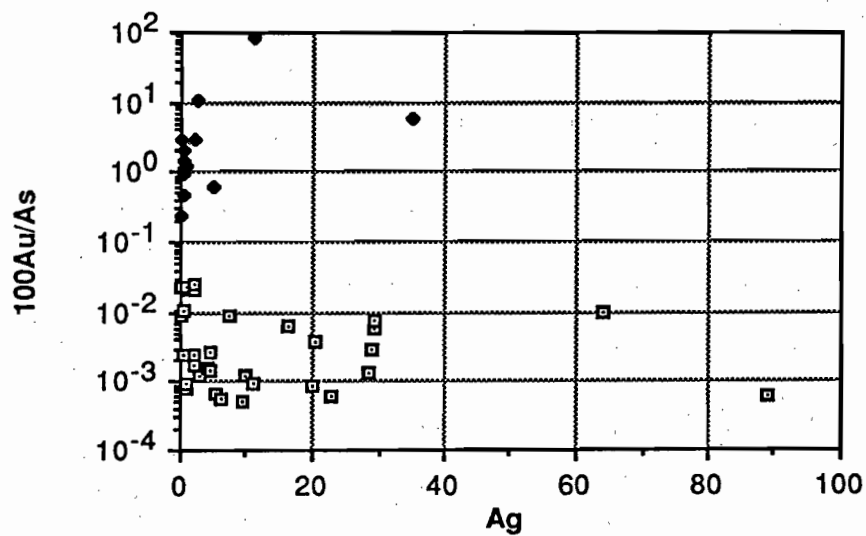
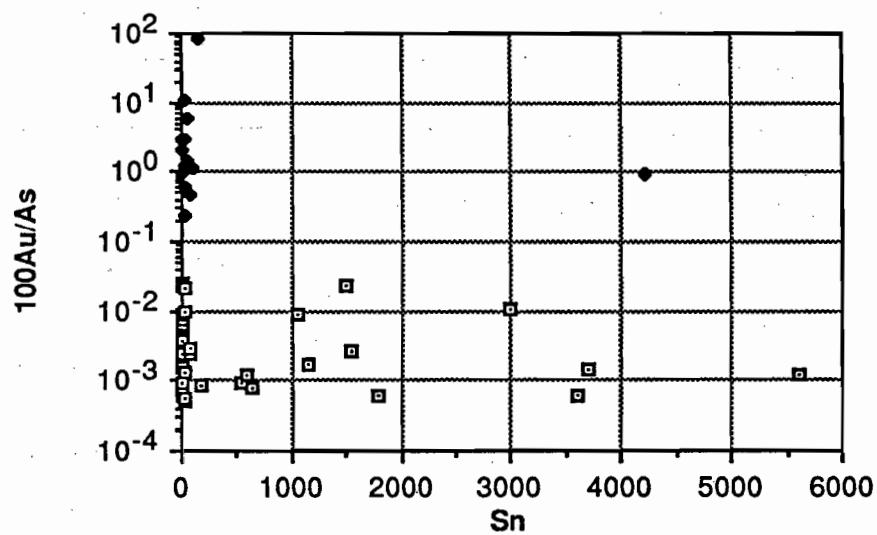
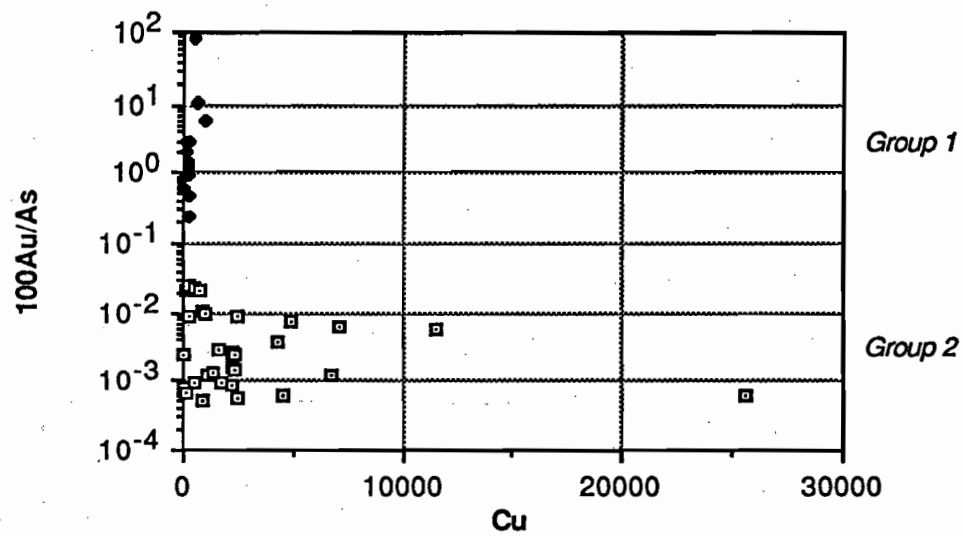
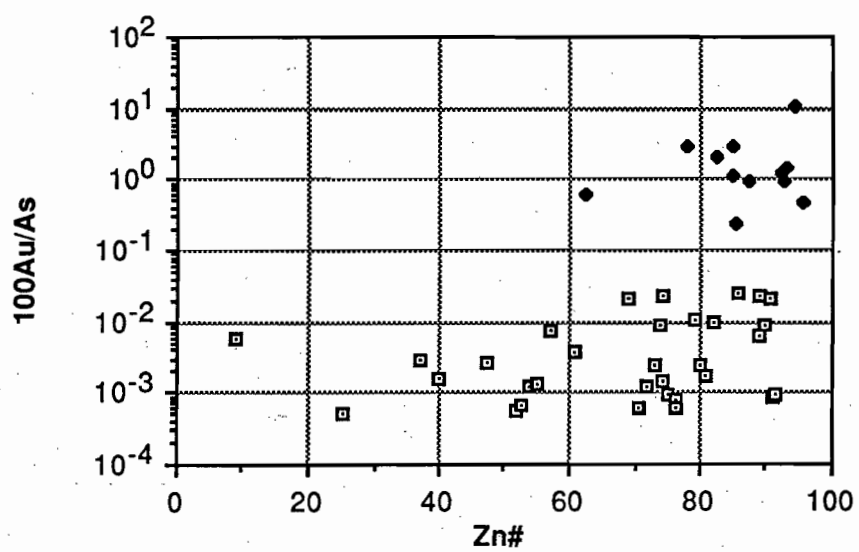
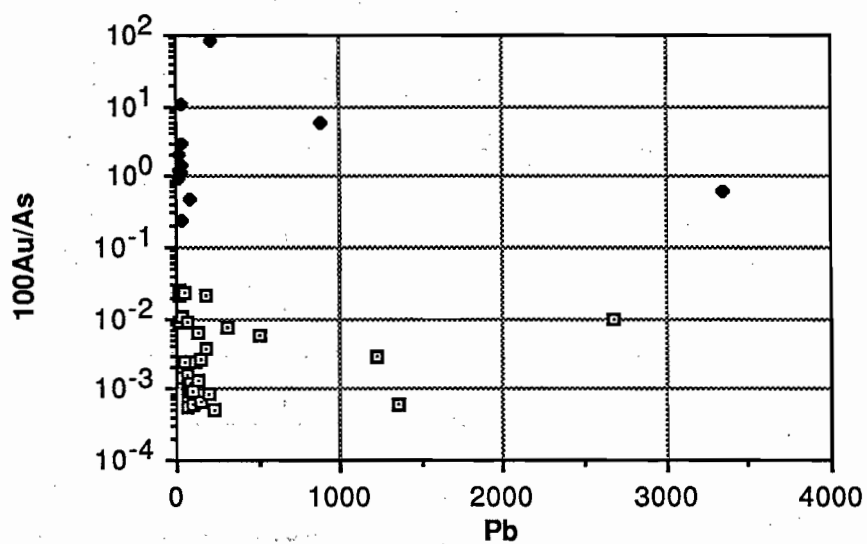
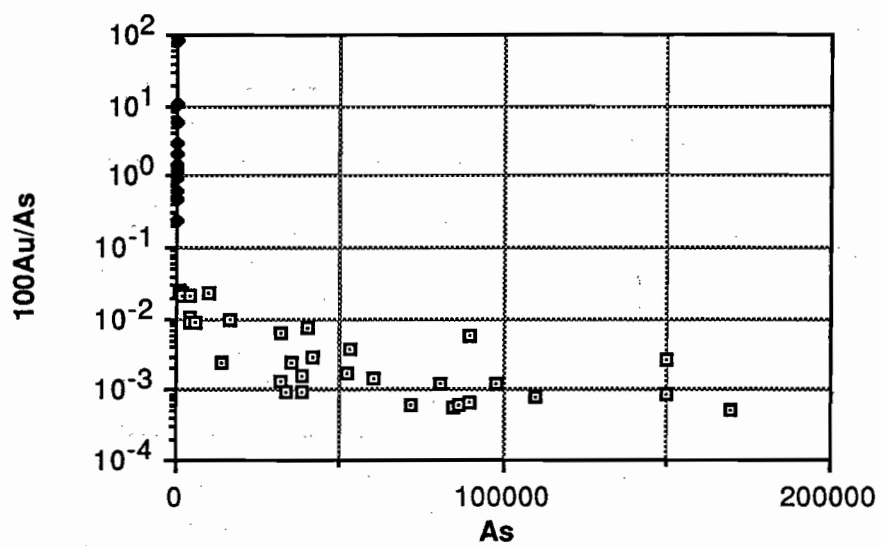


Figure 3: Gold/Arsenic discriminate ratio against other metal contents, showing characteristics of each group in fig. 2.



The second group is dominated by As and Sn bearing phases, with Cu and Ag contents also higher than group 1. Texturally the mineralisation is weakly to undeformed, with well preserved zoned veins and delicate comb structures, indicating a post major deformation age. The mineral assemblage observed constrains the depositional conditions in fO_2 - pH space as shown in figure 4. The depositional conditions (projected to 300°C) for the Renison tin deposit (Patterson 1979) is also shown. The two fields fall quite close together, further indicating that this mineralisation is related to a Devonian magmatic source. The presence of Devonian granites at relatively shallow depth under the Sterling Valley has been suggested by Large (1986) on the basis of gravity data. Although the only temperature data available at this stage is an upper limit of 462°C, which is the limit of stability of co-existing stannite and chalcopyrite, temperatures of 300° to 350° have been suggested for the Renison Bell deposit (Patterson 1979).

Further Work

Work during 1987 will concentrate on the petrography and geochemistry of the Sterling Valley mineralisation. Isotopic work for temperature and age information is planned. Fluid inclusion studies will be carried out on gangue phases from all styles of mineralisation. Some further mapping of the Murchison Volcanics is also planned.

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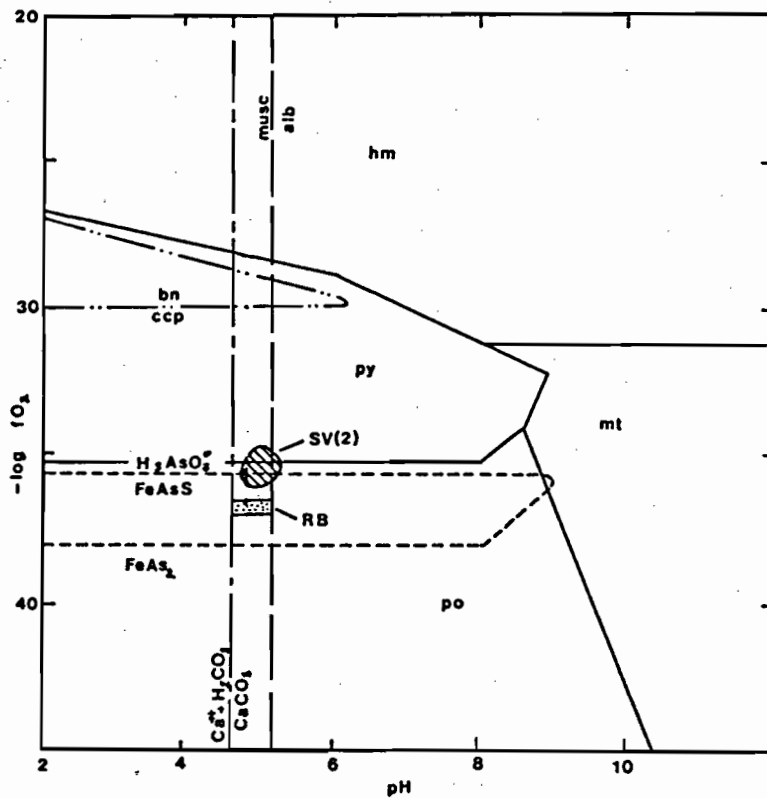


Figure 4: log fO_2 vs. pH diagram demonstrating how the mineral assemblage in Table 1 constrains the depositional conditions for group 2 mineralisation. The field for the Renison Bell (RB) deposit is included for comparison (Patterson 1979 -projected from 350° C)

$T=300^\circ \text{C}$; $\log a_{\text{SS}} = -2$; $\log a_{\text{Na}^+} = 0$; $\log a_{\text{K}^+} = -1$; $\log a_{\text{H}_3\text{AsO}_3} = -4$; $\log m_{\text{Ca}^{++}} = -1$;
 $\log m_{\Sigma\text{C}}(\text{as H}_2\text{CO}_3) = -1$; $\gamma_{\text{Ca}^{++}} = 0.3$; $\gamma_{\Sigma\text{C}} = 0.7$

LAKE SELINA PROSPECT E.L.9/66

Steven Hunns

Introduction

The aims of this project as outlined previously (April 1986 Progress Report) are to study the "barren" pyrite deposit at Lake Selina and compare it with other ore bearing pyrite systems in the Mt. Read Volcanics. On completion of mapping and logging of drill-core during 1986, the focus of attention has centred on the alteration assemblages and alteration style(s) at Lake Selina.

Background

The Lake Selina Prospect is an extensive development of veined and disseminated pyrite hosted by volcanoclastics. Forming two distinct linear belts flanking Mt. Selina, with a total strike length of approximately 7km (Fig. 1).

Major lithological units recognised within the Lake Selina Prospect are:

Quaternary	- Moraine, scree, alluvium
Ordovician	- Owen Conglomerate Dora Conglomerate (Jukes Breccia correlate)
Cambrian	- Granitic intrusives Selina Volcanoclastics Sticht Range Beds
Precambrian	- Quartzites and quartz mica schists.

Method

A period of approximately ten weeks (Jun-Aug) were spent field mapping and logging drill-core provided by Goldfields Exploration Pty Ltd. As a result of this study, a preliminary alteration map of the Selina prospect has been produced (Fig 2). Alteration logs of two selected drill holes (DDH LS6 & DDH LS10) are presented.

The ground magnetics survey of 1970/71 was contoured and profiled in order to establish whether the magnetics formed linear anomalies that paralleled the I.P. anomalies, or if the Selina Volcanoclastics were folded and or faulted. Work on these aspects is continuing.

A representative set of thin and polished sections is partially completed. These combined with the sections provided by Goldfields will give a very good basis for the documentation of the

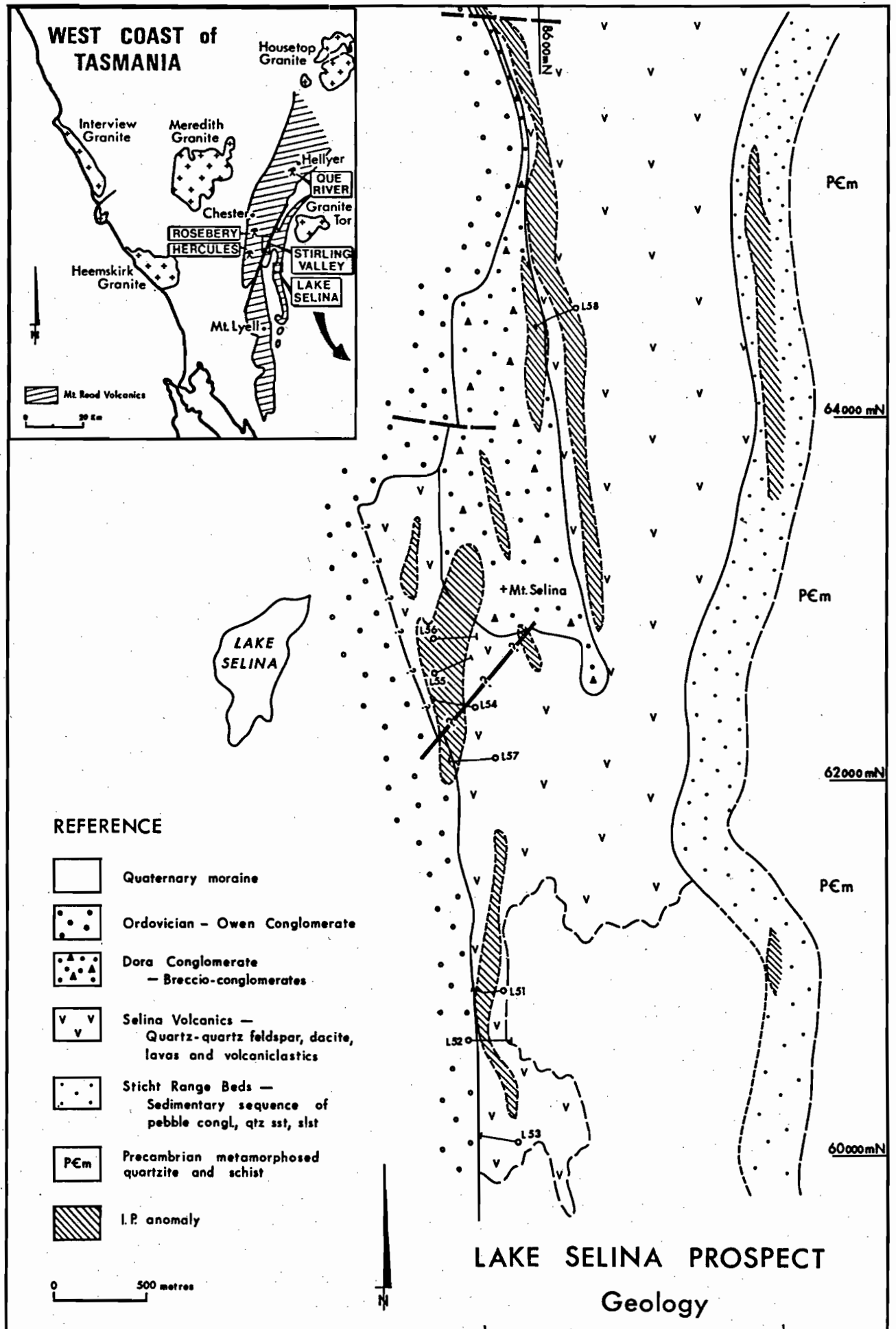


Fig. 1

alteration history at Lake Selina.

A number of drill-core and outcrop samples are currently being analysed, for both major and trace element to give a geochemical basis to the alteration study, and to define any geochemical alteration halo(s) on the surface, and selected drill holes.

Results and Discussion

Hydrothermal Alteration:

The extensive alteration at Lake Selina has partially to fully destroyed the primary rock fabric and mineralogy. The rocks were therefore mapped and described according to their alteration assemblage, rather than trying to determine (guess) what the original rock type was. The major alteration minerals are chlorite, K-feldspar, sericite, quartz, magnetite, pyrite, haematite, calcite and/or dolomite, muscovite and epidote. These form a variety of assemblages, which for the purposes of clarity have been divided into three broad zones, based upon the dominant alteration mineral phase present.

1) K-feldspar Zone:- Limited staining of samples with cobaltinite has shown that the dominant feldspar phase present is K-feldspar (K-spar). This alteration type forms an elongate zone on the western margin of the Selina Prospect, that parallels the contact between the Selina Volcaniclastics and the Owen Conglomerate (Fig.2).

Within this alteration zone the pink K-spar content varies from total replacement of the rocks to minor veining. The groundmass K-spar forms an equigranular mosaic with quartz. The K-spar in parts has been over printed by pervasive chlorite $\pm$ magnetite, giving the rocks a brecciated appearance. Alteration of K-spar phenocrysts to sericite and clay minerals is common.

2) Chlorite Zone:- The chlorite alteration forms two major and two minor zones (Fig.2), and occurs in a variety of modes. In the more intensely altered areas of this zone the rocks can be entirely composed of chlorite. Moving out of these strongly altered areas the chlorite alteration may be pervasive, or confined to thin wisps following the foliation. Where this alteration is intense it imparts a brecciated appearance to the rocks. In parts the chloritic fluids hydrothermally brecciated the host rocks. Chlorite alteration of mafic minerals where present is common.

3) Sericite/Quartz Zone:- This zone forms the largest area of alteration. It occurs as narrow elongate zones within the K-spar and chlorite alteration zones, and forms the dominant alteration assemblage outside these two zones. The sericite is found replacing K-spar phenocrysts and with quartz forms the groundmass for a large percentage of the rocks within the prospect. Consequently any original texture or mineralogy tends to be destroyed. Sericite to some degree

LAKE SELINA PROSPECT ALTERATION MAP (60000mN-65000mN)

- G** Granite or granitic rocks
- P** Quartz porphyries
-  Owen Conglomerate
-  Dora Conglomerate
-  I.P. Anomaly
- ALTERATION
ASSEMBLAGES**
-  K-Feldspar Dominant - chl,magt,py,sert
-  Chlorite Dominant - magt,py,sert,k-spar
-  Sericite Dominant - chl,py,magt,sl

0 500M



60000mN

64000mN

62000mN

60000mN

Sticht Range Beds

Glacial Moraine

Fig.2

can be replaced by pervasive later chlorite.

Pyrite:

Pyrite forms the most common sulphide phase at Lake Selina. The pyrite occurs in massive veins (up to 40mm across), narrow (1-3mm) veinlets forming stockworks, aggregations of pyrite euhedra or as fine disseminations. It tends to be associated with magnetite and /or chlorite, though not always. The pyrite generally has a crystalline euhedral form.

Magnetite:

Magnetite maybe massive forming veins up to 80mm across, as veinlets giving a stockwork appearance to the rocks, or as fine disseminations. Magnetite is generally associated with either chlorite and or pyrite, and can be replaced by martite and haematite.

Haematite:

Alteration by haematite occurs either as a replacement of other minerals (e.g. magnetite), in veins as specular haematite, or as intense alteration swamping the original rock. The strongest zone of haematite alteration occurs along or near the contact between the Selina Volcaniclastics and the Owen Conglomerate (Fig.1).

Alteration Logs for DDH LS6 and DDH LS10:

The alteration logs with their corresponding ground magnetic profiles are illustrated in figures 3 and 4 respectively. These two holes were selected for study for a number of reasons. Firstly because both were drilled through their respective pyrite zones (LS6 - Western Pyrite Zone and LS10 Eastern Pyrite Zone). Secondly LS6 was drilled towards a postulated granitic intrusive and LS10 was drilled going away from this intrusive. So that an alteration profile moving into and away from the granitic intrusive could be described.

LS6:- The most prominent feature of this hole is the extensive zone of moderate to intense chlorite alteration. The top half of the hole is dominated by sericite, silica and minor K-spar and associated minor pyrite and magnetite. The chlorite content increases down hole and is coincident with a significant increase in later pyrite and magnetite alteration. The ground magnetitic profile anomalies correspond to the two zones of strong magnetite alteration within the drill hole.

LS10:- This hole was drilled to test an I.P. anomaly in the Eastern Pyrite Zone. The alteration in this hole is characterised by lesser chlorite alteration compared to LS6. Magnetite is associated with the chlorite alteration zone, and is reflected in the ground magnetic profile. The amount of chlorite and haematite decreases down hole (i.e. W-E), while silica, sericite and pyrite increase down hole.

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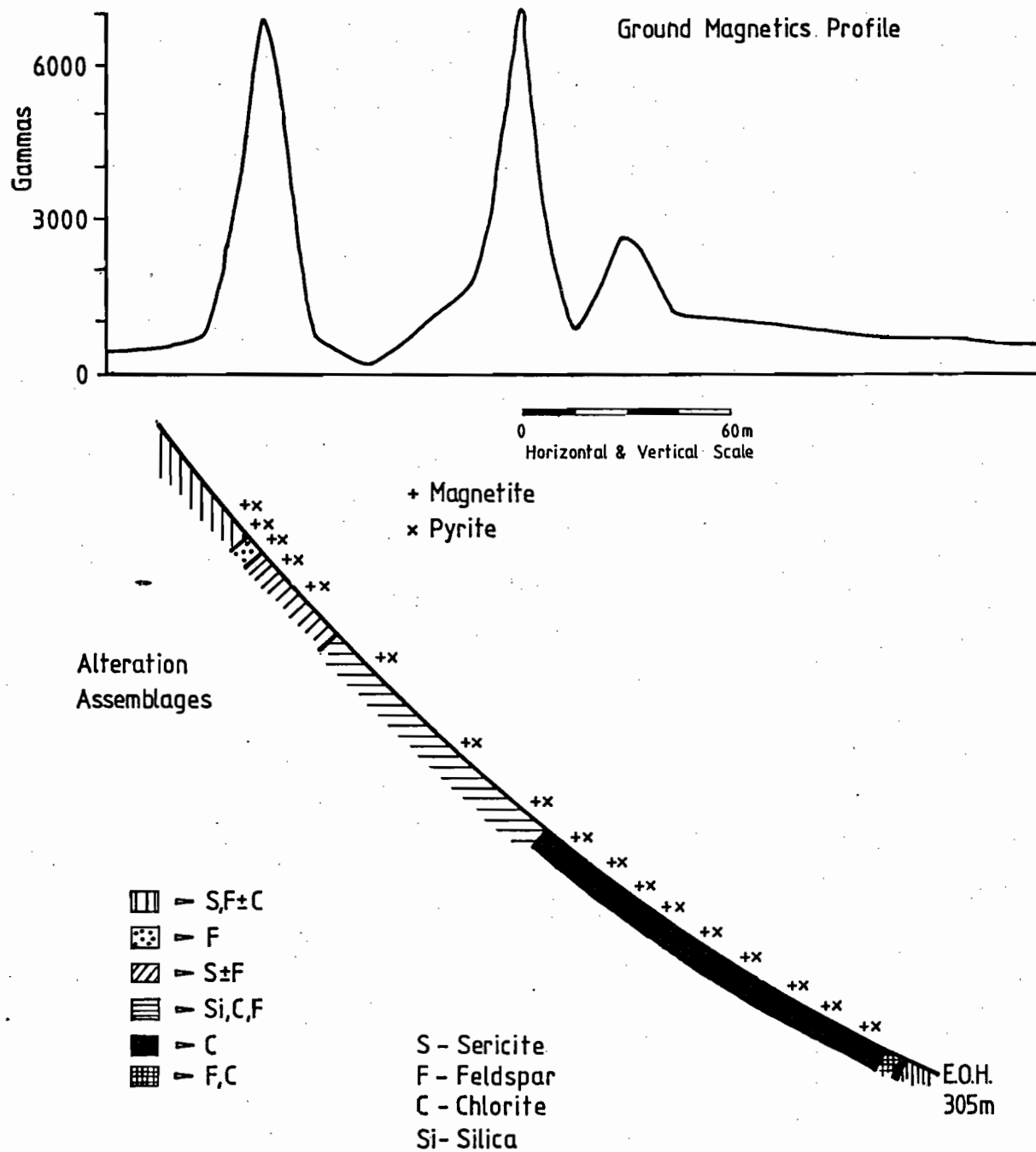


Fig.3 Ground magnetic profile and alteration log for DDH LS6

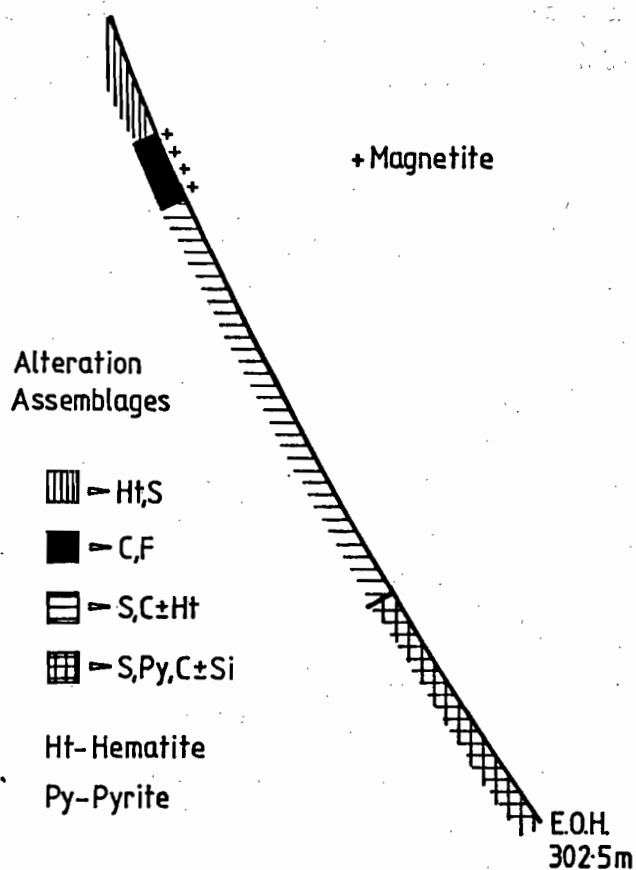
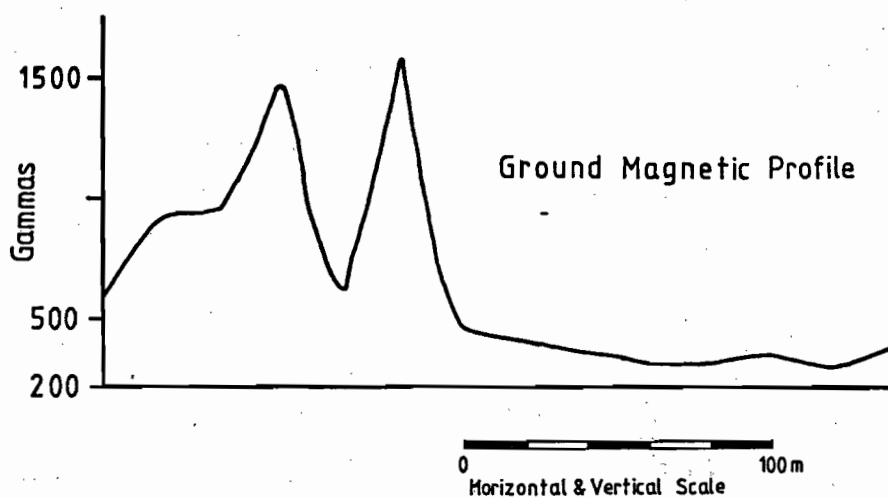


Fig.4 Ground magnetic profile and alteration log for DDH LS 10

Veining:

There are number of vein mineral assemblages present at Lake Selina. The most common is the quartz, chlorite $\pm$ feldspar $\pm$ carbonate veins. This assemblage forms veins from a millimetres across up to 0.5m. The smaller quartz, chlorite veins have a striped appearance due to alternating bands of chlorite and quartz. Feldspar are generally 1-3mm thick and are composed of pink K-spar. The greatest intensity of veining appears to be associated with the K-spar dominant and Chlorite dominant zones.

Mineralization:

Base metal values are very low within the Lake Selina Prospect. (Cu 10 - 7200ppm, Pb 10 - 1150ppm, Zn 10 - 10,600ppm). Sphalerite appears to be associated with quartz, chlorite, carbonate veins. Galena can occur by itself as discrete blebs, associated with veins or as a breccia matrix. Chalcopyrite occurs as a remobilized phase, either associated with pyrite or by itself as discrete blebs or with veins. Silver values for the prospect are anomalous (e.g. LS5 4.6m @ 24 g/t, LS6 6.1m @ 44 g/t), but gold is almost absent. Molybdenite was identified in DDH LS4. Malachite and possibly azurite were noted coating outcrops near old workings. The mineralization appears to be associated with the K-spar and chlorite alteration zones.

Structure:

The structure of the Lake Selina Prospect is poorly understood at this stage. Bedding within the volcanics was not noted in the field. But tentative observations in drill-core give a facing towards the west. Mapping by McKibben in 1972 and subsequently confirmed by the author recorded uniformly westerly dips and facings in the Sticht Range sedimentary sequence to the east. Two dominant cleavages were noted in the field. These trend approximately NNW and dip steeply to the west and east. These cleavages impart a strong schistosity to the volcanics and wrap around quartz phenocrysts. Hutton (1982) inferred that the Dora Conglomerate on Mt. Selina occupies the core of a north plunging syncline based on stratigraphic evidence and E-W foliations to the east of Mt. Selina. A number of NW trending faults have been postulated by Hutton (1982) based upon geophysical and airphoto interpretation.

A major NNW trending fault (Anthony Fault) is thought to form the contact between the Owen Conglomerate to the west and the volcanics to the east. A mylonitic zone was mapped along the Goldfields Exploration road near grid reference AMG 385600mE, 5361500mN. Within this mylonitic zone the volcanics and granitic rocks are highly sheared and altered. A faulted contact between the Owen Conglomerate and volcanics was logged in DDH LS7. Mylonitic zones were logged in DDHs LS1 and LS3. These zones consist of massive haematite to banded haematite and sericite and are strongly sheared. These have a core length of 80m and 30m respectively. This fault is thought to continue northwards into the southern foothills of Mt. Murchison and to extend southwards based upon airphoto interpretation.

A NW trending fault is thought to form the contact between the Sticht Range Beds and the Precambrian basement to the east.

Granitic and Quartz Porphyry Intrusives:

Several occurrences of granitic and quartz porphyry intrusives were described by Hutton (1981) and re-confirmed by this study (fig.2). Two intrusive types are found within the Lake Selina area, both in outcrop and in drill-core. Fifty metres of granite were intersected in DDH LS12.

1) Coarse-grained adamellite to quartz monzonite with a granoblastic texture. Similar to the Murchison Granite.

2) Porphyritic microgranite to microgranodiorite, with quartz, feldspar and biotite(?) phenocrysts in a fine grained groundmass. These porphyries were intersected at the base of DDHs LS5 and LS6, and were mapped in outcrop (fig 2).

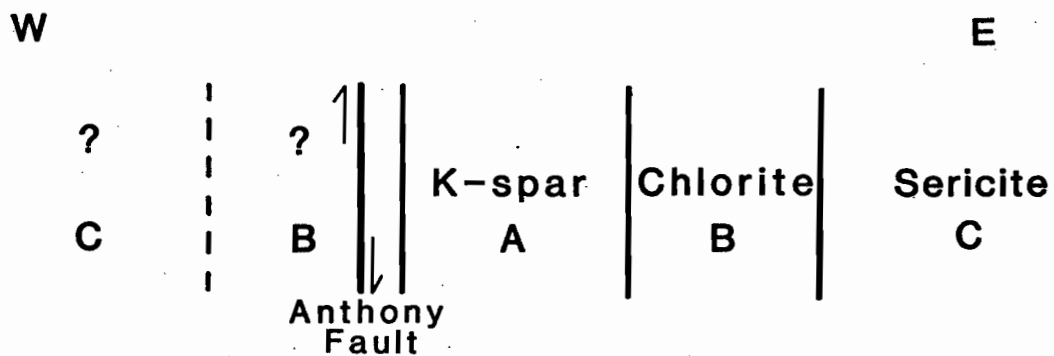
Models for the Origin of the Mineralization/Alteration:

In recent years two models for the formation of the mineralization and alteration at Lake Selina have been proposed. Eastoe (1981) concluded that the pyrite-magnetite mineralization is related to a deep granite intrusion within the volcanic pile, and that circulating hydrothermal waters produced the alteration. Purvis *et al.* (1983) drew comparisons between the alteration/mineralization seen in the Western Pyrite Zone and the footwall mineralization seen in the Kuroko deposits in Japan. In terms of a volcanogenic massive sulphide(VMS) exploration model the pyrite zones were thought to be the stockwork footwall mineralization to a VMS (Cartwright 1984).

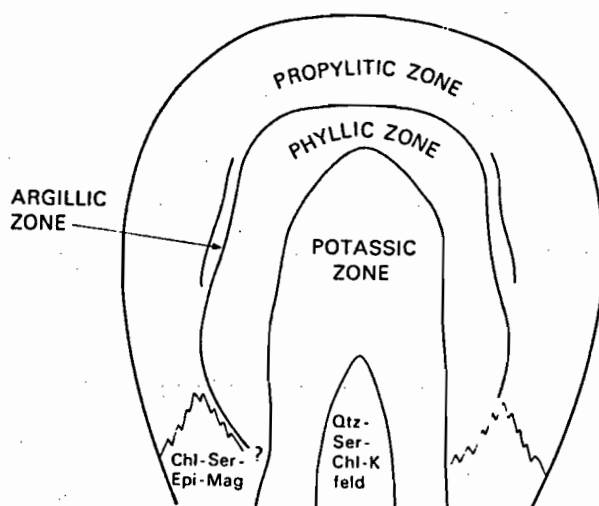
A broad alteration cross section can be inferred for the Lake Selina Prospect. The central part of the alteration system is composed of pink K-spar alteration, either as pervasive matrix and phenocryst flooding the original rock or occurring as veins. This zone is within an envelope of moderate to strong chlorite alteration $\pm$ magnetite $\pm$ pyrite, and encompassed by a sericite/quartz $\pm$ magnetite $\pm$ pyrite alteration assemblage (Fig.5).

Comparison Between Lake Selina and other VMS Deposits in Western Tasmania and known Porphyry Copper/Molybdenum Deposits:

Table 1 summarises the precious metal grades, Zinc Number (Zn#), presence or absence of magnetite and pervasive pink K-spar alteration.



**Fig.5 Schematic cross section
of the alteration at Lake Selina**



**Fig.6 Hydrothermal alteration zoning pattern
in the Lowell-Guilbert(1970) model
of porphyry copper deposits. From Evans (1980)**

Deposit	Deposit Style	Au	Ag	Mo	Zn#	Magt	K-spar
Selina	?	<0.01ppm	1-2ppm	25-80ppm	50.9	P	P
Que River *	VMS	4.4g/t	241g/t	-	64.1	A	A
Rosebery *	VMS	2.9g/t	155g/t	-	72.0	A	A
Goonumbla ** Parkes, NSW	PC	0.28g/t	3.5g/t	-	-	A	P
Climax - Type ***	PC	-	-	0.01-0.05%	-	P	P
Porphyry Deposits Western, USA	PM	-	-	0.30-0.45%	-	P	P

Table 1

VMS - volcanogenic massive sulphide, PC - porphyry copper, PM - porphyry molybdenum, P - present, A - absent (Mo grades for the Climax -Types deposits are expressed as %MoS₂).

* This report, ** Jones (1985), *** White *et.al.* (1981)

The major differences between Lake Selina and VMS deposits are in the precious metal values and the presence of extensive and intense magnetite and K-spar alteration. The Zn number of Huston and Large (in press) for Tasmanian VMS have a range of mean values between 64-77. The mean Zn number for Lake Selina is 50.9. The broad alteration cross section for Lake Selina has comparisons with the alteration cross section for porphyry copper and porphyry molybdenum deposits (Fig.6).

The presence of granite, granitic rocks and quartz porphyries in outcrop and core. The alteration sequence and the dissimilarities to other Tasmanian VMS deposits, suggests that the alteration /mineralization at Lake Selina is more akin to a porphyry - style mineralization than to a volcanogenic origin.

Speculative Model for the Alteration/Mineralization at Lake Selina:

- 1: Sedimentary basin ("Selina Basin") infilling with coarse pebble conglomerates, sandstones and shales (Sticht Range Beds)
- 2: Input of volcanoclastics and minor lavas from a distant volcanic centre
- 3: Rifting, causing down faulting of the "Selina Basin" bringing the Sticht Range Beds into contact with the Precambrian basement to the east. Granitic and porphyries intrusions along the Anthony Fault resulting in the alteration and mineralization of the rocks.

4: Subsequent re-activation of the Anthony Fault brought the Owen Conglomerate into contact with the Selina Volcanics. This faulting focussed intense shearing, haematisation and alteration along the fault zone.

Acknowledgements: I particularly wish to thank Paul Roberts and Fergus Fitzgerald of Goldfields Exploration Pty.Ltd for useful and stimulating discussions on the geology of Lake Selina, and to Goldfields Exploration Pty.Ltd for assisting with field equipment and supplying an outside link to the world when conducting field mapping and for providing access to drill-core.

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PRIMARY AND ALTERATION CHEMISTRY OF THE MOUNT READ VOLCANICS *

Ross Large, Anthony Crawford and Sharon Adrichem

In our previous report to AMIRA (April, 1986, p 30-35) Anthony Crawford presented the results of 128 chemical analyses conducted in the Geology Department, University of Tasmania, on a range of unaltered samples from the Mount Read Volcanics (MRV) and Dundas Trough. This data (plotted on Harker diagrams) showed that the MRV have close affinities with high - k calc-alkaline suites from active continental margins (i.e. arcs developed above continental-type crust, rather than the oceanic crust).

Two additional sets of data have recently been included into the MRV data base;

- 1) Analyses of footwall and hanging wall rhyodacites in the Rosebery area, from a recently completed Ph.D. thesis of Naschwitz (1985).
- 2) Analyses of dacites, andesites and mineralised volcanoclastics in the Que River area, from work by the CSIRO (Whitford et. al. ,1983).

The inclusion of this data now allows;

- a) A comparison between the chemistry of volcanics close to ore and those distant from ore.
- b) A comparison of the chemistry of footwall volcanics and hanging wall volcanics at both Rosebery and Que River.
- c) A comparison of the chemistry of the Central Volcanic Sequence (CVS) with the Que-Hellyer Sequence (now considered by Corbett, 1986, to lie within the Dundas Group).
- d) A study of the chemistry of hydrothermal alteration associated with ore formation.

The first three points will be addressed in this report, and the fourth at a later time.

Use of the Ti/Zr Variation Diagram

In the previous AMIRA report (Crawford, 1986) the MRV analyses were plotted on SiO_2 variation diagrams. However, due to the mobility of SiO_2 during hydrothermal alteration (eg. chloritisation or silification) it was decided to plot the new data on variation diagrams with the ratio Ti/Zr on the horizontal axis. Previous studies (eg. Winchester and Floyd, 1977 and Whitford et. al., 1983) indicate that both Zr and Ti, are relatively immobile elements, even under conditions of hydrothermal alteration. Consequently the Ti/Zr ratio, which is a good index of magmatic differentiation, remains relatively constant during alteration associated with mineralisation. The Ti/Zr variation diagram is therefore a powerful tool because it enables a clear distinction between chemical trends due to magmatic differentiation (i.e. primary

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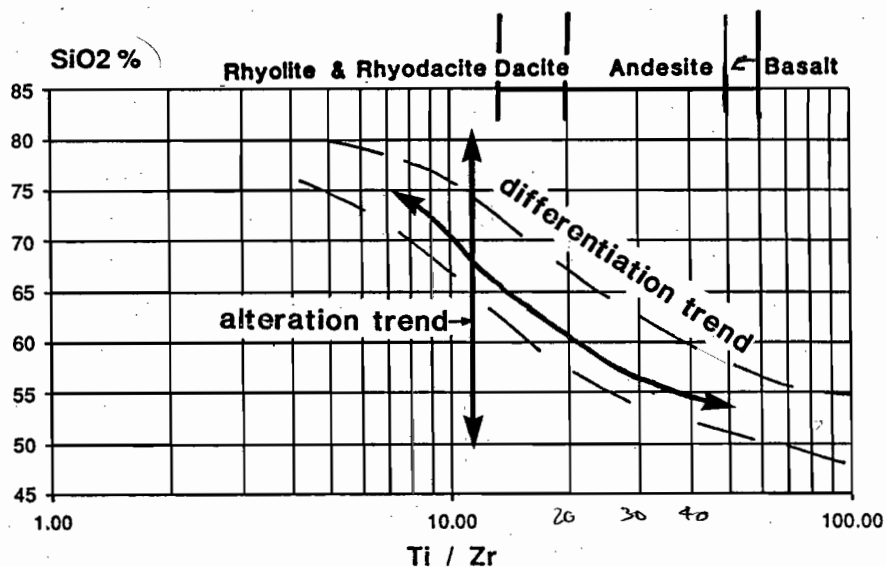


Figure 1a : Use of the Ti/Zr variation diagram to discriminate chemical trends due to magmatic differentiation from those due to hydrothermal alteration. A vertical spread of analyses at constant Ti/Zr indicates hydrothermal alteration of a constant primary composition. Sub-horizontal variation of the Ti/Zr ratio indicates a primary differentiation trend unrelated to alteration.

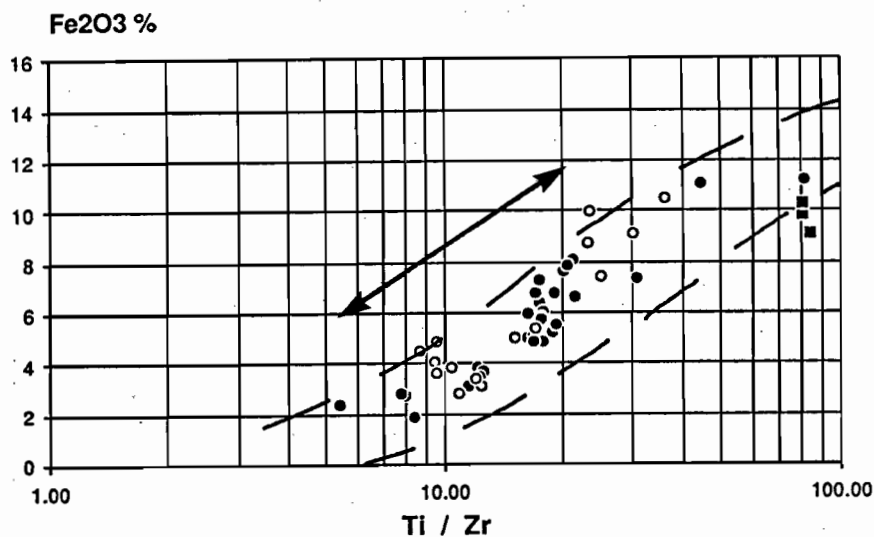


Figure 1b : A typical example of the magmatic trend of rhyolite-dacite-andesite-basalt for Fe₂O₃ in the MRV.

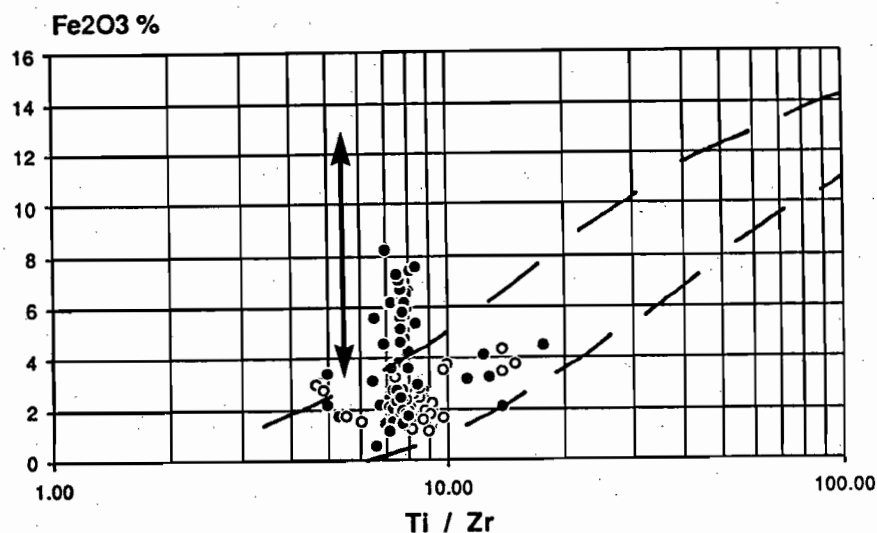


Figure 1c : A typical example of the vertical hydrothermal alteration trend (enrichment of Fe₂O₃ at constant Ti/Zr) superimposed on a magmatic differentiation trend of rhyolite-dacite. (Rosebery data - black dots are FW pyroclastics, open circles are HW pyroclastics).

rock type differences) from those due to later hydrothermal alteration (see Fig. 1, for an explanation).

Calc/alkaline volcanics commonly show the following Ti/Zr ranges;

	Ti/Zr
rhyolites and rhyodacites	4 to 12
dacites	12 to 20
andesites	20 to 60
basalts	60 to 120 +

However the exact boundary between each group is likely to vary from one volcanic pile to the next.

Discussion of Results

Central Volcanic Sequence (CVS) : A group of 31 analyses of undisputed CVS were selected from the original data base and plotted in Figures 2a, 3a and 4a. They provide a spectrum from rhyolite to basalt which enables us to outline the *typical unaltered CVS trend* on all the Ti/Zr variation diagrams. Note that the majority of CVS samples plot in a group close to the dacite-andesite boundary (Ti/Zr = 20). At this stage, no distinction is possible between CVS north west of the Henty Fault and those south east of the Henty Fault.

Samples from the *Western Sequence* (open circles on Figs. 2a, 3a, 4a) commonly plot within the CVS trend. However three ankaramites - in the Howards Plains area plot off the trend, probably due to accumulation of cpx (high Ti/Zr) phenocrysts.

Basalt dykes from the CVS (black squares in Figs. 2a, 3a, 4a) plot at the mafic end of the CVS trend, but REE studies show that the dykes are unrelated to CVS magmatism.

Rosebery Area:

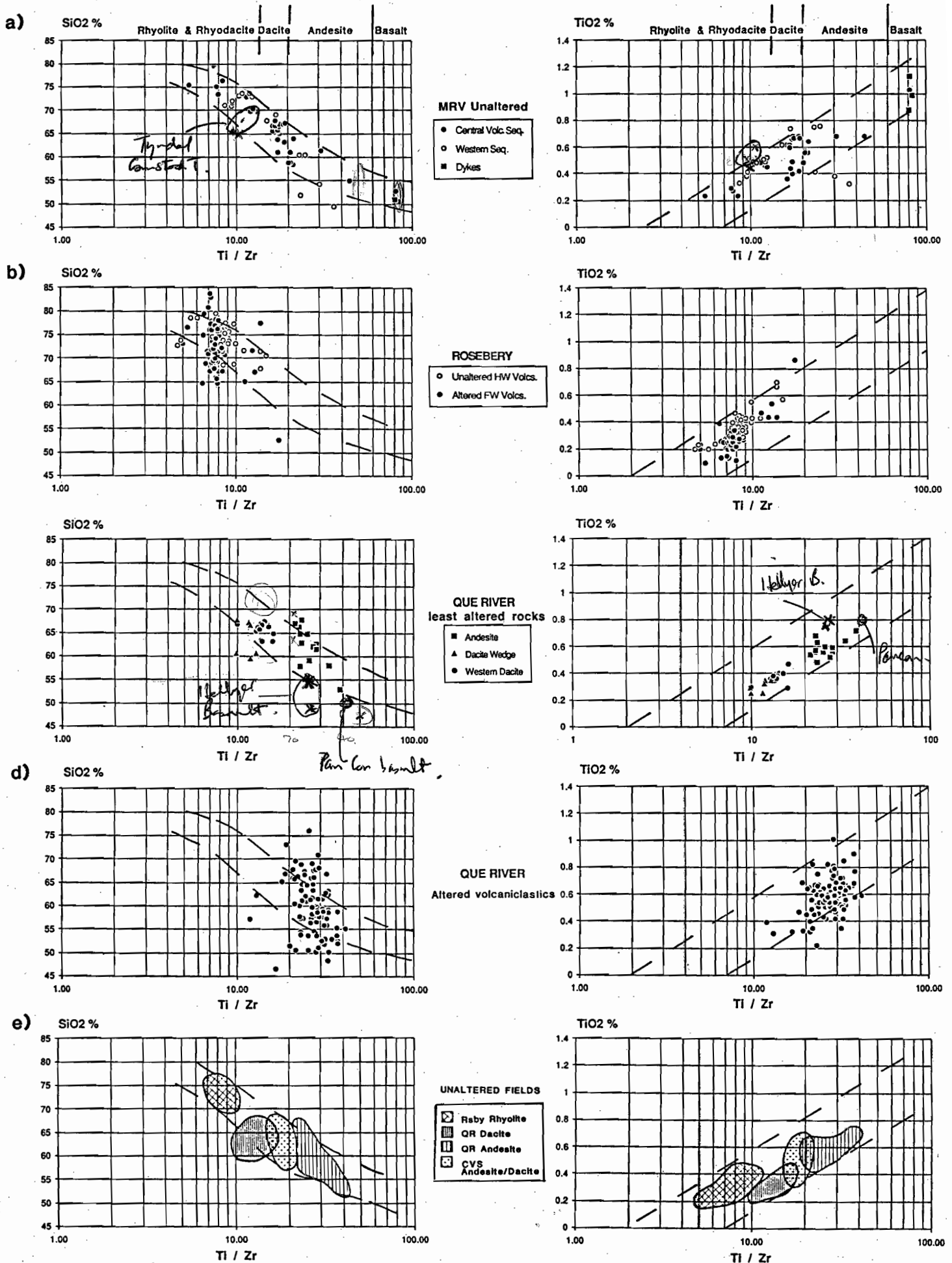
Volcanics from the Rosebery area plot in a relatively tight cluster in the rhyolite field (Figs. 2b, 3b and 4b). The altered footwall volcanics show a vertical spread indicative of hydrothermal alteration. No clear magmatic trend is suggested by the data. In terms of primary chemistry, the hanging wall volcanics are indistinguishable from the footwall volcanics. In terms of alteration, the footwall volcanics are strongly depleted in Na₂O (Fig. 4b) and some samples show Fe₂O₃ and MgO enrichment. Naschwitz (1985) also reports strong depletion in Sr and CaO near the orebody, and enrichment in Rb, K₂O and SiO₂.

Que River Area:

The Que River CSIRO analyses have been split into two groups for plotting (Figs. 2c and d)

a) Unaltered volcanics, including;

- footwall andesites (about 150 m stratigraphically below the ore lenses)

Fig 2 : Ti/Zr variation diagrams for SiO₂ and TiO₂.

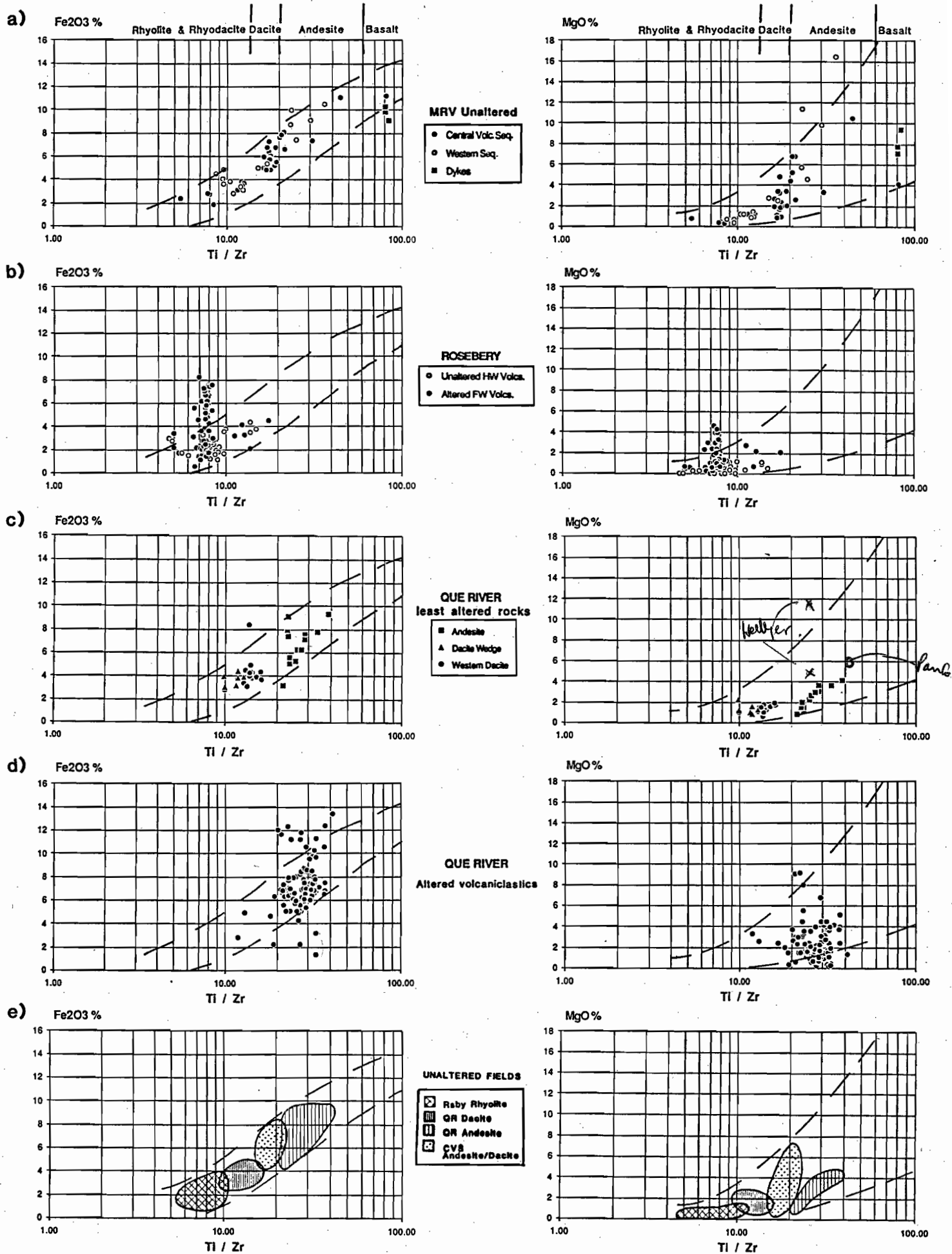


Fig 3 : Ti/Zr variation diagrams for Fe₂O₃ and MgO.

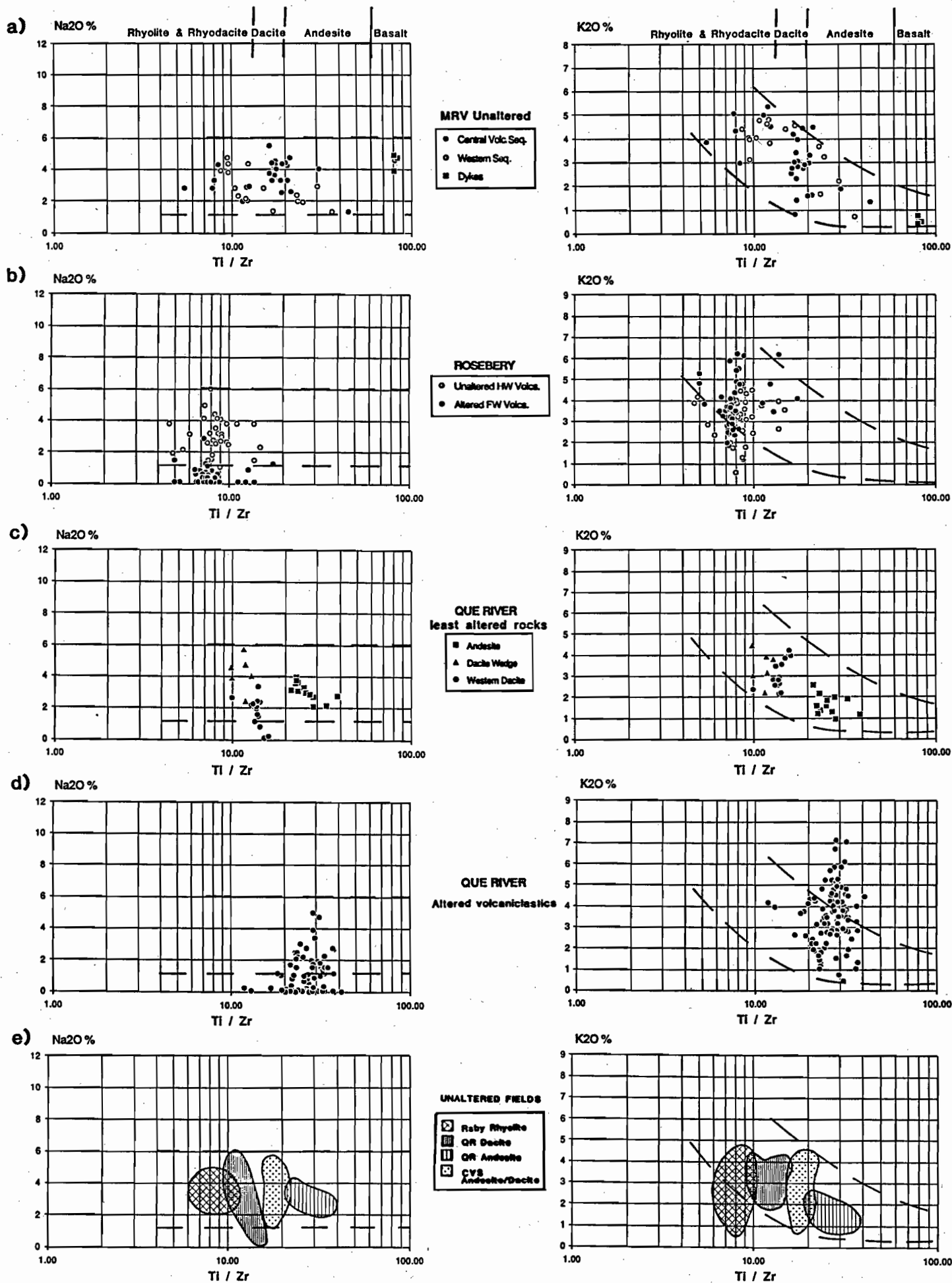


Fig 4 : Ti/Zr variation diagrams for Na2O and K2O

- hanging wall dacite wedge (immediately above PQ lens)
- Footwall western dacite (post-mineralisation intrusive).

b) Altered and mineralised footwall lavas and volcaniclastics (including samples within the stringer pyrite zone).

The unaltered volcanics (Figs. 2c, 3c, 4c) plot in two distinct groups which correspond to the pre-mineralisation footwall andesites and the post-mineralisation dacites. They coincide with the magmatic trend defined by the CVS, although minor carbonate alteration of the dacites has lead to lower SiO_2 and higher CaO values than normal.

The altered volcaniclastics (Figs. 2d, 3d, 4d) show a vertical spread of values typical of hydrothermal alteration, but with Ti/Zr values indicative of andesites (Whitford et. al., 1983). Na_2O depletion and K_2O enrichment are the most obvious chemical changes due to alteration.

Implications of the Primary Chemical Patterns

Rather than a complete spectrum of volcanic compositions, as was originally suggested from the MRV data base, the inclusion of the Rosebery and Que River analyses suggests there may be four distinct compositional groups within the MRV (see Figs. 2e, 3e and 4e).

Group 1- Rhyolites with Ti/Zr from 6 to 10, characteristic of the hanging wall and footwall sequences at Rosebery.

Group 2 - CVS andesite/dacite with Ti/Zr from 16 to 22, characteristic of the Mt. Lyell area, Bradshaws Road and Tullah area.

Group 3 - Que River dacite with Ti/Zr from 10 to 15, confined to post-mineralisation rocks at Que River.

Group 4 - Que River andesites, with Ti/Zr from 20 to 44, confined to the pre-mineralisation volcanics at Que River (but probably similar to the hanging wall andesite/basalt sequence at Hellyer).

One may speculate that Groups 1 and 2 represent bimodal volcanism in the CVS, and Groups 3 and 4 bimodal volcanism in the Que-Hellyer sequence. However, bimodal suites are generally considered to have a significant SiO_2 gap (eg. Wheller and Varne, 1986) which is certainly not the case for these groups in the MRV. Bimodal or not, the groups are real and require an explanation. A number of possible explanations exist, but at this stage there is insufficient data to resolve them;

- differentiation in subvolcanic magma chambers
- subduction related back-arc rifting
- simple continental margin rifting.

Further analyses from other areas in the MRV are required to confirm the groups, and then, in conjunction with isotopic analyses (Sr, Nd/Sm), it may be possible to resolve these possibilities in the near future.

Exploration Implications

In the CVS, at Rosebery and Hercules, there is no difference in the primary chemical composition of pre-mineralisation and post-mineralisation volcanics. The development of a shale generating environment appears to be the key to ore formation. This may be associated with a major caldera collapse event (Green et. al., 1981 and Lees, in prep.). In the Que-Hellyer Sequence the orebodies occur at stratigraphic intervals representing a change in chemistry of volcanism. At Que River volcanism changed from andesitic to dacitic, whilst at Hellyer it changed from andesitic to basaltic. Such changes may be a pre-requisite for ore-formation, and control the development of hydrothermal circulation required to build a massive sulphide deposit.

Based on our present knowledge of Que River, stratigraphic boundaries between the Group 1 rhyolites and Group 2 andesite/dacite in the CVS would be good exploration targets.

Future Work

Continuing work on the MRV chemical data base will include;

- 1) Further analyses from the CVS to better define the two volcanic groups. Including the Pinnacles area, Anthony Road and south of Mt. Lyell.
- 2) Sampling and analyses of the Tyndal Group for comparison with the CVS.
- 3) REE and isotopic analysis of selected samples to allow better interpretation of the source of the volcanics and related groups.
- 4) Continued study on the effects of hydrothermal alteration. Especially alteration in the footwall precious metal zone at Que River and the K-feldspar and chlorite-magnetite zones at Lake Selina and Red Hills.

Acknowledgements

Thanks to David Whitford (CSIRO) and Aberfoyle for permission to use their Que River analyses, and to Winfried Naschwitch and E.Z. Co. for permission to use their Rosebery analyses. Thanks also to Phil Robertson for keeping the XRF in operation.

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SUMMARY

The geological setting and occurrence of the Golden Grove deposits - Gossan Hill and Scuddles - are briefly described.

The Gossan Hill Cu-Zn mineralisation has been reinterpreted. The deposit consists of early stratabound, podiform magnetite phase which is cross-cut by later copper-bearing sulphide stringers. Minor Zn/Pb/Ag/Au massive sulphide deposition in the hangingwall to the main mineralisation, is stratigraphically equivalent to the Scuddles deposit 4km to the north.

The Scuddles Zn/Ag/Cu/Pb/Au deposit is a stratabound massive sulphide underlain by a blanket sulphide stringer zone.

Scuddles is made up of three main ore types massive sphalerite, massive pyrite and copper-bearing massive pyrite.

A paragenetic mineral sequence containing early euhedral magnetite with later pyrite, chalcopyrite and sphalerite has been identified. Significant late stage pyrite/chalcopyrite overprinting, effects the distribution of Zn in the ore. Outline drilling of the massive sulphide should be based on the thickness and not the Zn grade of the ore blanket.

Metal zonation on long section using m x % and ppm x % indicates a strong linear control on metal distribution. These linear features represent conjugate fracture sets which controlled the emission of hydrothermal fluids on to the sea floor during ore formation. Extensions to these linears form the most prospective areas for future ore discovery.

Metal zonation on cross-sections, using assay values shows a strong correlation between Zn/Ag and Pb. Cu has two occurrences: a) within the stringer zone parallel to, but separated from the Zn/Ag/Pb trend and b) associated with copper-bearing massive pyrite in the massive ore blanket. Au broadly follows the massive sulphide but is concentrated at the transition between massive sphalerite and massive pyrite ore in the centre of the blanket.

INTRODUCTION

Two mineral deposits with volcanogenic massive sulphide affinities have been discovered in the Golden Grove area, 500km NNE of Perth, Western Australia.

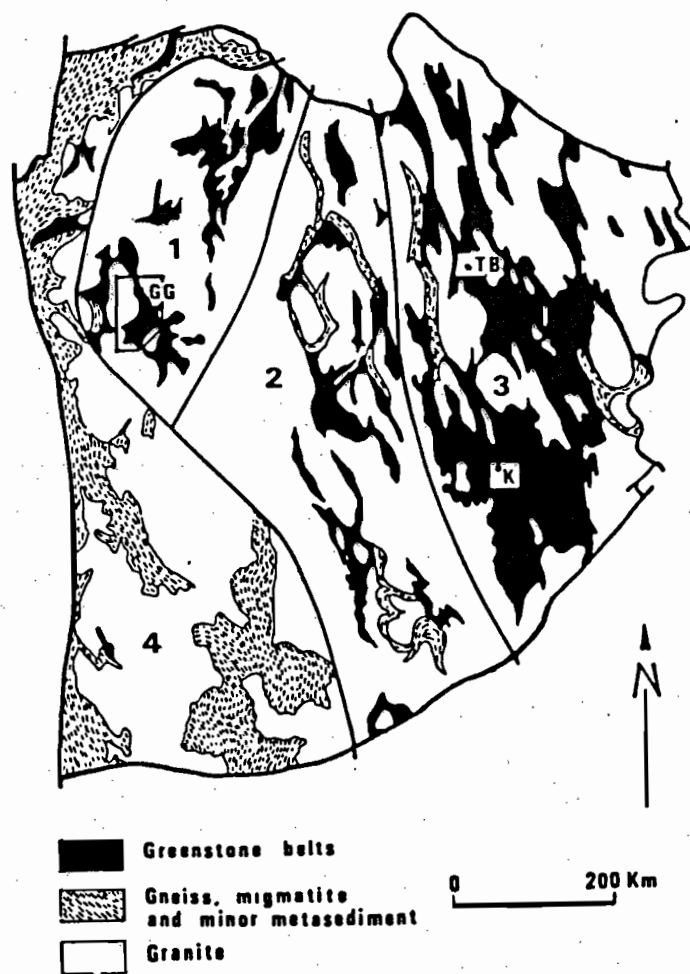
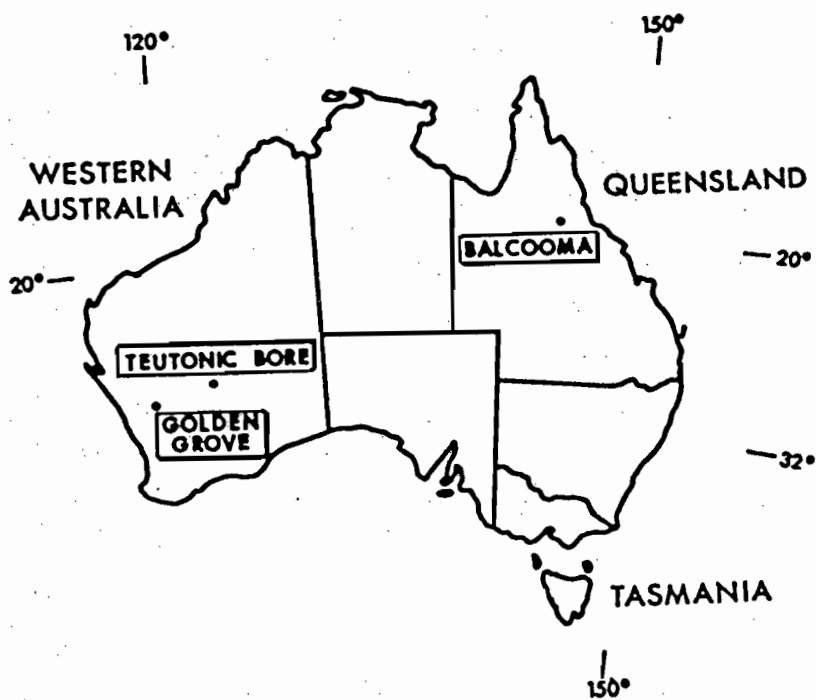


FIG. 1. Location and Regional Geology : Golden Grove.

- a) The **GOSSAN HILL** Cu/Zn deposit (Golden Grove prospect of Frater, 1983a). Copper and zinc are associated with iron sulphides which cross-cut podiform magnetite bodies and green epiclastics. Sulphide and magnetite gossan outcrops were located on Gossan Hill by Joshua Pitt of AZTEC in 1971. Drilling has outlined a geological reserve of 15 million tonnes of 3.4% Cu, 0.1% Zn, 14 ppm Ag and 0.1 ppm Au with a further 1.7 million tonnes of 14% Zn, 1.6% Pb, 0.4% Cu, 87 ppm Ag and 2.2 ppm Au in the hangingwall zinc lenses (Frater, 1983a).
- b) The **SCUDDLES** Zn/Ag/Cu/Pb/Au deposit is a blanket-shaped stratabound volcanogenic massive sulphide situated four kilometres to the north of Gossan Hill. Scuddles was discovered by a combination of geological mapping, R.A.B. drill geochemistry and magnetics by ESSO in 1979. Surface and underground exploration drilling has defined a geological reserve of:
- i) Main Lens 11.0 mt @ 9.3% Zn, 81 ppm Ag, 1.1% Cu, 0.6% Pb and 1.5 ppm Au.
 - ii) Zinc Lens 7.6 mt @ 9.9% Zn, 73 ppm Ag, 0.4% Cu, 0.8% Pb and 0.7 ppm Au.
 - iii) Copper Lens 7.5 mt @ 0.6% Zn, 12 ppm Ag, 2.1% Cu, 0.1% Pb and 0.3 ppm Au.
- (AZTEC annual report December 1984).

The Golden Grove licence is held under Joint Venture by E.Z., A.C.M., ESSO and AZTEC.

REGIONAL GEOLOGY

The Archaean Yilgarn Block of the Western Australian Shield consists of a typical greenstone - granitoid terrain in which synformal greenstone belts are surrounded by large volumes of granite (Fig. 1). The Golden Grove deposits form part of the Yalgoo Greenstone Belt in the Murchison Province, N.W. Yilgarn. The Murchison Province is typified by a lack of a single well defined greenstone belt trend and lower greenschist facies regional metamorphism.

The stratigraphic succession in the vicinity of Golden Grove is characterised by two volcano-sedimentary cycles separated by an unconformity (Fig. 2). Massive sulphide mineralisation is confined to the basal unit of the first cycle. The stratigraphy is summarized in Table 1. Four phases of deformation f1 to 4 and two cleavages S2 and S3 are defined. Rb/Sr whole rock dating of granites in the Murchison Province confirm an age of 2550 to

Igneous Intrusive Rocks

-  Gneiss
-  Granitoid
-  Mafic layered sill
-  Ultramafic

Volcanic and Sedimentary Rocks

-  Unit 6: lutites, minor arenites
-  Unit 5: volcanogenic rocks
-  Unit 4: rudites, arenites
-  Unconformity
-  Unit 3: sedimentary rocks, basalts
-  Banded-iron formation
-  Unit 2: volcanogenic sedimentary rocks
-  Unit 1: Golden Grove volcanoclastic rocks

-  Rock-unit boundary
-  Unconformity
-  Strike and dip of bedding
-  Strike of vertical beds
-  Fault
-  Inferred fault
-  Syncline, axial trace and plunge direction
-  Anticline

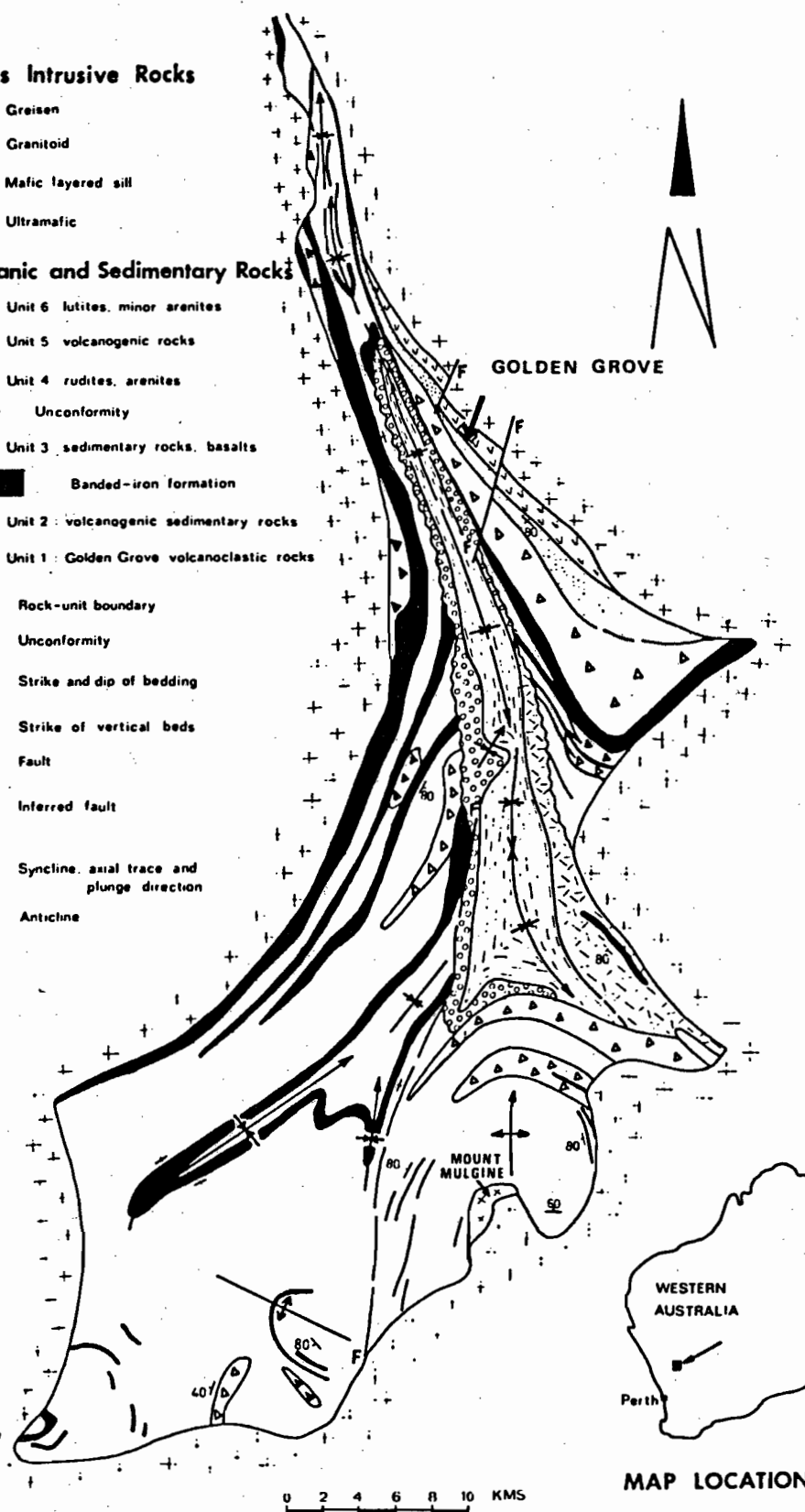


FIG. 2. Geology of the Yalgoo Greenstone Belt (From Frater, 1983a).

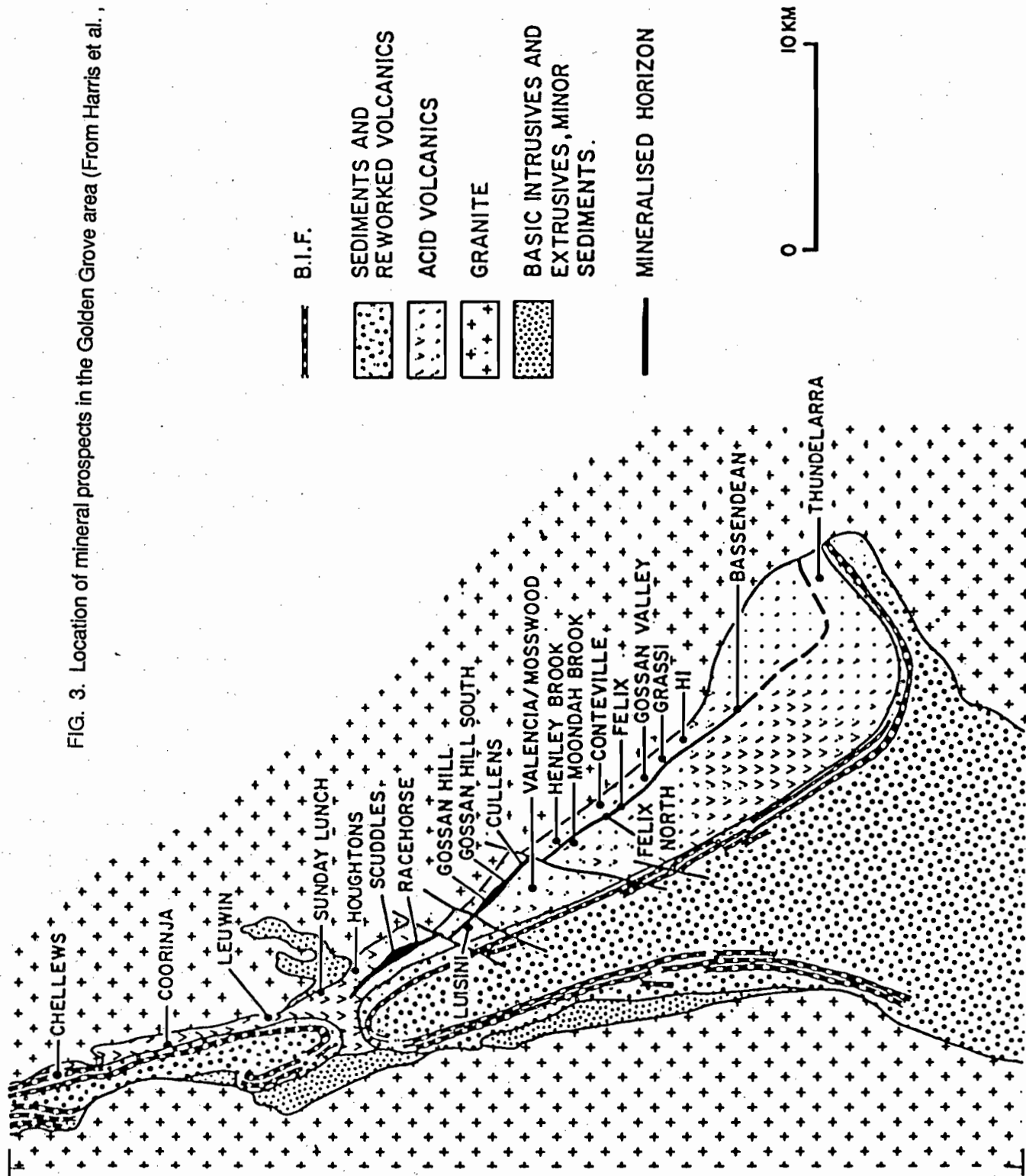
<u>UNIT</u>		
	6	Carbonaceous and pyrite lutite, minor arenite.
<u>CYCLE 2</u>	5	Coarse and fine grained volcanogenic rocks, minor RIF. (1km thickness).
	4	Pebbly arenite and rudite (0.5 km thickness).
Unconformity		
	3	BIF intercalated with fine grained clastic rocks and laterally equivalent to Fe-rich chert in a basaltic volcanic succession. (<7km thickness).
<u>CYCLE 1</u>	2	Fine grained volcanoclastics - dominantly quartz-sericite schists (0.5km thickness).
	1	Volcanoclastic, lavas and pyroclastics MASSIVE SULPHIDES (1km thickness).

TABLE 1

STRATIGRAPHY OF THE GOLDEN GROVE AREA (after Frater, 1983).

CONFIDENTIAL

FIG. 3. Location of mineral prospects in the Golden Grove area (From Harris et al. , 1982).



2700 Ma from muscovites in the Mt. Mulgine W-Mo-bearing skarn (de Laeter et. al., 1981). Significant volumes of unmetamorphosed diabase and dolerite dykes of Proterozoic age cut the stratigraphy.

LOCAL GEOLOGY

Unit 1 of the first volcanosedimentary cycle crops out over 20km on the eastern limb of a regional synform. Facies within this unit show a remarkable lateral continuity. More than 20 mineralized prospects have been identified along the belt confined to a well defined horizon (Fig. 3).

The stratigraphy of the Gossan Hill and Scuddles areas has been the subject of some discussion. Published accounts are given by Frater (1983a) and Harris et. al. (1982). Recent work by B. Clifford (Ph.D. student at Monash University, supervised by R. Cas) has led to the reinterpretation and simplification of the succession. Figures 4 and 5 summarize the stratigraphy of the Gossan Hill and Scuddles areas following Clifford (1986). The sequence beneath the mineralized horizon is typified by coarse grained sediments with minor lavas and fine grained epiclastics. The mineralised horizon itself is characterized by fine grained green epiclastics, tending from massive towards the base to finely laminated at the top. The fine sediments represent a quiescent deposition phase. Rhyodacite lavas overly the mineralized horizon and pass up into andesitic sediments and dacite lavas. The top of the mineralized horizon marks a boundary between a dominantly sedimentary environment in the footwall, to a volcanic setting in the hangingwall.

Regional deformation is characterized by broad folding. Superimposed folds are not common. The strata between Gossan Hill and Scuddles dip uniformly to the west at 80° and 60° respectively.

GOSSAN HILL DEPOSIT

The Gossan Hill deposit has been extensively studied and reported by Frater (1983a, b, c and d) and Seccombe and Frater (1981). Figure 6 outlines the surface geology of Gossan Hill. Footwall tuffaceous horizons have been reinterpreted as volcanoclastics and fine grained epiclastics and the upper crystal tuff as rhyodacite lava. The sequence dips steeply to the west and is invaded by significant volumes of diabase and dacite dyke material. Intrusive boundaries are highly irregular leading to problems in defining precise ore limits. Sulphide and magnetite gossan is located in

GOLDEN GROVE SCHEMATIC STRATIGRAPHY 19370N-23110N.

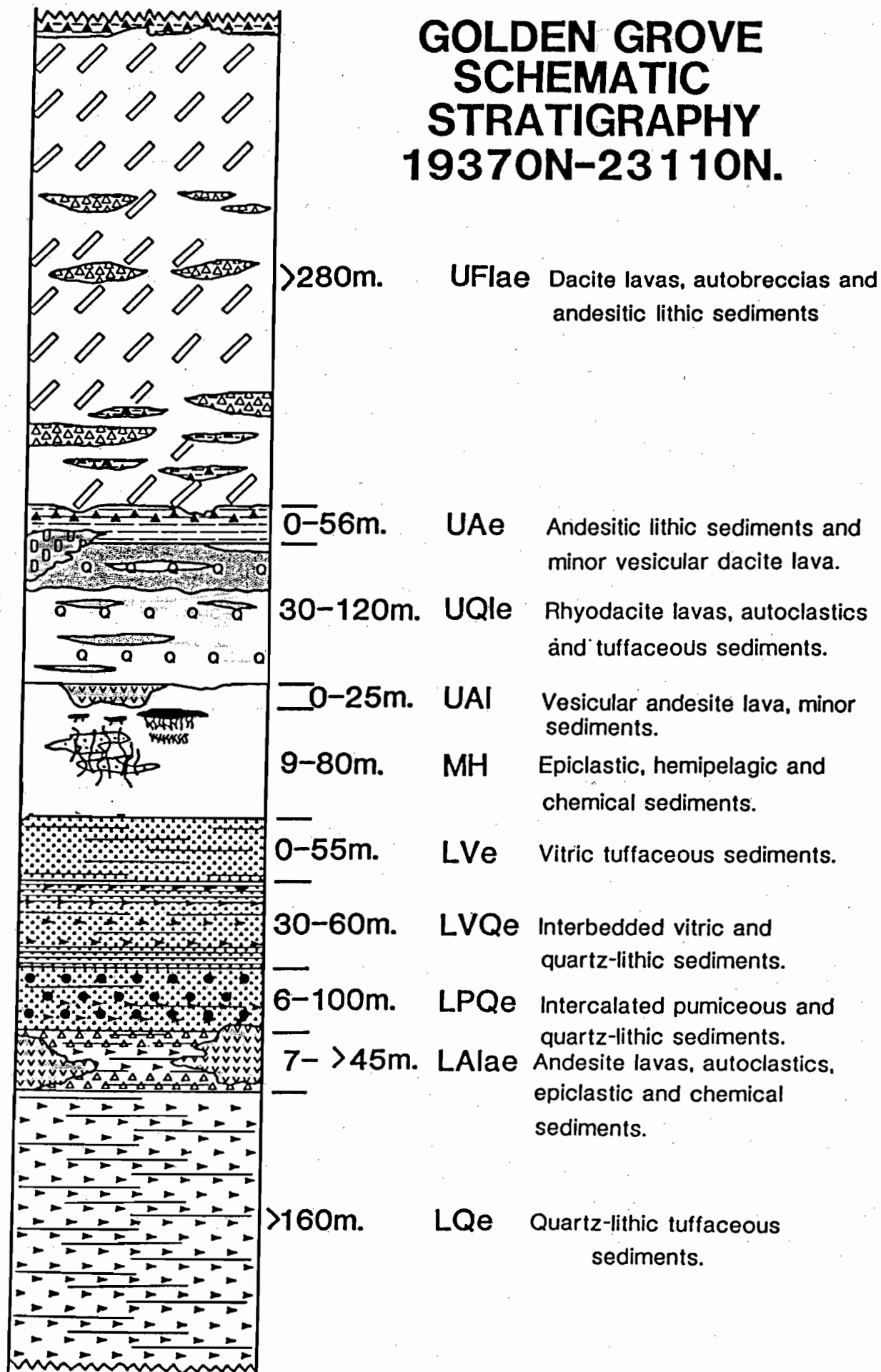


FIG. 4. Stratigraphy between Gossan Hill and Scuddles (adapted from Harris et al., 1982).

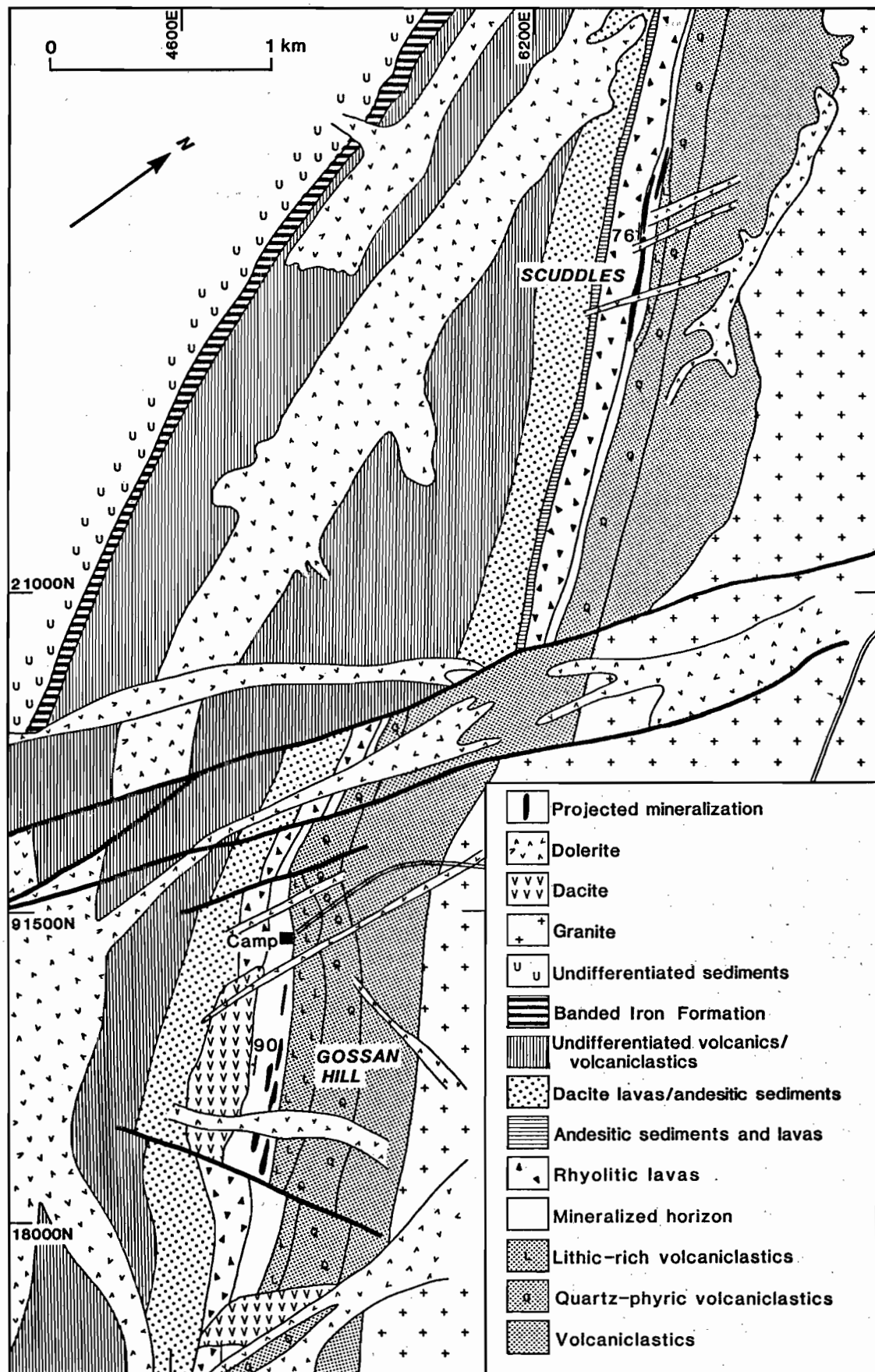


FIG. 5. Geology of the Gossan Hill and Scuddles area (redraw from Harris et al. , 1982).

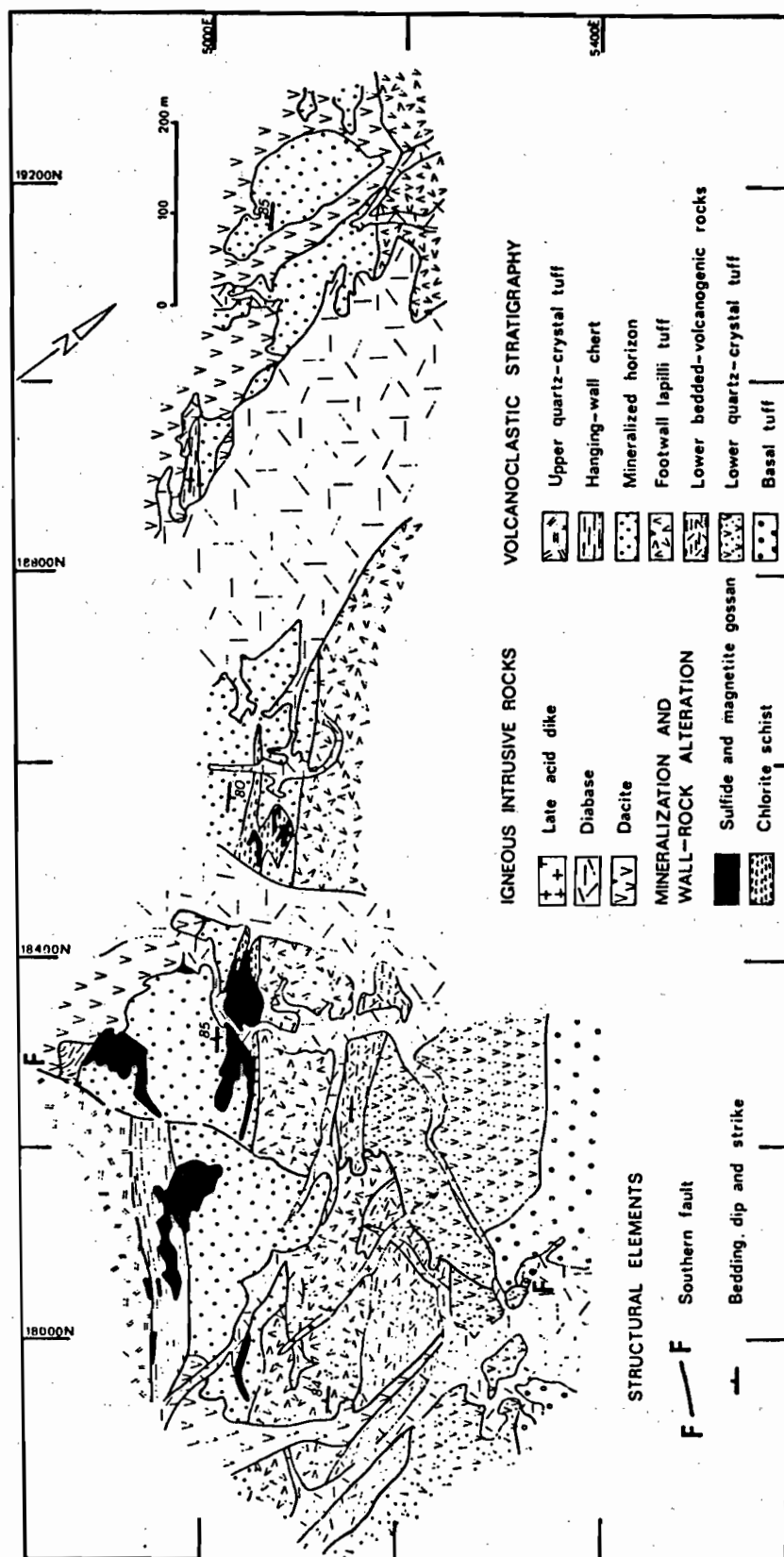


FIG. 6. Surface geology of the Gossan Hill deposit (after Frater, 1983a).

the hangingwall chert and throughout the mineralised horizon. Two types of mineralization occur: 1) massive magnetite bodies cross-cut by sulphide stringers in the main part of the mineralised horizon and 2) stratabound massive sulphide deposits in finely laminated epiclastics of the "hangingwall chert" unit (the zinc lenses).

Massive magnetite and stringer sulphide occur as footwall to the stratabound hangingwall zinc-rich lenses. Frater (1983a) outlined eight ore lenses in the main zone based on copper grade. Figure 7 represents a cross-section on 18,500N and indicates the distribution of >50% magnetite and ore lenses (as defined by elevated copper grade). The distribution of magnetite and copper sulphide is clearly different. Examination of drill core indicates early development of massive magnetite with associated chloritic alteration. Magnetite distribution is irregular and apparently replaces green epiclastic rocks. Sulphide veins and stringers cross-cut both massive magnetite and green epiclastic units. This separation of magnetite and sulphide events is a departure from data presented by Frater (1983a).

Stratabound massive sulphide deposits developed in the hangingwall chert horizon are clearly distinct from the main mineralised zone. These deposits are Zn, Ag and Au-rich (+Pb) with respect to the main lens and are similar to the Scuddles deposit.

SCUDDLES DEPOSIT

Mineralization at Scuddles is confined to the upper part of the mineralized horizon and is stratigraphically equivalent to the hangingwall chert zinc lenses at Gossan Hill, 4 km to the south (Figs. 5 & 8). The deposit consists of a massive sulphide lens underlain by a stringer blanket zone which decreases in intensity with depth (Fig. 10). Three types of massive ore occur: 1) massive sphalerite (>50% sphalerite), 2) massive pyrite (<50% sphalerite, <5% chalcopyrite) and 3) copper-rich massive pyrite (>5% chalcopyrite). Massive sphalerite ore generally occurs at the top of the ore lens and may interfinger with massive pyrite. Copper-rich massive ore occurs towards the base of the deposit and contains patches of recognizable stringer material (Fig. 10). Massive ore is underlain by a stringer blanket which varies from >80% sulphide, to >30% to >10% sulphide. Siliceous fine grained sediments are spatially associated with intense stringer developments.

Three ore lenses have been defined, the Main and Central lenses consisting of massive stratabound ore and the North lens which represents a coalescence of stringer veining at a lithological boundary in the footwall

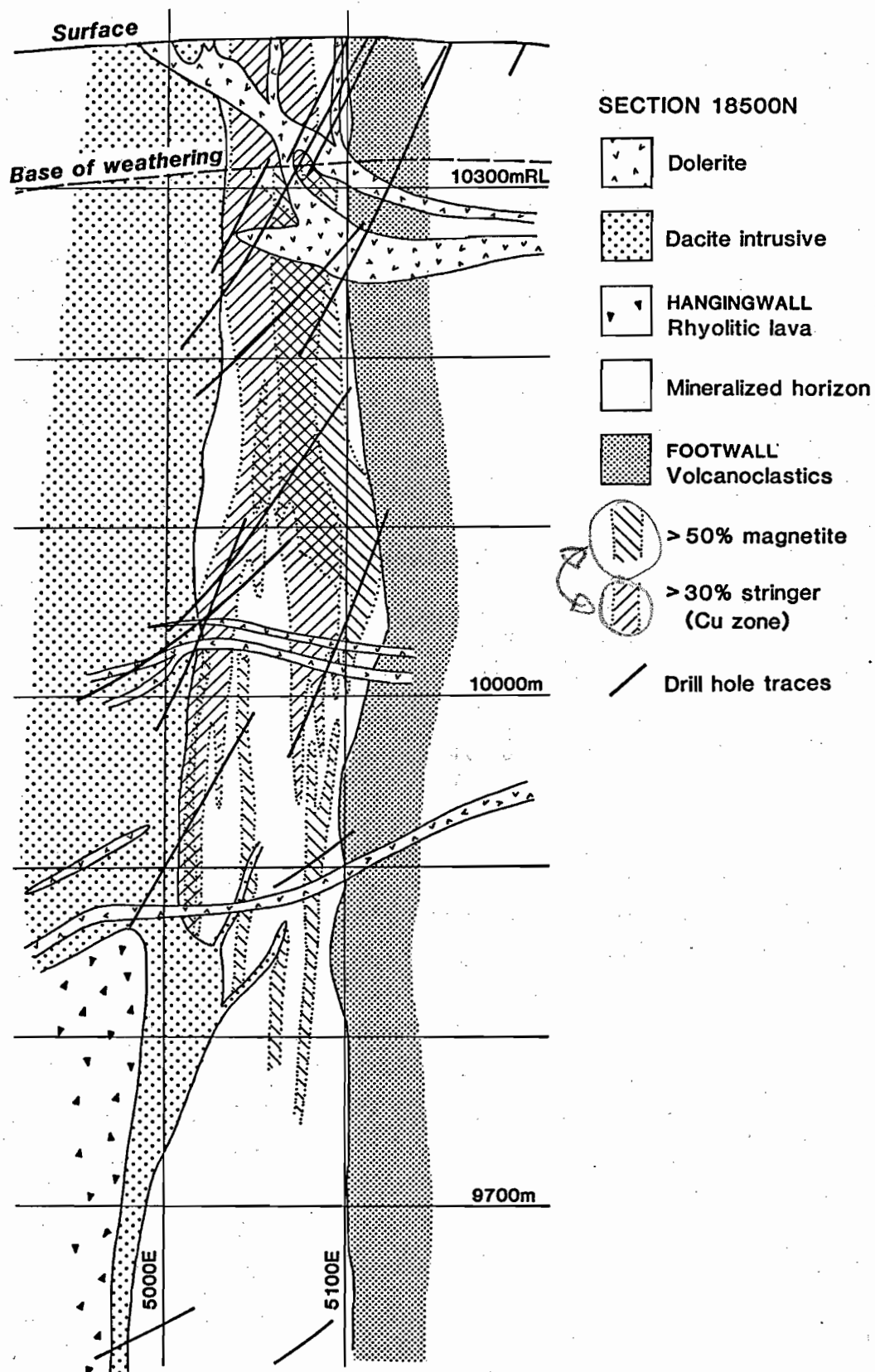


FIG. 7. Cross-section on 18500N through the Gossan Hill deposit indicating the relative distribution of massive magnetite (>50%) and elevated copper grades in sulphide stringer.

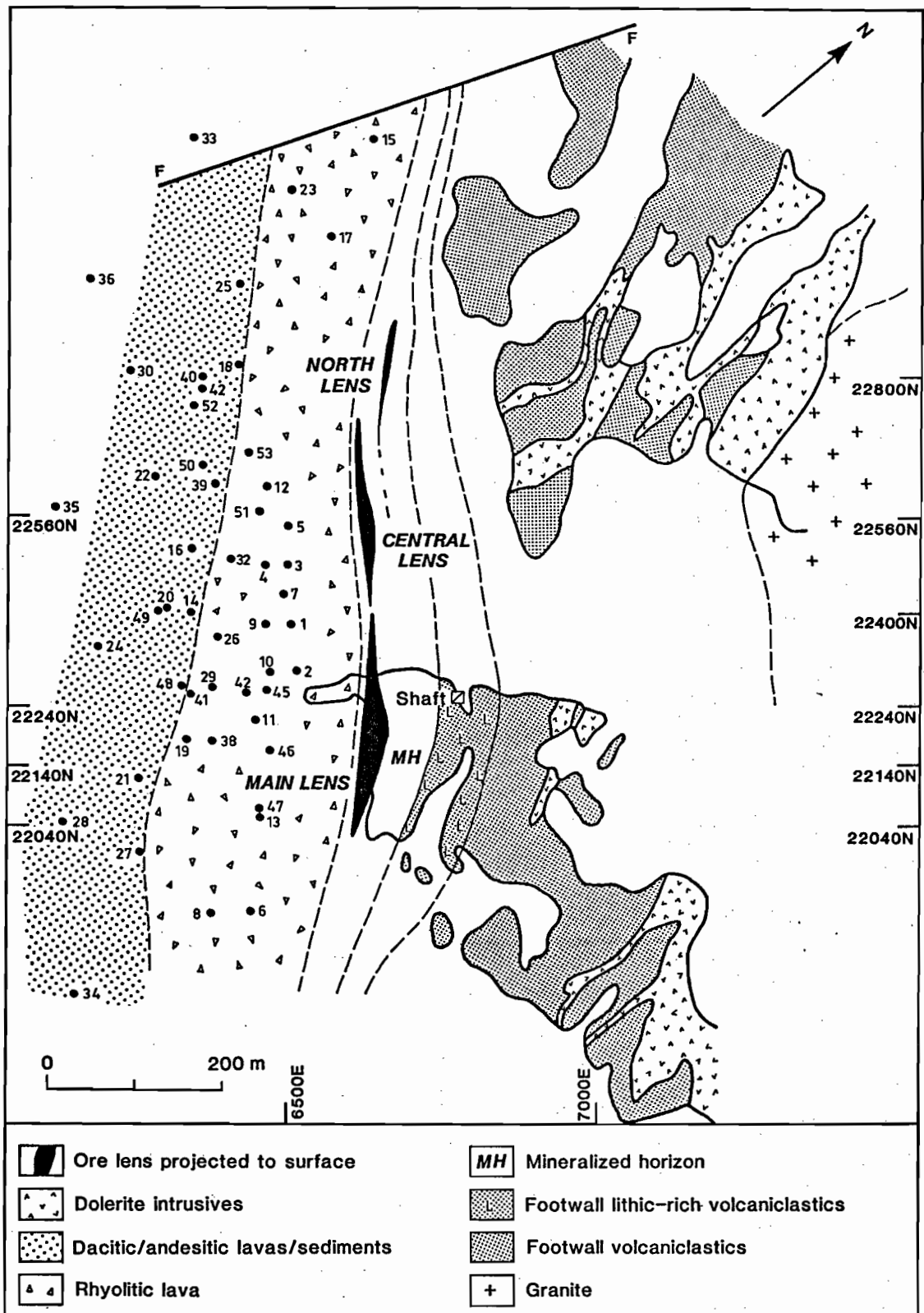


FIG. 8. Surface geology of the Scuddles deposit.

(Fig. 8). The mineralization extends over 1000m strike, is greater than 400m wide and upto 50m thick.

MINERALOGY

Massive sphalerite ore consists mainly of coarse grained (average 2 to 3mm) sphalerite which varies in colour from honey to deep red/brown. Pyrite bands and blocks are common. Accessory sulphides include galena, chalcopyrite, pyrrhotite, with trace arsenopyrite and tetrahedrite. Gangue mineralogy consists of euhedral magnetite, quartz, sericite, talc, albite, tourmaline, clino-amphibole, carbonate and cassiterite (Ryall, 1983). Massive pyrite ore contains dominantly pyrite with sphalerite, chalcopyrite, pyrrhotite and magnetite. Gangue minerals include quartz, chlorite, carbonate, sericite and talc. Copper-rich massive pyrite is similar to the massive pyrite ore with the addition of significant chalcopyrite and pyrrhotite.

Gold occurs as electrum. Silver is contained in electrum, as native silver, pyrargyrite, argentian tetrahedrite (friebergite) and in solid solution in galena. Both gold and silver minerals are fine grained <10 μ m (Townsend, 1985).

A strong fabric or banding is developed in the massive sphalerite ore. The presence of rotated pyrite blocks, nodules and boudinage structures imply a tectonic origin for this fabric (Eisenlohr, 1985). Massive pyrite ores are not sheared, a result of a large competency difference between massive pyrite and sphalerite under strain.

Examination of drill core has realized a paragenetic mineral sequence developed throughout the deposit. The earliest mineral in the sequence is euhedral magnetite occurring as disseminated cubes (1 to 3mm across) in both the massive sulphide and finely bedded epiclastics of the hangingwall. In the massive sulphide euhedral magnetite is commonly associated with talc and sericite plus inclusion free nodular pyrite (Fig. 9). This texture is termed the Leopard Texture. Late pyrite growth around existing nodules may incorporate inclusions of matrix magnetite, talc and sericite. Fine grained pink sphalerite is common constituent of the matrix mineralogy. Chalcopyrite develops at the margins and in cracks within the nodular pyrite. minor chalcopyrite may occur as matrix disseminations. Pyrrhotite is associated with chalcopyrite. Shearing of chalcopyrite/pyrrhotite

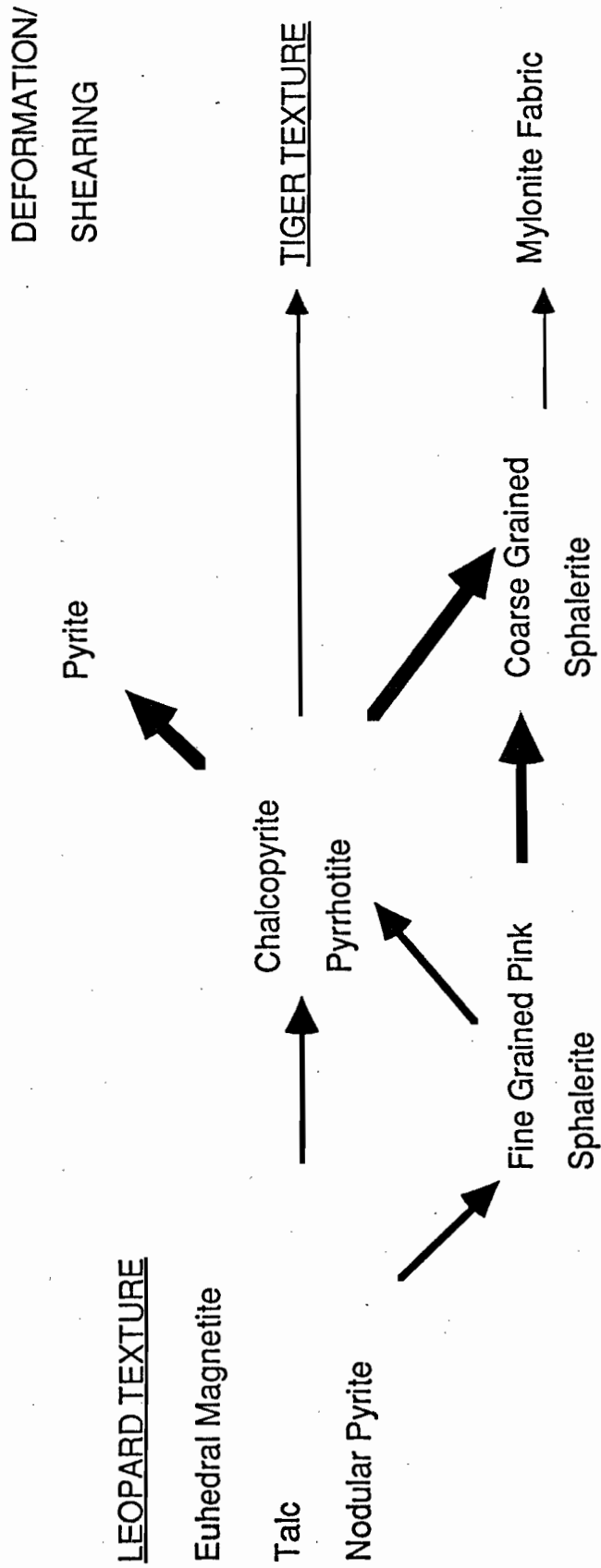


FIG. 9. Paragenetic mineral sequence at Suddles recognized in hand specimen.

leopard texture produces a banded rock called the Tiger Texture. Recrystallization of pink fine-grained sphalerite results in coarse grained sphalerite. In parts coarse grained sphalerite appears to replace talc and sericite to produce sphalerite/magnetite/pyrite $\pm$ chalcopyrite/pyrrhotite assemblages. Significant late stage pyrite overprinting is observed. Inclusion-free nodules of pyrite with rims of chalcopyrite are recognized in a mass of pyrite with euhedral magnetite and chalcopyrite inclusions. This texture indicates pyrite overprint of the leopard texture.

Metal Zonation - Long Section

Metal distribution in the Scuddles deposit was contoured on long section using m x % and m x ppm. The data was derived from Kriged ore reserve estimates made by Siromines (1986) using 20m x 20m x 3m blocks. Mineralization was divided into three types on the basis of zinc grade with minor geological adjustment:

Massive Zinc Ore	greater than 4.5% Zn,
Massive Copper Ore	less than 4.5% Zn and greater than 1.5% Zn
Stringer Copper Ore	less than 1.5% Zn.

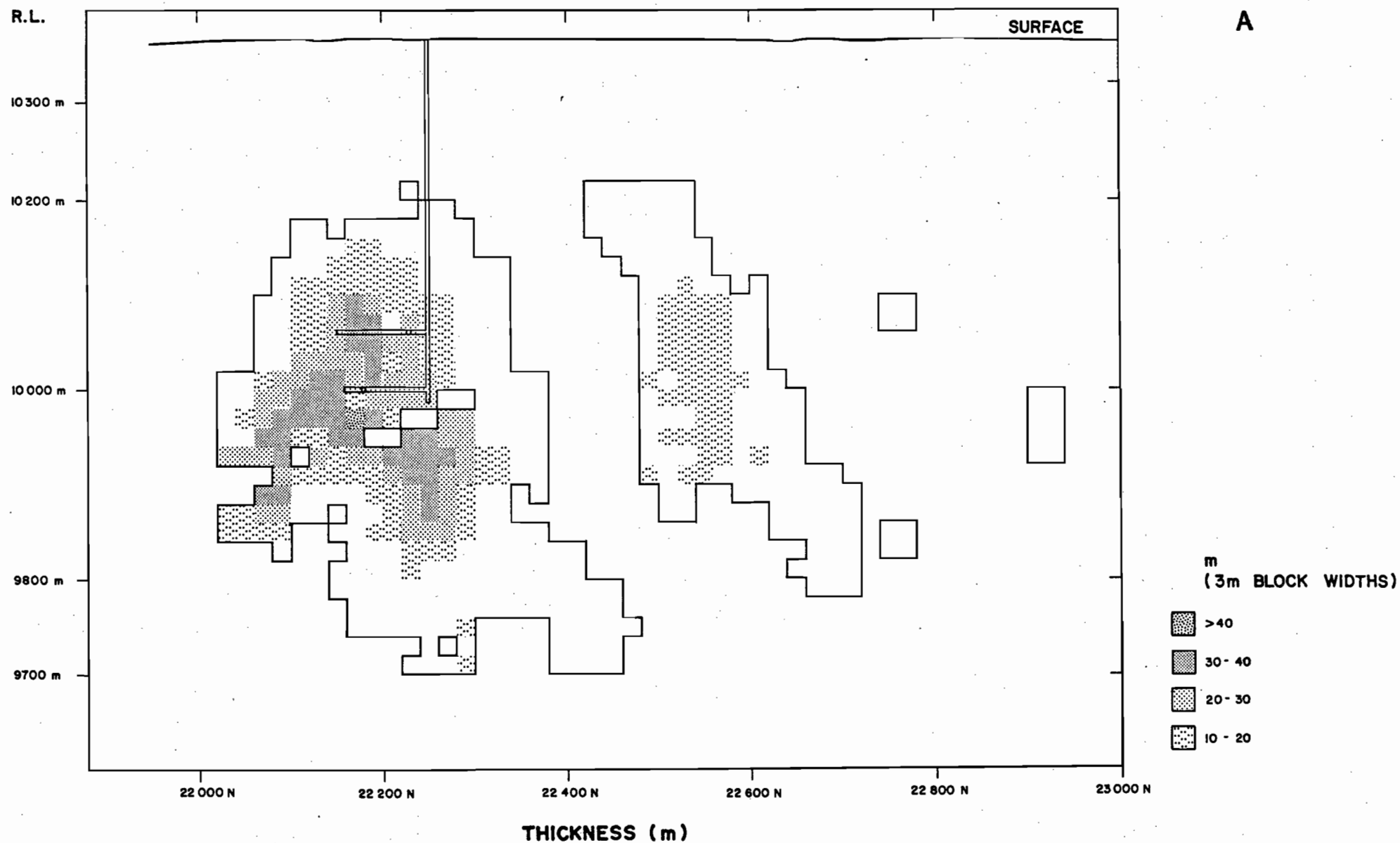
Five metals were contoured for each ore type: Zn, Pb, Cu, Ag and Au. The results are presented on Plans 1, 2 and 3.

The distribution and thickness of ore blocks illustrate the relationship between ore types. The Massive Zinc Ore forms the most extensive mineralization style with the thickest part of the Main lens forming a strong NE and subordinate NW trend to form an inverted "V" shape. The thickest part of the smaller Massive Copper Ore is offset to the south of the main Massive Zinc Ore zone lying between the arms of the inverted "V" (Plan 2). The Stringer Copper Ore underlies both Massive Ore types and may indicate a continuum of mineralization from the Main to the Central lens (Plan 3).

In the Massive Zinc Ore (Plan 1) Zn distribution in the Main lens is greatest in the thickest part of the ore (42m) with a strong NE and subordinate NW linear trends in the plane of the ore body. Ag and Pb follow the Zn distribution closely. Cu broadly follows Zn but with the highest concentrations in the southern part of the main lens, straddling the NW Zn trend. Au follows the general trend of Zn and Cu with two high concentrations, one coincident with high Zn on the NE linear and a second high on the southern end of the NW trend at the margins of the drilled zone.

PLAN 1: MASSIVE ZINC ORE

Longitudinal Projection of the Scuddles deposit. Massive Zn Ore (cut-off > 4.5% Zn). A. Thickness, B. Zn - m x %, C. Pb - m x %, D. Cu - m x %, E. Ag - m x ppm, and F. Au - m x ppm. Data from Siromines (1986). Contoured Kriged Ore Reserve Estimate blocks (20m x 20m x 3m).



R.L.

SURFACE

B

10 300 m

10 200 m

10 000 m

9800 m

9700 m

22 000 N

22 200 N

22 400 N

22 600 N

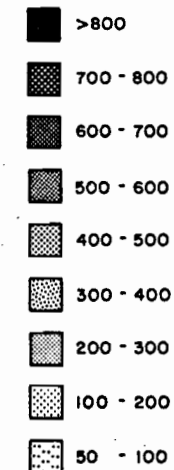
22 800 N

23 000 N

m x % Zn CONCENTRATION

MAXIMUM BLOCK GRADE
= 32.77%

Zn
m x %



R.L.

SURFACE

C

10 300 m

10 200 m

10 000 m

9800 m

9700 m

22 000 N

22 200 N

22 400 N

22 600 N

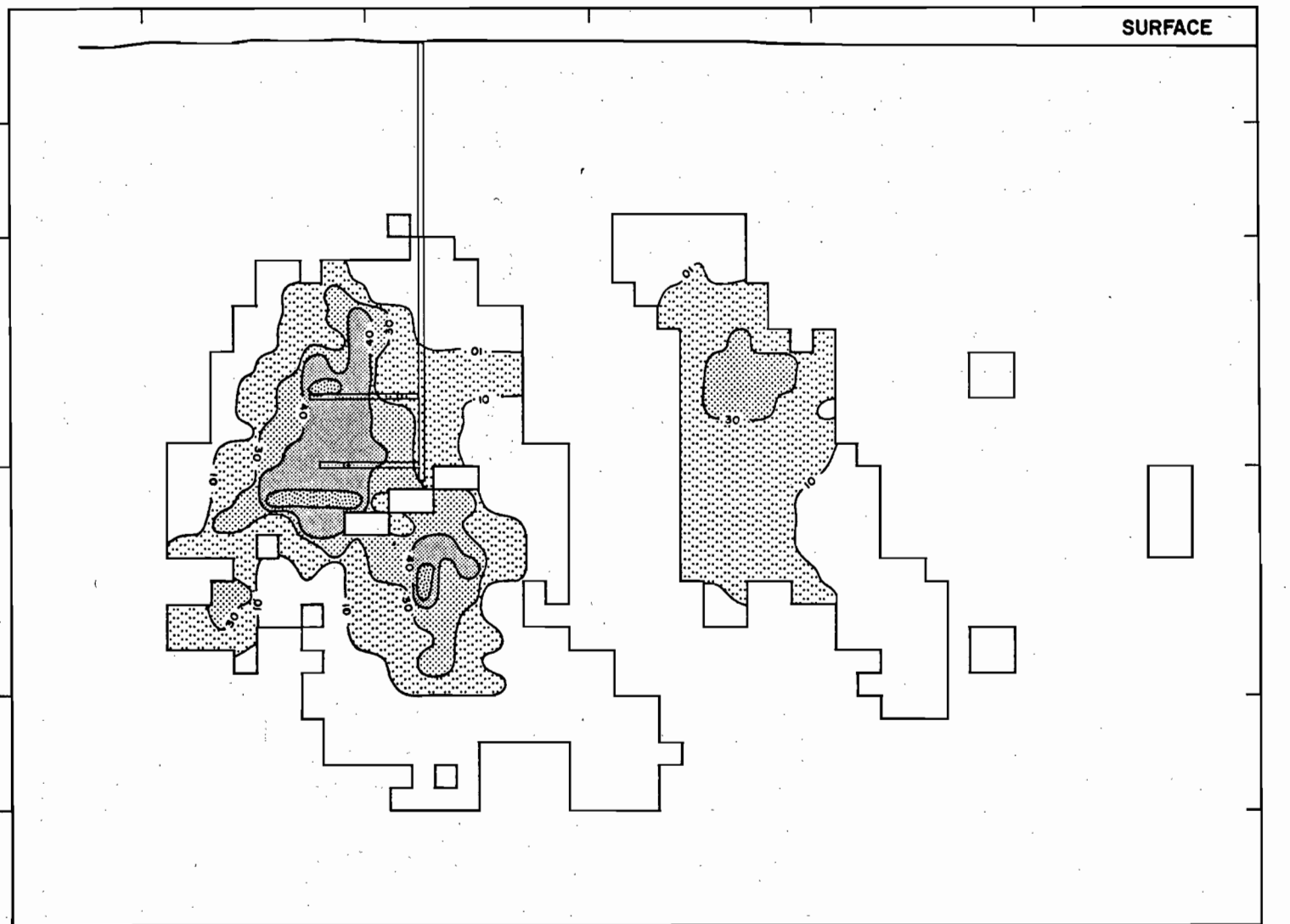
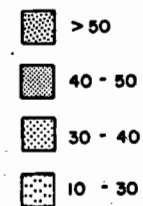
22 800 N

23 000 N

m x % Pb CONCENTRATION

MAXIMUM BLOCK GRADE
= 3.28 %

Pb
m x %



R.L.

SURFACE

D

10 300 m

10 200 m

10 000 m

9800 m

9700 m

22 000 N

22 200 N

22 400 N

22 600 N

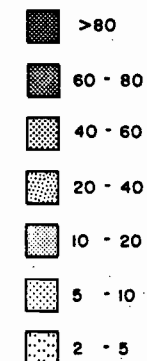
22 800 N

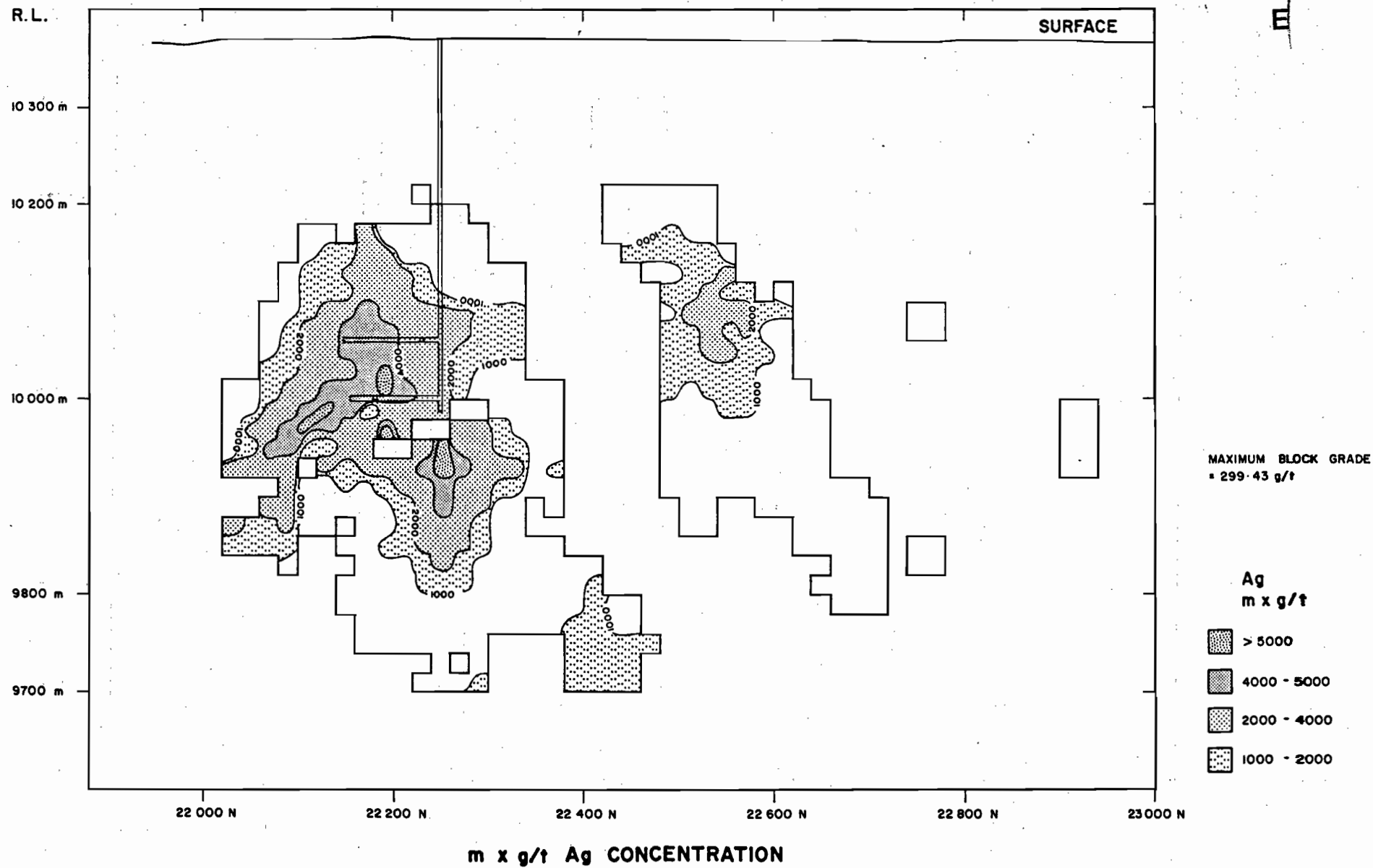
23 000 N

m x % Cu CONCENTRATION

MAXIMUM BLOCK GRADE
= 5.94 %

Cu
m x %





R.L.

SURFACE

F

10 300 m

10 200 m

10 000 m

9800 m

9700 m

22 000 N

22 200 N

22 400 N

22 600 N

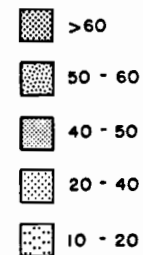
22 800 N

23 000 N

m x g/t Au CONCENTRATION

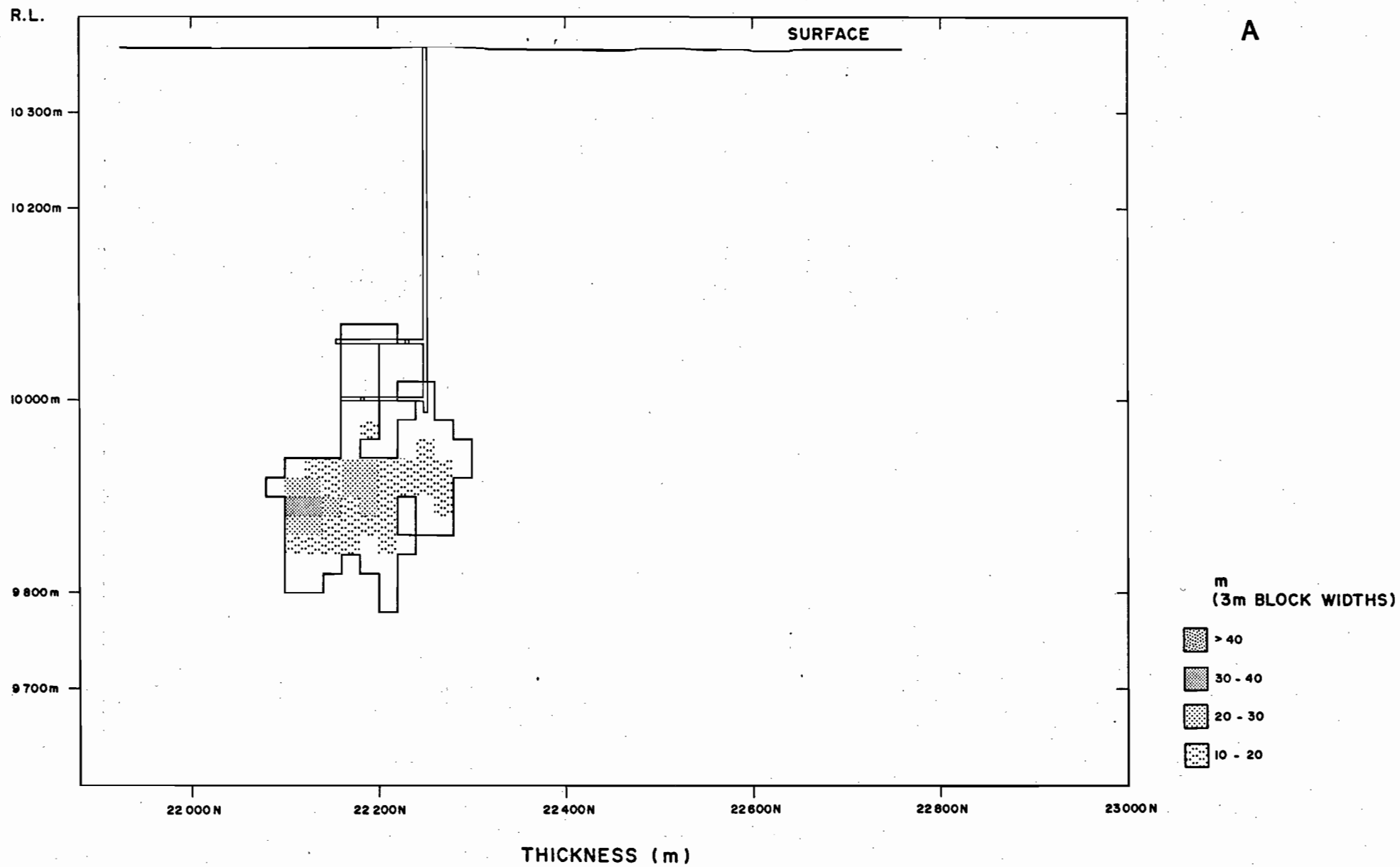
MAXIMUM BLOCK GRADE
= 3.27 g/t

Au
m x g/t



PLAN 2: MASSIVE COPPER ORE

Longitudinal Projection of the Scuddles deposit. Massive Cu Ore (cut-off $< 4.5\%$ Zn and $> 1.5\%$ Zn). A. Thickness, B. Zn - m x %, C. Pb - m x %, D. Cu - m x %, E. Ag - m x ppm, and F. Au - m x ppm. Data from Siromines (1986). Contoured Kriged Ore Reserve Estimate blocks (20m x 20m x 3m).



R.L.

SURFACE

B

10 300m

10 200m

10 000m

9 800m

9 700m

22 000 N

22 200 N

22 400 N

22 600 N

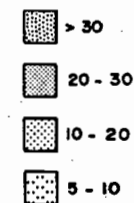
22 800 N

23 000 N

m x % Zn CONCENTRATION

MAXIMUM BLOCK GRADE
= 1.89%

Zn
m x %



R.L.

SURFACE

C

10 300m

10 200m

10 000m

9 800m

9 700m

22 000 N

22 200 N

22 400 N

22 600 N

22 800 N

23 000 N

m x % Pb CONCENTRATION

MAXIMUM BLOCK GRADE
= 0.14 %

Pb
m x %

▨ > 2.0

▤ 1.0 - 2.0

▥ 0.5 - 1.0

R.L.

SURFACE

D

10 300m

10 200m

10 000m

9 800m

9 700m

22 000 N

22 200 N

22 400 N

22 600 N

22 800 N

23 000 N

m x % Cu CONCENTRATION

MAXIMUM BLOCK GRADE
= 12.94 %

Cu
m x %

> 200

100 - 200

50 - 100

R.L.

SURFACE

E

10 300m

10 200m

10 000m

9 800m

9 700m

22 000N

22 200N

22 400N

22 600N

22 800N

23 000N

m x g/t Ag CONCENTRATION

MAXIMUM BLOCK GRADE
= 116.2 g/t

Ag
m x g/t

-  > 2000
-  1500 - 2000
-  1000 - 1500
-  500 - 1000

R.L.

SURFACE

F

10 300m

10 200m

10 000m

9 800m

9 700m

22 000N

22 200N

22 400N

22 600N

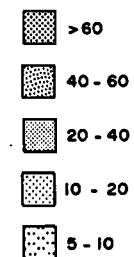
22 800N

23 000N

m x g/t Au CONCENTRATION

MAXIMUM BLOCK GRADE
= 6.7 g/t

Au
m x g/t





PLAN 3: STRINGER COPPER ORE

Longitudinal Projection of the Scuddles deposit. Stringer Cu Ore (cut-off <1% Zn). A. Thickness, B. Zn - m x %, C. Pb - m x %, D. Cu - m x %, E. Ag - m x ppm, and F. Au - m x ppm. Data from Siromines (1986). Contoured Kriged Ore Reserve Estimate blocks (20m x 20m x 3m).

R.L.

SURFACE

A

10 300 m

10 200 m

10 000 m

9 800 m

9 700 m

22 000 N

22 200 N

22 400 N

22 600 N

22 800 N

23 000 N

THICKNESS (m)

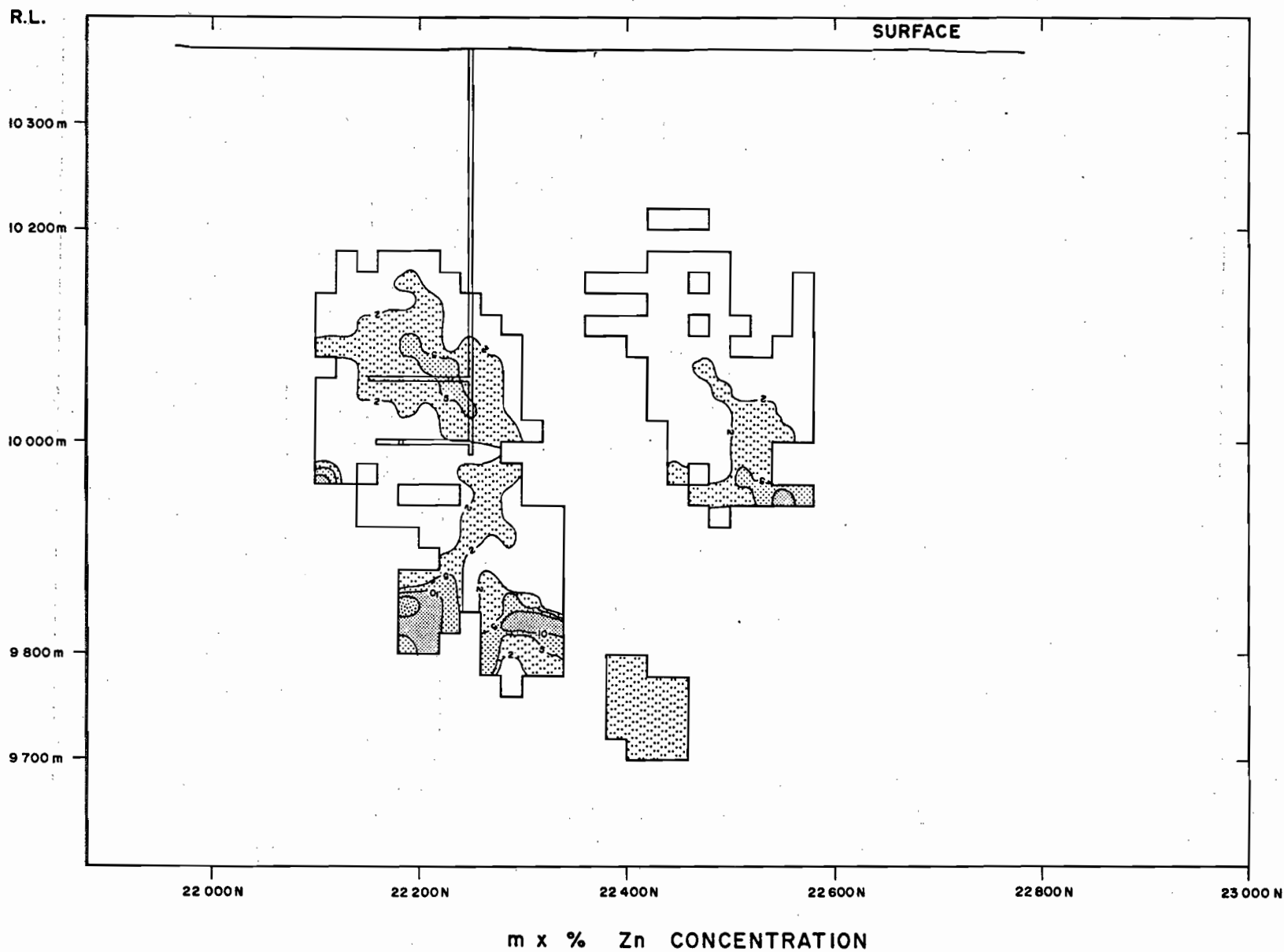
m
(3m BLOCK WIDTHS)

> 40

30 - 40

20 - 30

10 - 20



B

R.L.

SURFACE

C

10 300m

10 200m

10 000m

9 800m

9 700m

22 000N

22 200N

22 400N

22 600N

22 800N

23 000N

MAXIMUM BLOCK GRADE
= 0.27%

Pb
m x %

> 1.0

0.5 - 1.0

m x % Pb CONCENTRATION

R.L.

SURFACE

D

10 300m

10 200m

10 000m

9 800m

9 700m

22 000N

22 200N

22 400N

22 600N

22 800N

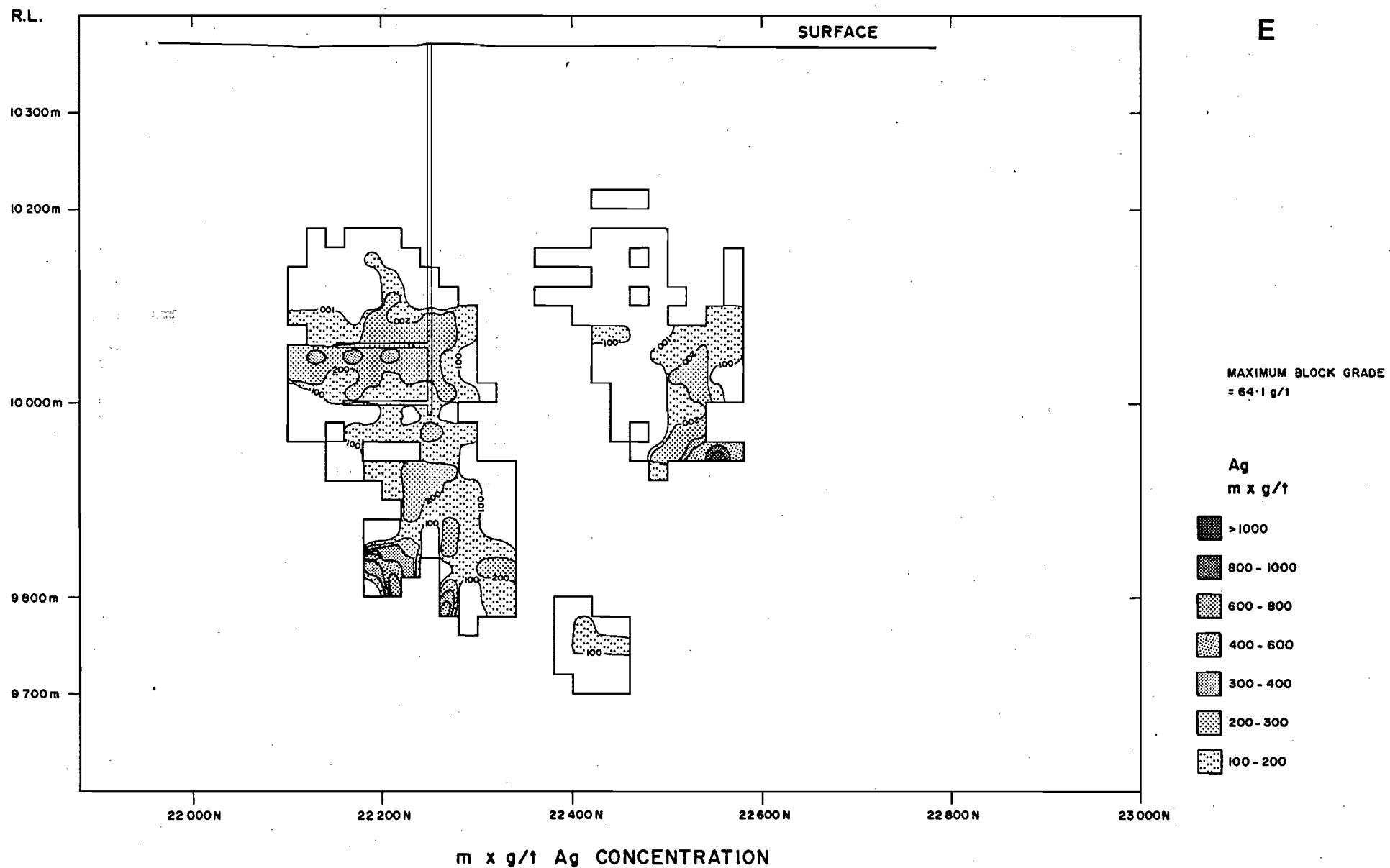
23 000N

m x % Cu CONCENTRATION

MAXIMUM BLOCK GRADE
= 6.6 %

Cu
m x %

-  > 100
-  60 - 100
-  40 - 60
-  20 - 40



R.L.

SURFACE

F

10 300m

10 200m

10 000m

9 800m

9 700m

22 000 N

22 200 N

22 400 N

22 600 N

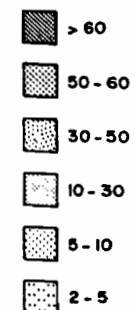
22 800 N

23 000 N

m x g/t Au CONCENTRATION

MAXIMUM BLOCK GRADE
= 5.7 g/t

Au
m x g/t



Metal distribution in the Central lens follows a parallel NE trend to the main lens Zn concentration.

Massive Copper Ore distribution is restricted to the Main lens. All metals are concentrated within the arms of the inverted "V" structure formed by the intersection of the dominant NE and subordinate NW trends in the Massive Zinc Ore. The metals are therefore located beneath the richest Cu-bearing portion of the Massive Zinc Ore.

Metal distribution in the Stringer Copper Ore is sporadic. Values of Zn, Pb, Ag and Au are generally low and the results are therefore of limited use. The Cu distribution in the main lens however forms a well defined NE trend parallel to the dominant Zn linear in the Massive Zinc Ore but slightly offset to the north.

The strong, NE linear trend in the Massive Zinc Ore and Cu in the Stringer Copper Ore is interpreted as a major focus for hydrothermal fluid discharge during mineralization. This NE trend and subordinate NW orientation imply that fluid emission was controlled by conjugate fracture sets on the sea floor during ore formation. NE and NW trends are apparent in the main lens with the NE orientation only in the Central lens. Extensions to these trends and parallel trends form the most prospective areas for the discovery of further ore.

On Section 22140N copper-bearing massive pyrite ore occurs at the top and bottom of the ore blanket. Textural evidence suggests that pyrite and chalcopyrite are overprinting the massive sphalerite ore. In this area the Zn concentration is low despite a massive sulphide thickness of 20m. Because of the patchy nature of pyrite/chalcopyrite overprinting within massive sulphide deposits it is important to drill the full thickness of massive sulphide and not base outline drilling on Zn grade.

Metal Zonation - Cross Sections

Four cross-sections through the Scuddles deposit were chosen for metal contouring: 22240N, 22140N, 22040N and 22560N. Section 22240N was chosen to give information on the main NE trend of Zn and a coincident Zn, Ag and Au high in the Massive Ore in addition to the distribution of Cu in the Stringer Copper Ore. Section 22140N was designed to intersect the main Cu-

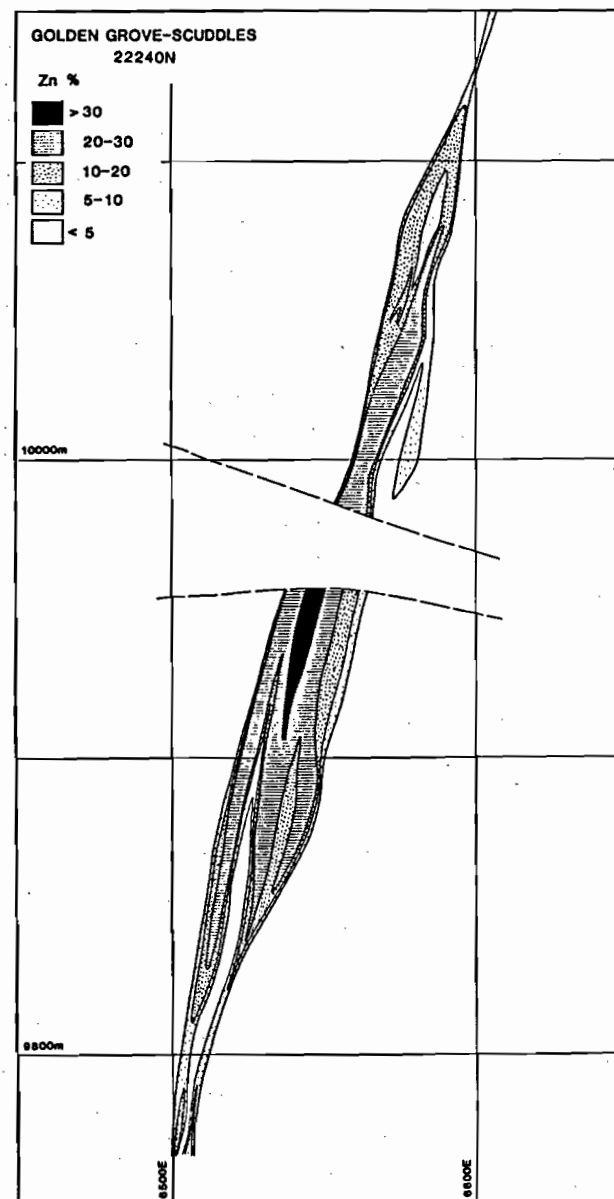
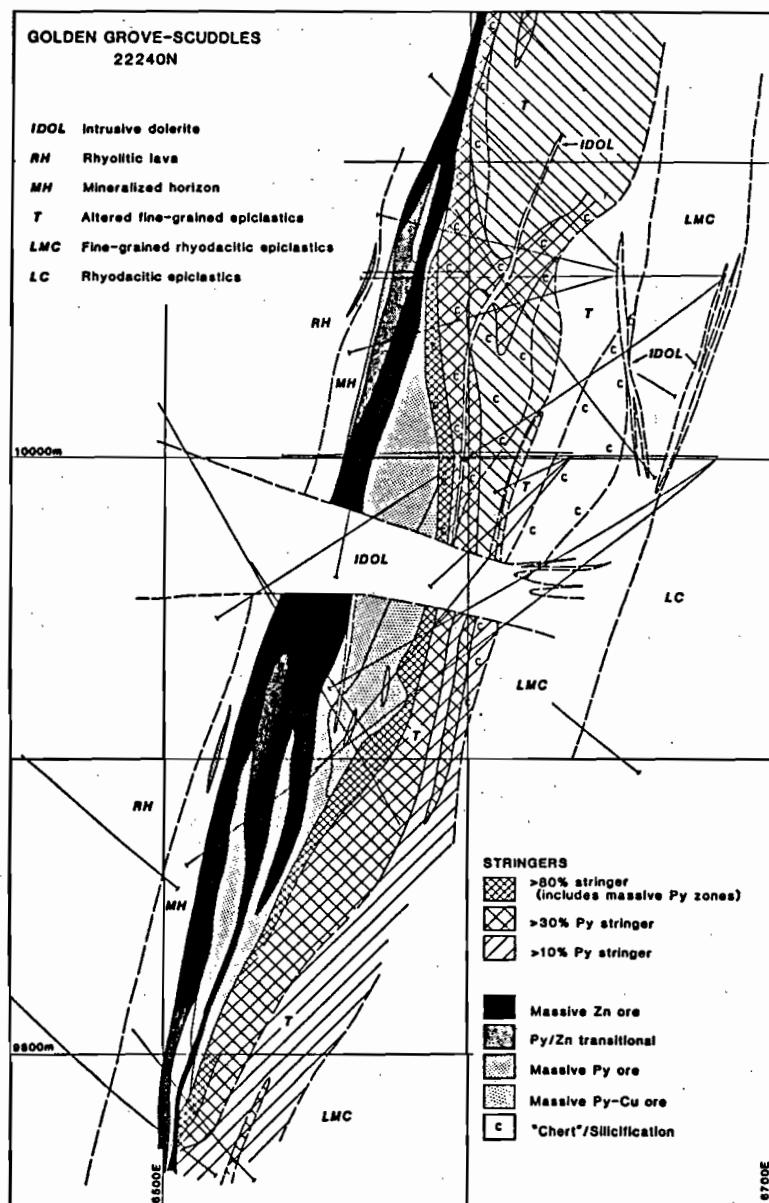
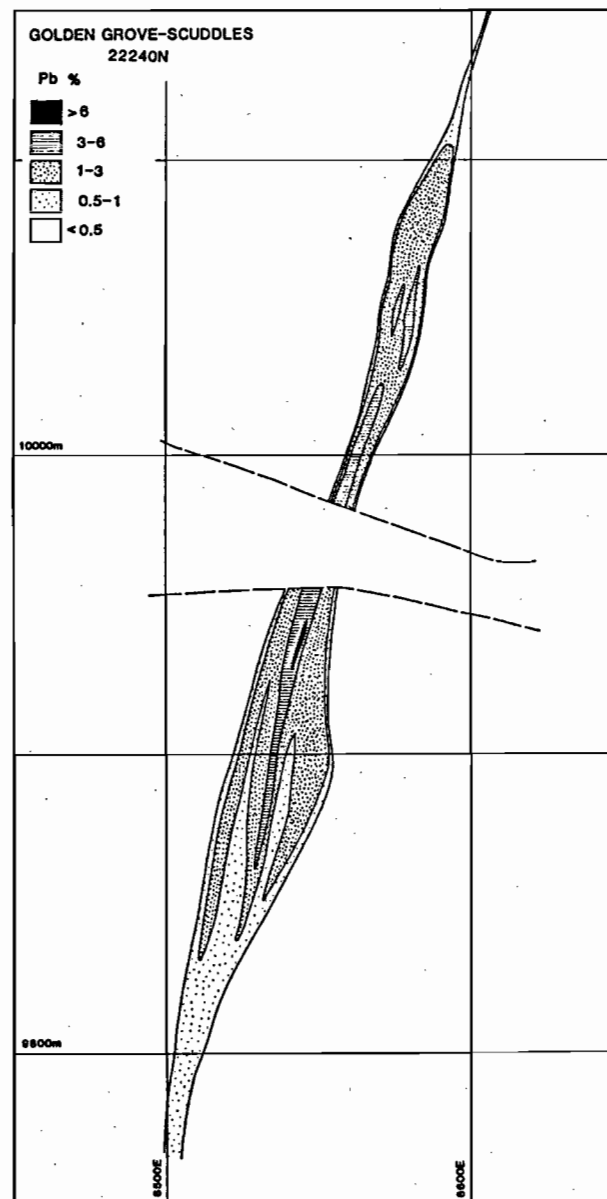
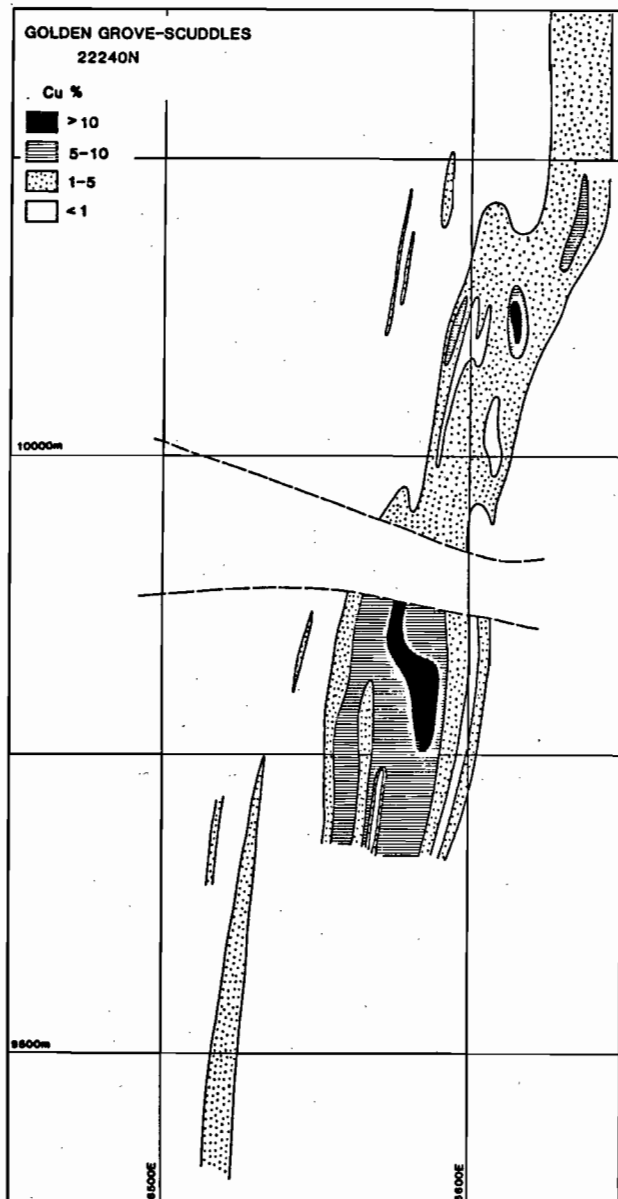
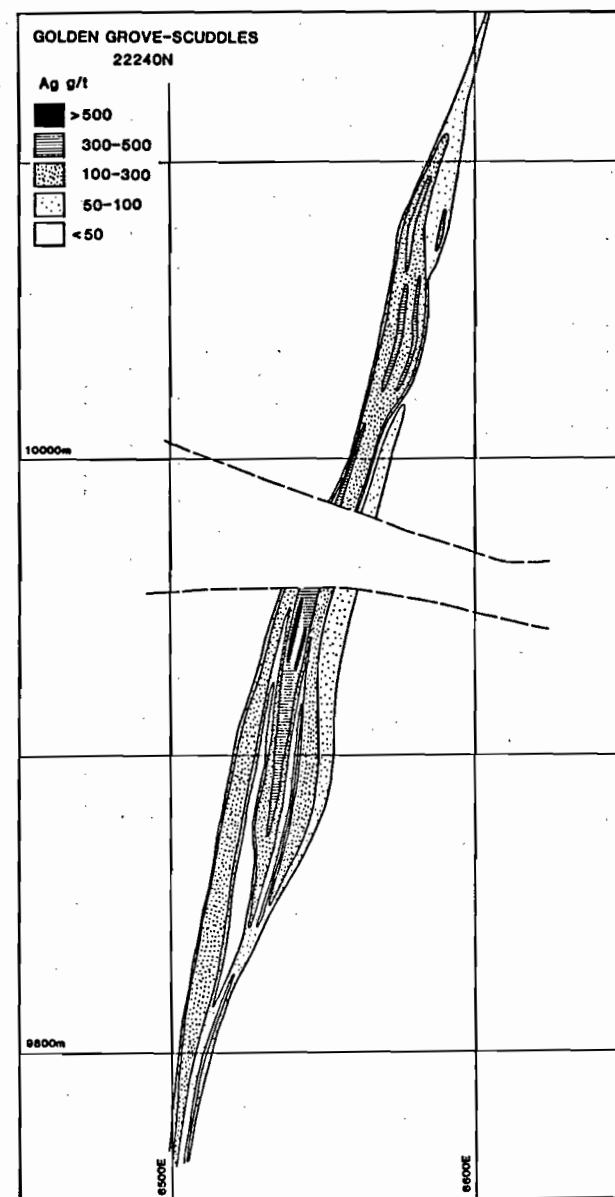
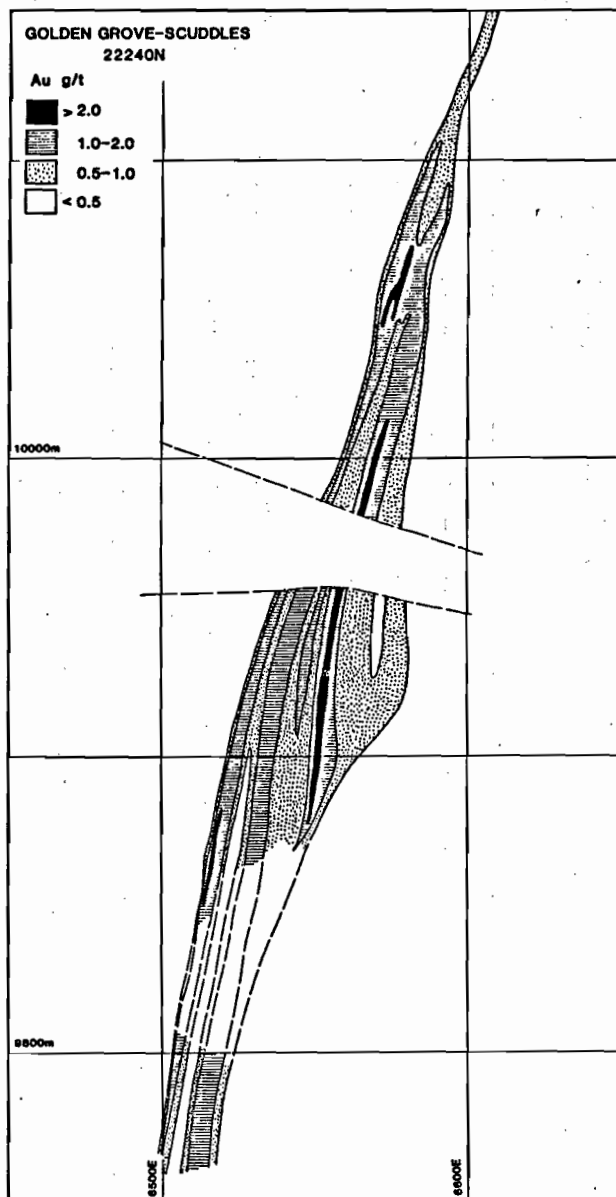


FIG. 10. Cross-section 22240N, Scuddles deposit. Geology and metal contours Zn - %, Pb - %, Cu - %, Ag - ppm, and Au - ppm.





rich part of the deposit. Section 22040N passes through the marginal Au-rich zone on the southern limit of the Massive Zinc Ore. Section 22560N cross-cuts the thickest part of the Central lens. To some extent the choice of section was determined by the extent of dyke intrusion intersected by drilling.

The geology and metal contours for each section are presented in Figures 10-13. Five metals were contoured for each section Zn, Pb, Cu, Ag and Au with assay values (% and g/t) used. The results were broadly similar throughout the Main and Central lenses.

Zn/Pb/Ag distribution - The distribution of Zn/Pb and Ag values is similar. All these metals closely follow the mapped massive sphalerite ore type (>50% sphalerite). Zn contours show >30% (maximum 48.6% over 2.5 m, 222240N), Pb values >6% (maximum 12.4% over 1 m, 22240N) with Ag up to >500 g/t (maximum 690 g/t over 1 m, 22240N). High spots of Zn correspond with Pb and Ag maxima.

Cu distribution - Cu distribution is markedly different from Zn/Pb and Ag. On sections 22240N and 22560N, both which show significant concentration of Cu in the Stringer Copper Ore from metal contouring on long section, Cu is confined to the stringer zone or copper-bearing massive pyrite lithologies. The copper zone lies in the footwall spatially separated from the Zn/Pb/Ag contours but parallel to the ore blanket. Values of >10% Cu (maximum 14.5% Cu over 2.5 m) occur on section 22240N. On the Cu-rich section 22140N and on section 22040N Cu values fall within the boundaries of the massive ore blanket. No significant values occur in the stringer zone. Elevated Cu grades are consistent with the two copper-bearing massive pyrite sections at the top and bottom of the ore blanket on section 22140N. Cu values decrease in the intervening massive sphalerite ore.

Au distribution. Au distribution broadly correlates with the massive ore blanket (massive sphalerite, massive pyrite and to a lesser extent copper-bearing massive pyrite ore types). Au grade is generally fairly homogeneous averaging 1 g/t. High zones of 2 to 3 g/t Au occur in the centre of the massive ore blanket at the transition between massive sphalerite and massive pyrite. This is in contrast to the west coast of Tasmania massive sulphides where gold is concentrated toward the top and flanks of the deposits.

Acknowledgements

Thanks to John Mill for all your help in Perth. Accommodation and field support at Golden Grove was very much appreciated.

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TEUTONIC BORE

Peter Ruxton

SUMMARY

The Teutonic Bore massive sulphide Zn/Pb/Cu/Ag deposit is Archaean in age, forming part of the Eastern Goldfields Province, NE Yilgarn Block, Western Australia.

Mining by open cut and underground methods began in 1980 and operations were completed in 1985. The deposit was small with 1.4 mt of high grade massive sulphide and 0.75 mt of lower grade stringer ore mined.

The deposit is hosted by tholeiitic basalts overlying a rift graben developed in footwall felsic volcanics. The felsic rocks are calc alkaline, highly silicified and chloritized containing sporadic sulphide stringers.

Teutonic Bore massive sulphide is underlain by a stringer pipe both disconformable and conformable to bedding. Footwall alteration of basalt is intense with sericite, green chlorite, black chlorite and siliceous zones mappable. The intensity of alteration increases towards the massive sulphide and the stringer sulphide pipe (Fig. 7).

The coincidence of uneconomic mineralization in a graben boundary fault within the felsic volcanics, and the alteration/stringer pipe within the basalts, suggests that the hydrothermal fluids passed up through the fault, along the stringer pipe, to deposit metals on the sea floor.

Metal contouring indicates that silver is closely allied to Zn and Pb in the massive sulphide, with minor Ag (>30 ppm) related to elevated Cu (>1%) in the stringer pipe zone.

Silver occurs as acanthite, argentiferous tetrahedrite and native silver. Gold values average well below 0.5 ppm.

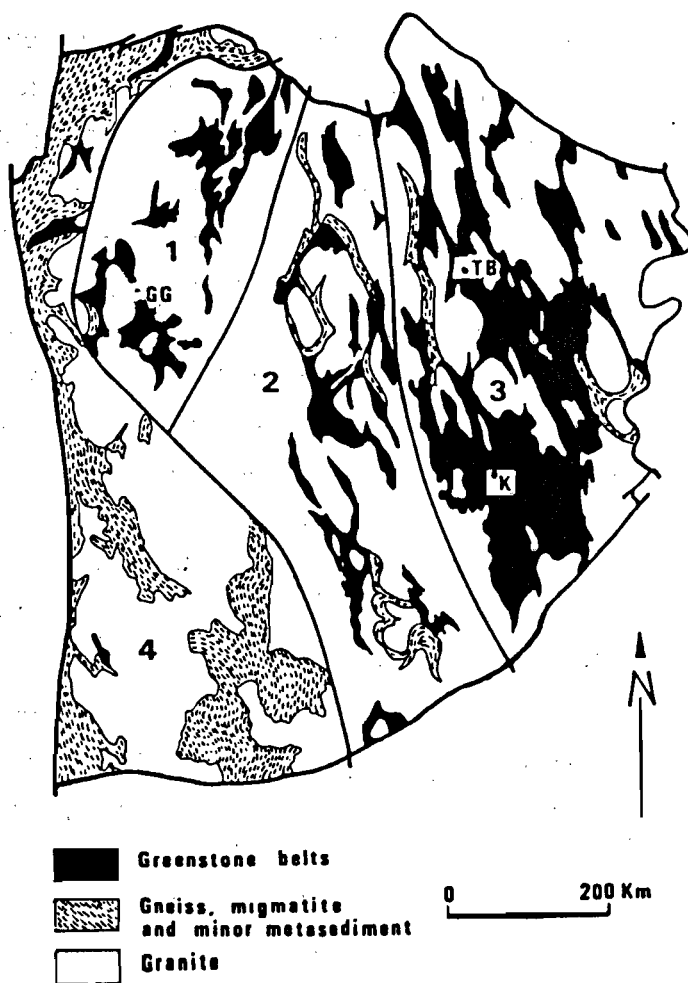
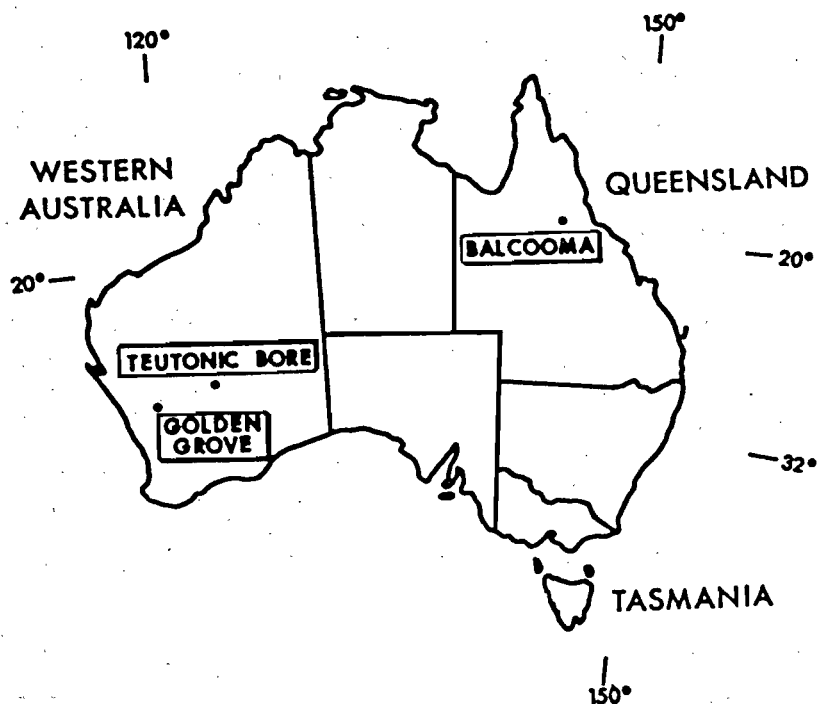


FIG. 1. Location and Regional Geology.

INTRODUCTION

The Teutonic Bore Zn/Pb/Cu/Ag deposit was located 320 km north of Kalgoorlie, Western Australia (Fig. 1). It consisted of a stratabound volcanogenic massive sulphide deposit with unoxidized reserves of 1.4 mt @ 16.4% Zn, 1.22% Pb, 4.16% Cu and 203 ppm Ag with an additional 0.75 mt @ 1.92% Zn, 2.38% Cu and 52 ppm Ag extracted from the stringer zone (Greig, 1984). Gold was not recovered with grades averaging well below 0.5 ppm.

Gossanous stringer mineralization in the adjacent felsic volcanics was discovered in 1974 by C.E.C. Drilling located the massive sulphide lens in 1976. The Joint Venture partners B.P. minerals and C.E.C. commenced open cut mining in March 1980 with underground development initiated in January 1982. Mining operations were completed in October 1984 with processing of the ore stockpile continuing until late 1985.

The search for further ore reserves during the latter stages of the mining operation has significantly added to the understanding of the deposit.

REGIONAL GEOLOGY

Teutonic Bore lies in the Archaean greenstone-granitoid terrain, Eastern Goldfields Province of the northeast Yilgarn Block (Fig. 1). The deposit occurs near the eastern margin of a complex linear zone of crustal extension - the Norseman-Wiluna tectonic zone - which stretches from Kalgoorlie to Agnew. A portion of this zone lies in the Leonora-Teutonic area - the Keith-Kilkenny tectonic zone (Hallberg and Thompson, 1985). The Keith-Kilkenny zone separates two volcanosedimentary sequences (Fig. 2). Rock types in the zone indicate deposition in an extensional environment dominated by graben and horst development. Subsequent isoclinal folding and penetrative deformation was accompanied by lower to middle greenschist facies regional metamorphism.

The oldest rocks in the Keith-Kilkenny tectonic zone are calc-alkaline andesite lavas which probably correlate with the Spring Well complex to the north (Giles, 1982). Andesites are overlain by massive and pillowed basalts which in turn are overlain by rhyolitic volcanic and volcanoclastic rocks. Maximum thickness of rhyolite is found in the Teutonic Bore area. Felsic rocks are overlain by pillowed basalts containing discontinuous lenses of conglomerate and shale. This basaltic sequence hosts the Teutonic Bore mineralization.

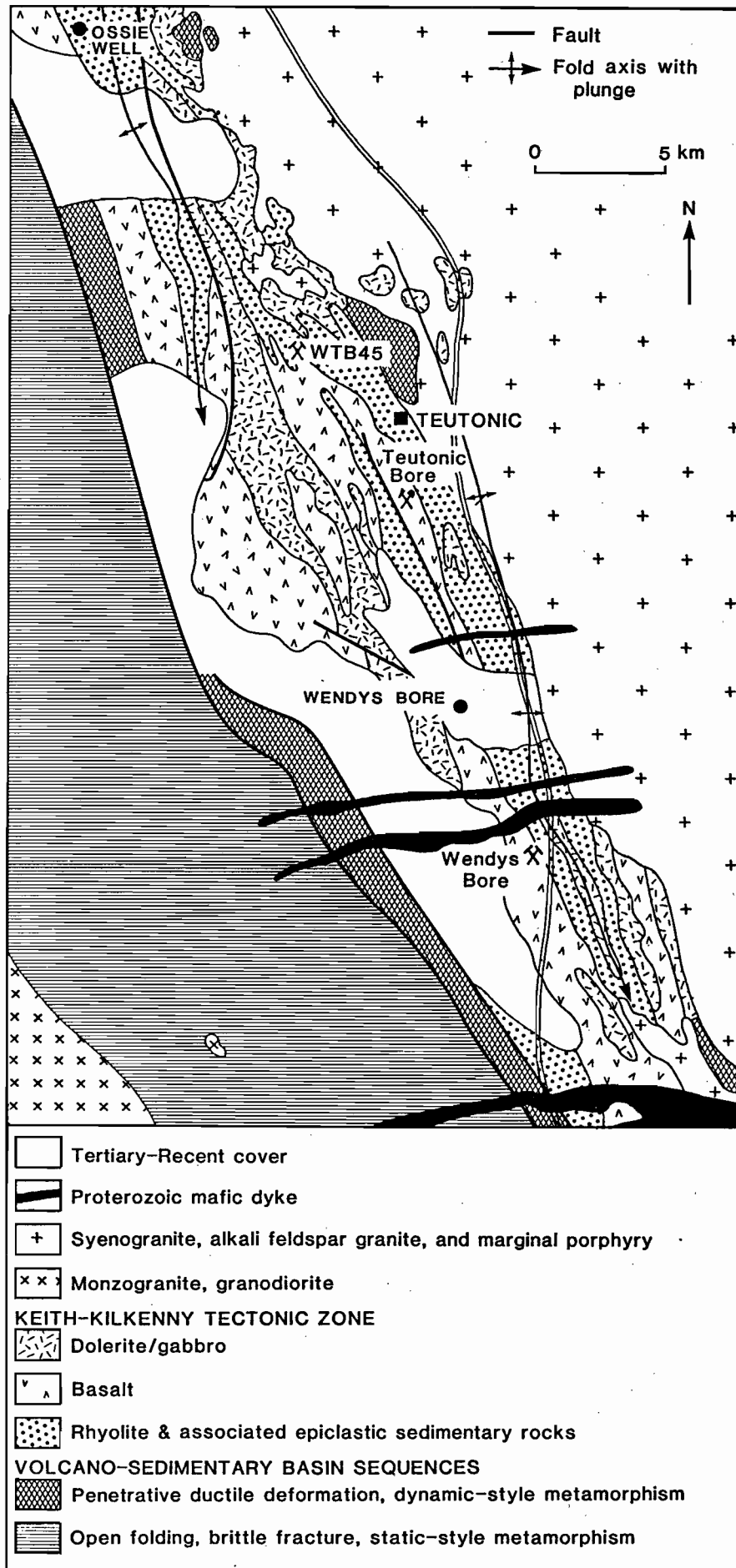
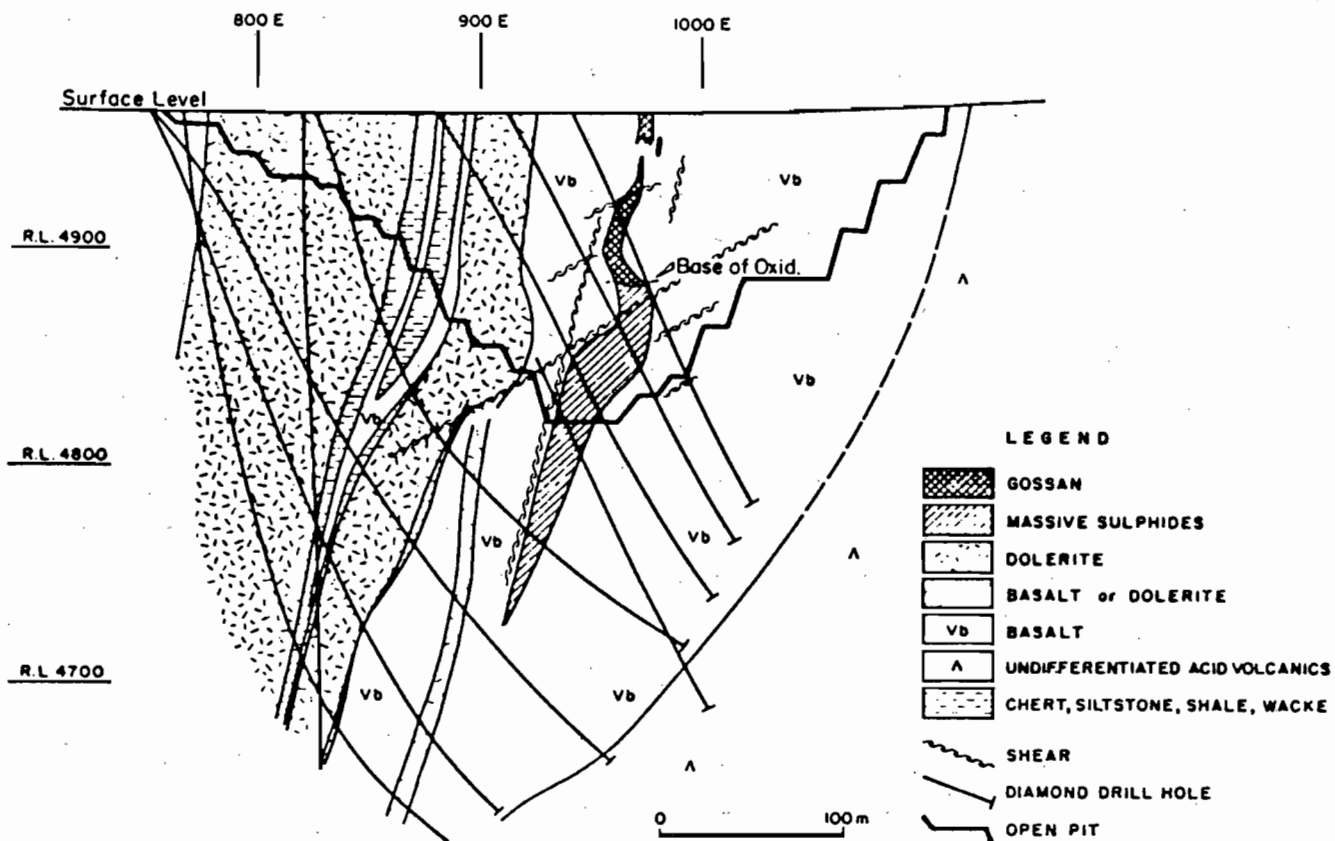
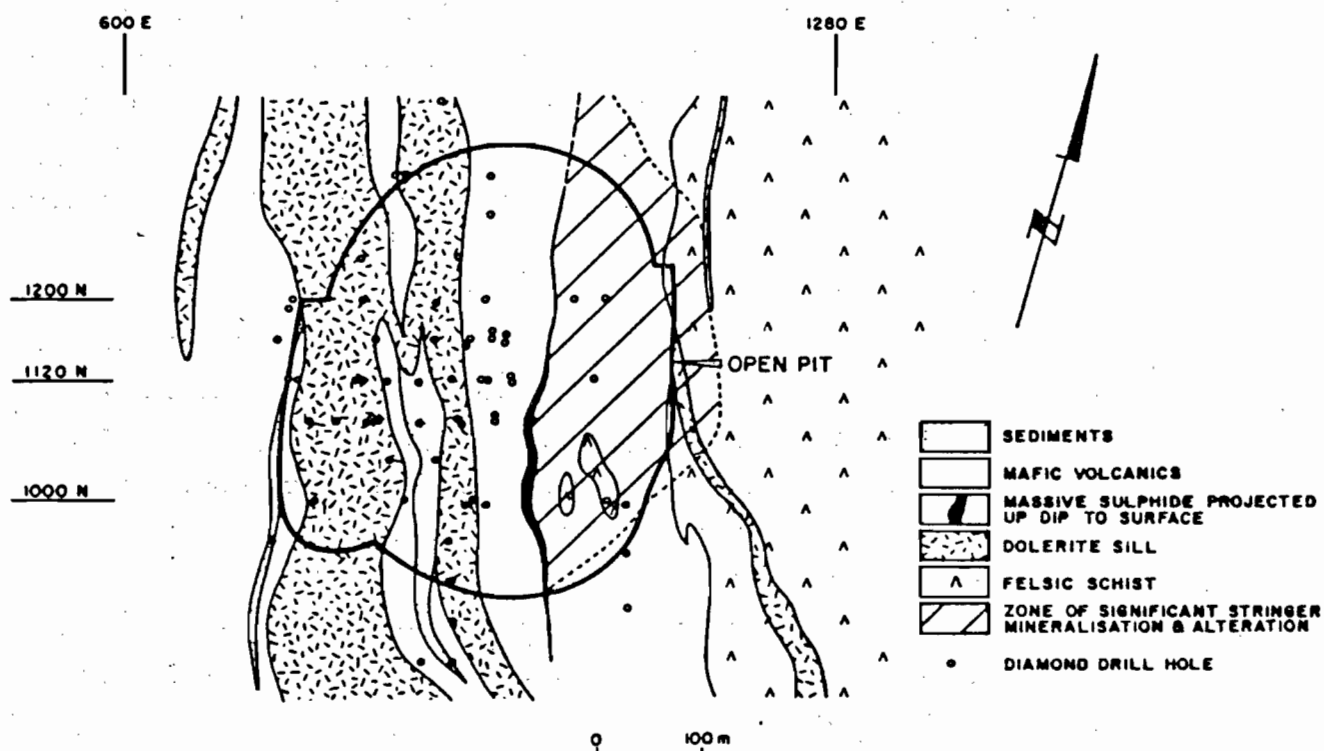


FIG. 2. Geology of the Teutonic Bore area and Keith - Kilkenny zone (after Hallberg and Thompson, 1985).



Simplified Geological Cross Section - Line 1120 N



Surface Geology and Drill Hole Locations

FIG. 3. Geology of the Teutonic Bore open cut.

All lithologies are intruded by sills and dykes of gabbro and dolerite with subsequent granitoid emplacement.

The thickness of the sequence is difficult to determine with numerous repeats of stratigraphy by steep south plunging isoclinal folds. Hallberg and Thompson (1985) suggest a thickness of 1 to 1.5 km.

The age of the Teutonic Bore deposit has been determined by Vaasjoki (1985) using the model lead "age" method of Cummings and Richards (1975), at 2700 to 2800 Ma. This figure agrees well with dates from mafic rock near Kalgoorlie, the Kambalda granite and from gneisses in the Province (see Vaasjoki, 1985).

TEUTONIC BORE DEPOSIT

Local Geology

The geology and mineralization of the deposit are discussed by Greig (1984). A brief summary is added below.

The conformable massive sulphide lens is contained in a NNW trending, steeply west dipping (75° to 85°) suite of metabasalts which are underlain by altered rhyolitic acid volcanics (Fig. 3). Extensive dolerite sills and dykes intrude the hangingwall basalts.

The footwall felsics are highly altered in the vicinity of the mineralization. Feldspars are absent due to pervasive sericitization. Silicification is ubiquitous. Gossanous cappings and sulphides are common along fractures and faults. Alteration decreases both laterally and vertically away from the deposit with primary textures visible a few hundred metres away.

Felsic volcanics have been intersected in numerous drill holes beneath the massive sulphide. A projection of depth to the felsic volcanics, onto a plane parallel to the ore horizon, indicates an irregular felsic/basalt contact (Fig. 4 - after Clough, 1984), first recognized by Greig (1984). Two cross-sections across this plane suggest that the massive sulphide is positioned over a graben structure (maximum relief of 150 m) in the underlying footwall felsic volcanics.

The contact between the footwall felsic and basaltic suite is commonly marked by a thin unit of black pyrite shale, chert or felsic epiclastic sediments (<3 m thickness).

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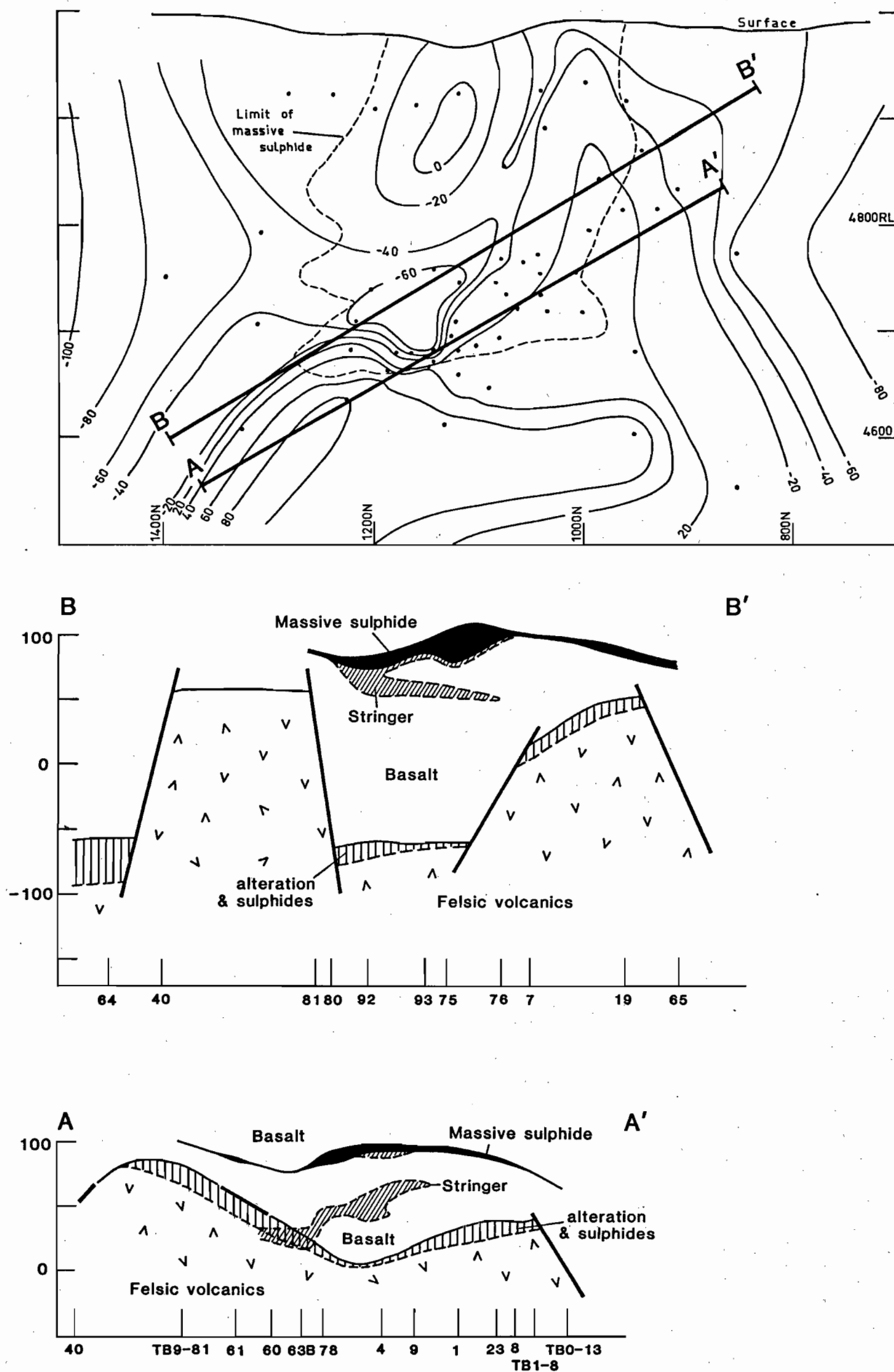


FIG. 4. Structural contours and palaeotopography of the felsic volcanic/basalt contact. Contours of depth to felsic contact projected on to a plane parallel to the massive sulphide lens. Cross-sections B - B' and A - A' indicate a graben and horst relief (adapted from Clough, 1984).

The footwall basalt suite consists of basalts, conglomerates and shale. Basaltic rocks are intensely hydrothermally altered in addition to regionally metamorphosed. Alteration types will be discussed below. Pillow lavas are common in the sequence. Conglomerates containing abundant highly irregular stretched basalt fragments indicate basalt flow into unconsolidated shales with minor felsic clasts. Sediments are generally confined to the immediate footwall of the massive sulphide with the thickest sediments corresponding to the central portion of the felsic graben structure (Fig. 6). The presence of shales and basaltic conglomerates in association with the massive sulphide lens suggests a quiescent period during the mineralizing event, with a temporary cessation of volcanic activity.

Hangingwall basalts are relatively unaltered green-grey fine grained albite, chlorite, calcite, sericite, rutile and quartz assemblages with sub-aplitic textures, amygdales, vesicles and pillow structures. Trace element compositions (Ni, Cr, V, Zr, TiO_2) indicate an original tholeiitic composition (Greig, 1984).

Mineralization

The massive sulphide lens at Teutonic Bore is 320 m long, 280 m down dip and up to 30 m thick. The ore consists of a combination of pyrite, sphalerite, chalcopyrite and galena with minor arsenopyrite and argentiferous tetrahedrite, and traces of pyrrhotite, famatinite (Cu_3SbS_4), cosalite ($\text{Pb}_2\text{Bi}_2\text{S}_5$), aikinite (PbCuBiS_3), stannite, bismuthinite (Bi_2S_3), galenobismutite (PbBi_2S_4), cuprobismutite (CuBiS_2), gudmundite (FeSbS) and cassiterite (Nickel, unpublished - Greig, 1984). Gangue minerals include quartz and siderite. Textures in the ore blanket indicate intense internal deformation with the development of a strong mylonite fabric in sphalerite-rich ore and brecciation in pyrite dominated areas. The ore is not easily divisible into different types, although a copper-rich massive pyrite zone occurs at the base of the lens on section 1080N (Fig. 15). Silver occurs as acanthite (Ag_2S), argentiferous tetrahedrite and native silver.

Hangingwall Basalt Alteration

Adjacent to the massive sulphide, the hangingwall basalts are highly schistose. Alteration to sericite, calcite and paragonite is documented

TEUTONIC BORE 1160N

-  Massive ore
-  Stringer sulphides
- Alteration:
 -  Sericitic
 -  Pale green chlorite
 -  Grey chlorite
 -  Black chlorite
 -  Silicification
-  Shaley layers in basalt
-  Finely laminated chert
-  Conglomerate
-  Silicified felsic volcanics
-  Basalt

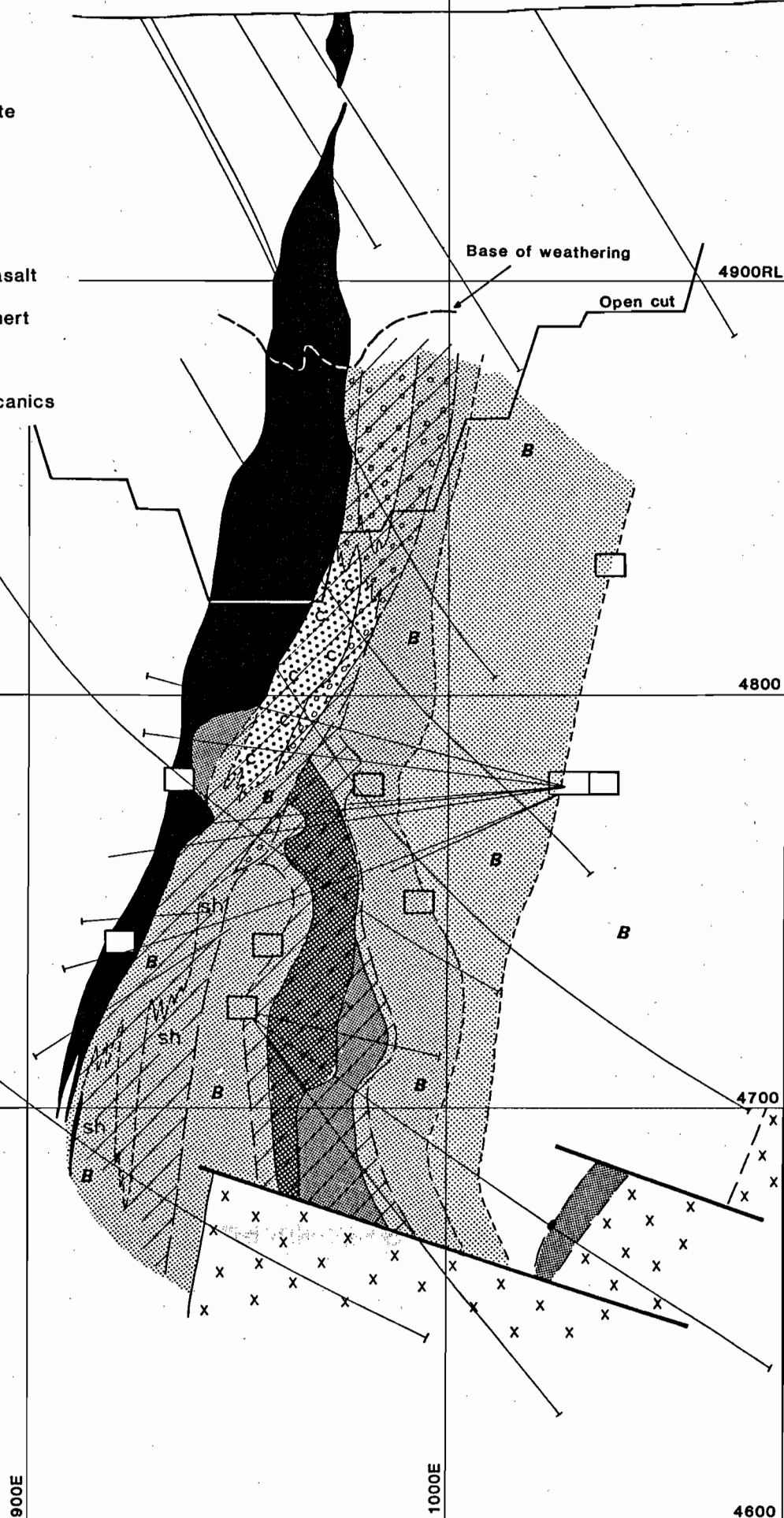


FIG. 5. Geology on cross-section 1160N.

(Greig, 1984). This zone is narrow extending 10 to 15 m into the hangingwall sequence.

Stringer Zone and Footwall Basalt Alteration

A pipe-like stringer zone is developed beneath the Teutonic Bore massive sulphide. Stringer is characterized by >5% sulphide veining with intense patches directly beneath the massive sulphide and in the stringer pipe containing 20% sulphide. The stringer pipe is best developed on cross section 1160N (Fig. 5) and extends from the centre of the massive sulphide to depth, both discordant and concordant with the stratigraphy. The pipe passes into a graben boundary fault which downthrows basalt against footwall felsic volcanics. In the horizontal plane the stringer is best developed on the southern side of the open pit. The stringer mineralogy is dominated by pyrite and chalcopyrite. Patches of sphalerite and galena are localized, generally confined to lithological or flow contacts and in the stringer pipe. 0.75 mt of stringer material was mined from immediately beneath the massive sulphide. Grades tend to decrease with depth.

Two morphological types of alteration are recognized in the footwall basalt suite: (1) alteration parallel to the massive sulphide blanket up to 100 m thick and (2) alteration related to the stringer sulphide pipe (Fig. 5, Section 1160N). A progressive alteration sequence is common to both morphological types.

Unaltered footwall basalt is light grey and homogeneous similar in physical and chemical aspects to the hangingwall basalt. Initial alteration is characterized by a pale yellow heterogeneous to homogeneous rock with quartz/sericite/siderite development. This passes up into a pale green rock composed of quartz/pale chlorite/siderite + minor yellow sericite. Quartz occurs as amygdaloidal fills with siderite forming rosettes and irregular veins in both these alteration types. Pale green chlorite alteration forms a layer beneath the massive sulphide and at the margin of the alteration pipe. The centre of the stringer pipe and immediate footwall to the ore are characterized by black chlorite alteration. Green chlorite and yellow sericite are absent in this alteration type and quartz is rare. At the top of the stringer pipe, directly beneath the massive sulphide lens, the host rocks are silicified. A finely laminated chert is the product of silicification in bedded black shales. Basalt-dominated conglomeratic units are also silicified.

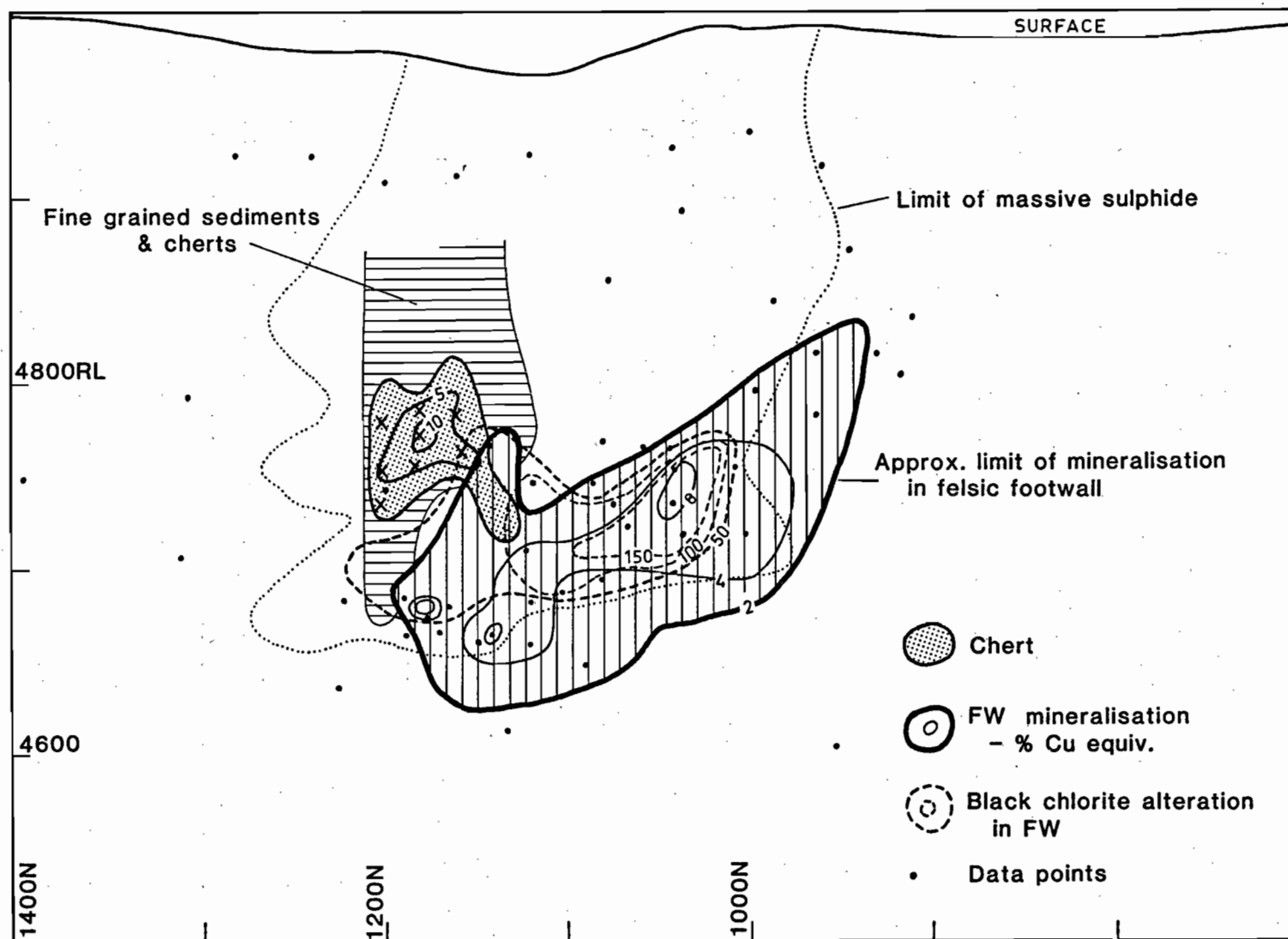


FIG. 6. Distribution of footwall mineralisation and black chlorite alteration superimposed on the massive sulphide lens. Fine grained chert and sediments are indicated (after Clough, 1984).

All alteration types are cross-cut by sulphide stringers. Chert units are strongly brecciated by pyrite/chalcopyrite veins.

Metamorphism of the alteration assemblages produced andalusite and chloritoid minerals which also characterize the Mattabi massive sulphide deposit in Canada (Campbell et al., 1981).

Mineralization and Alteration in the Footwall Felsic Volcanics

During the final stages of mining the footwall basalt/felsic volcanic contact was drilled in the search for further ore. Sub-economic Zn, Pb, Cu and Ag mineralization was intersected close to a graben growth fault adjacent to the depth limit of the massive sulphide blanket (Fig. 6). Mineralization occurs as veins and stringers in the felsic volcanic pile to a depth of 40 m beneath the contact. M x % contours of Cu Equivalent range from 0-8 (Fig. 6). This zone is coincident with black chloritic alteration of the felsic volcanics. Anastomosing veins of black chlorite in the silicified volcanics forms a "chicken-wire" texture characteristic of this alteration type. This mineralization/alteration zone in the felsic volcanics is associated with the same graben fault as the stringer pipe recognized on section 1160N. This relationship strongly suggests that this graben fault formed the main channel way of the hydrothermal fluids during massive sulphide formation. Fluids probably moved up the fault zone and through the stringer/alteration pipe to deposit metals on the sea floor (Fig. 7).

Geochemistry of the Footwall Alteration

The most striking characteristic of the footwall alteration is a strong localized Na_2O depletion in the basaltic rocks (Greig, 1983 and 1984; summarized in Figure 8). Less pronounced depletion of Sr and CaO with enrichment of base metals Fe, K_2O , Ba, F and MgO .

Metal Zonation - Long Section

Metal zonation of the massive sulphide and stringer zone was presented by (Greig 1984). Contours were constructed using metal grades only and therefore do not give a true pattern of metal distribution within the entire deposit.

M x % and m x ppm contour diagrams were constructed for data beneath the weathered zone (Figs. 9-13). All four metals contoured (Zn, Pb, Cu and Ag) in the massive sulphide ore are preferentially concentrated in the

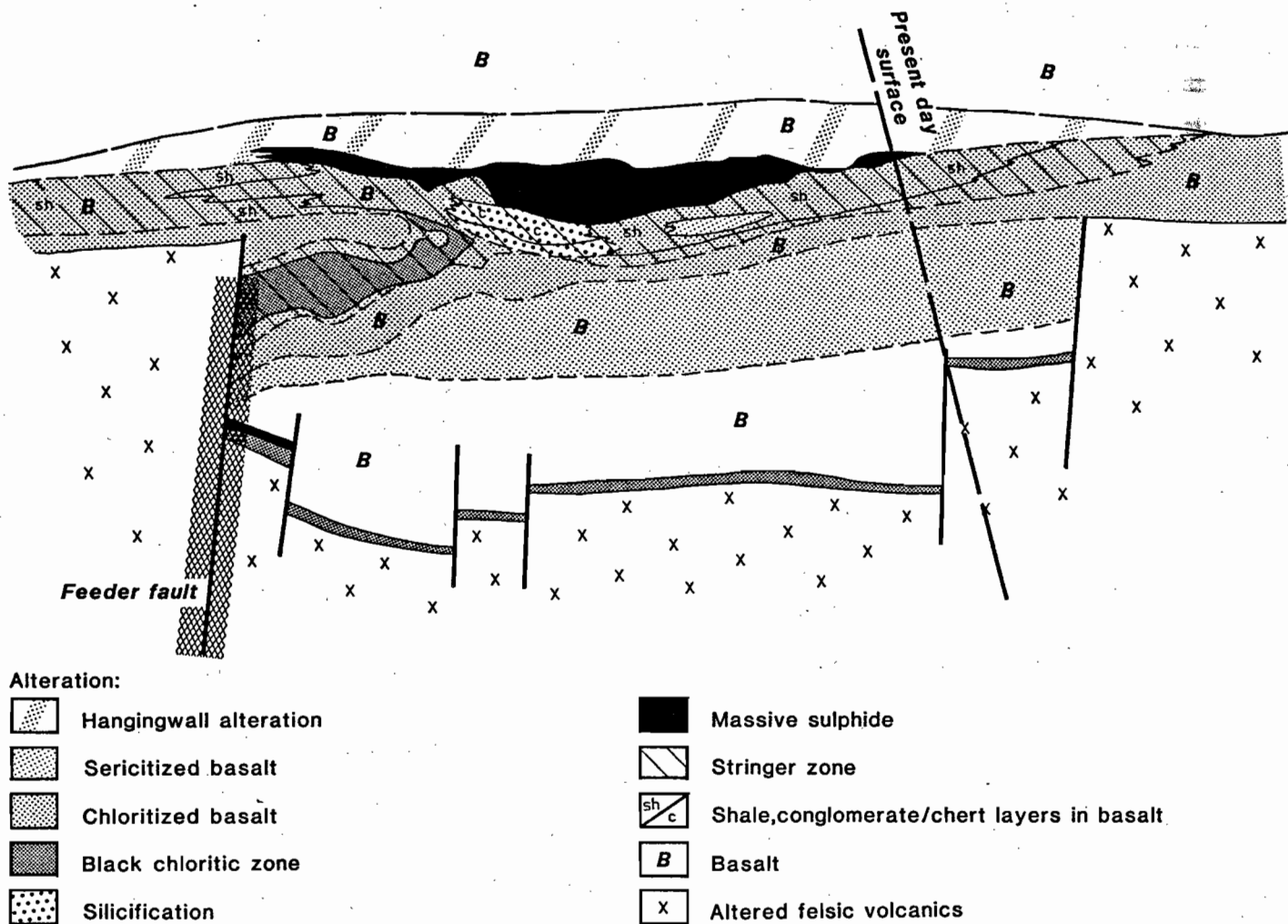


FIG. 7. Reconstruction of the Teutonic Bore massive sulphide showing the position of the feeder fault and alteration pipe.

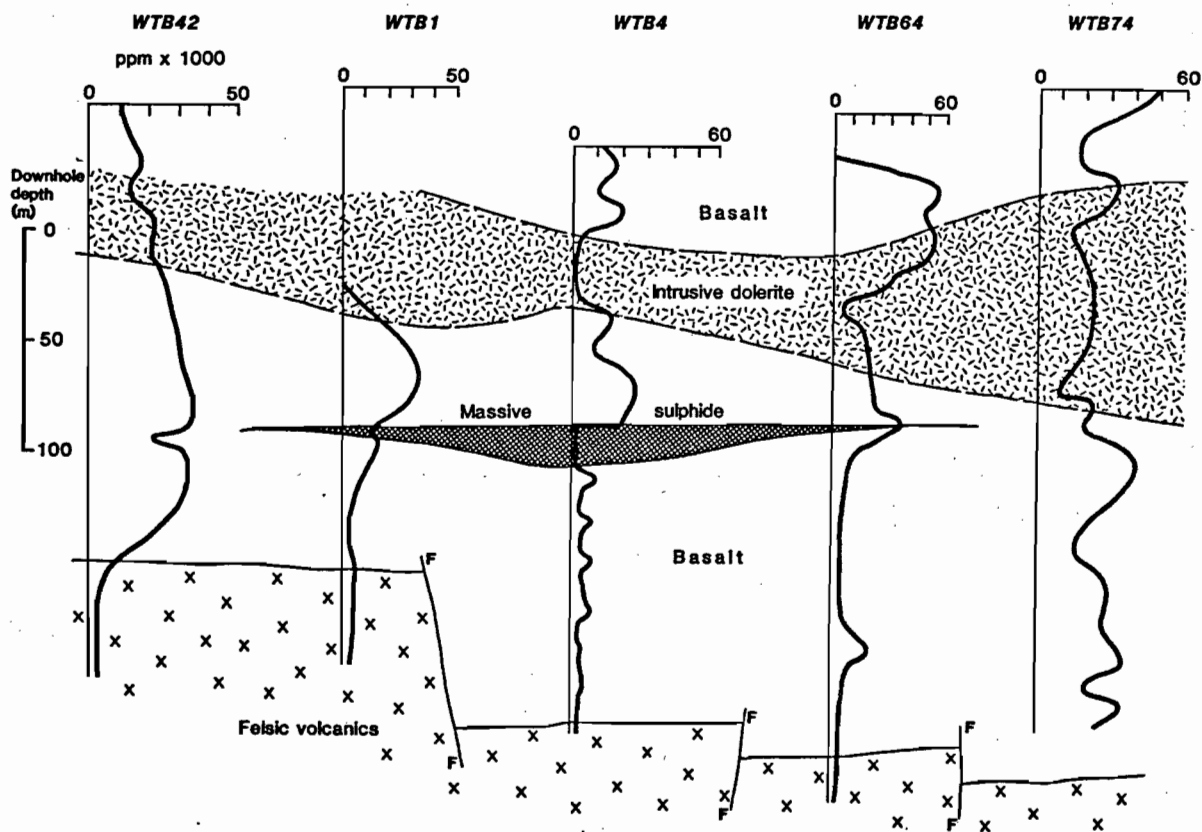
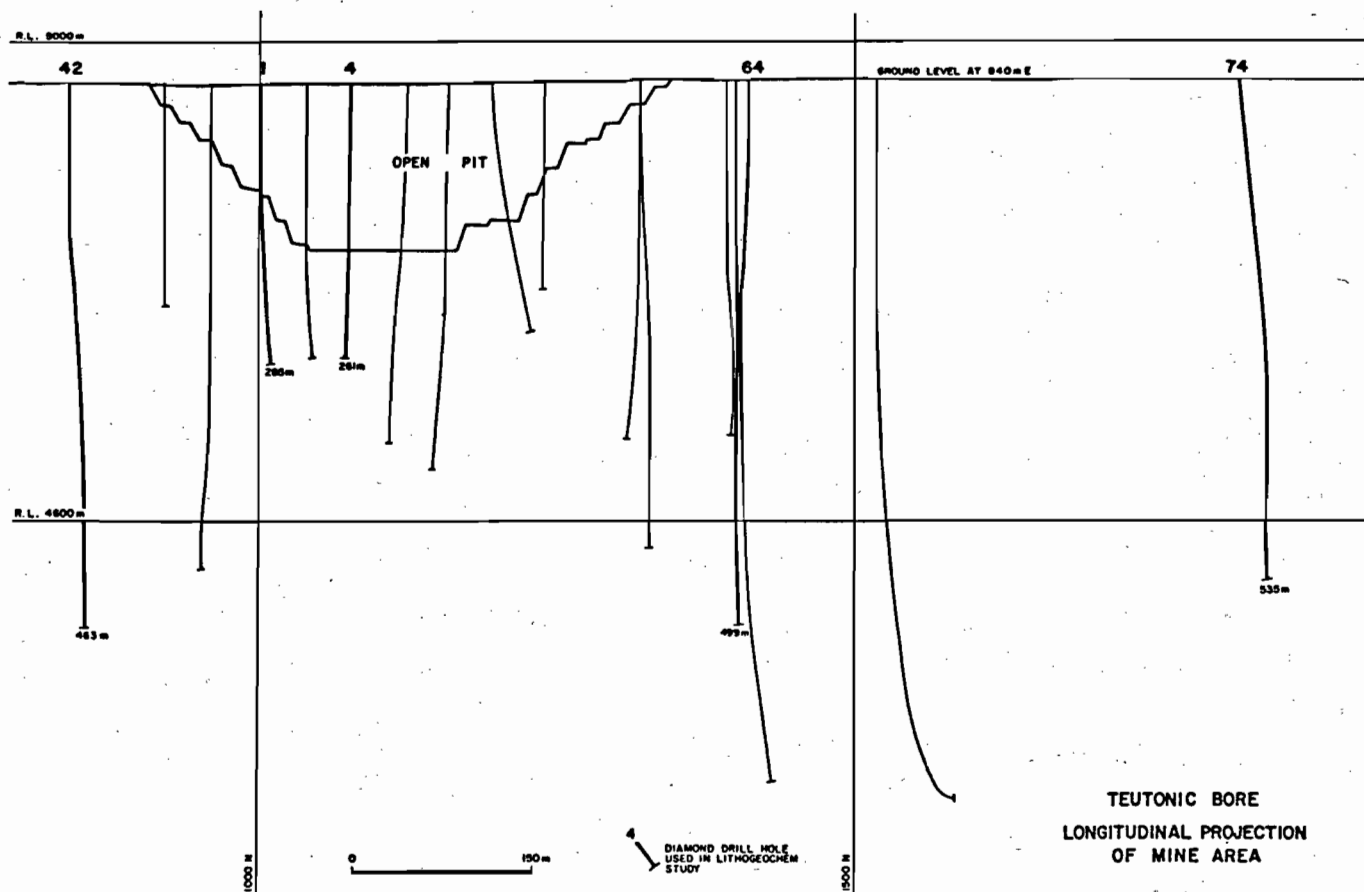


FIG. 8. Na₂O depletion in the footwall basalts at Teutonic Bore (data from Greig, 1984).

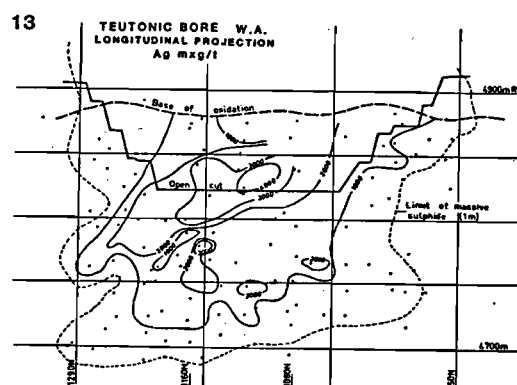
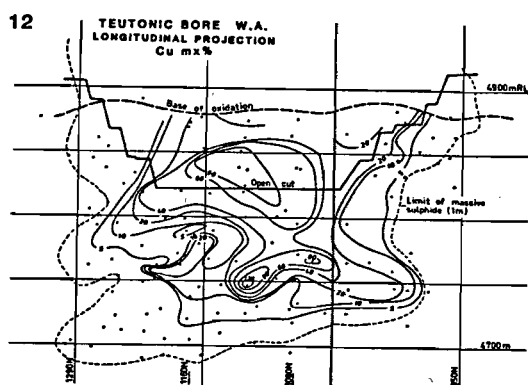
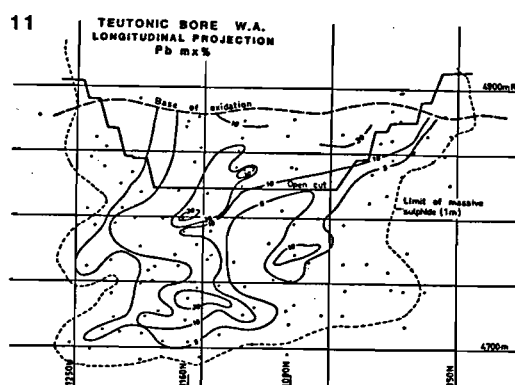
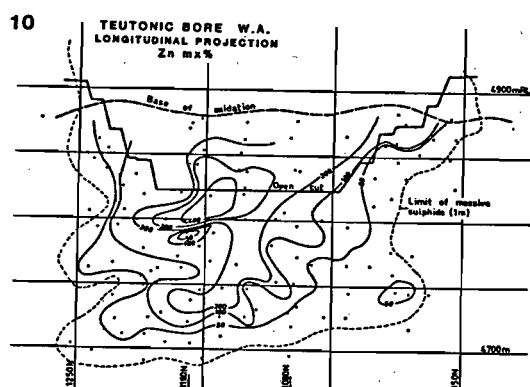
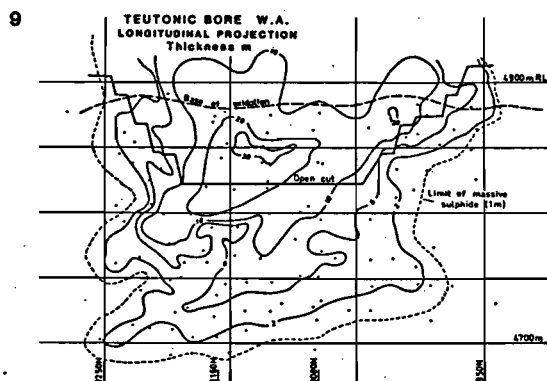


FIG. 9-13. Longitudinal section through the Teutonic Bore deposit. Diagrams indicate 9. Thickness of massive ore, 10. Zn - mx %, 11. Pb - mx %, 12. Cu - mx %, and 13. Ag - mx ppm.

thickest part of the deposit. High Zn, Pb and to a lesser extent Ag were located in the southern part of the lens (in the plane of the deposit, Figs. 9-13) centred on section 1160N. A high Cu zone on the same level is offset to the east centred on 1090N. These high Zn/Pb/Ag and Cu zones in the southern portion of the projection are adjacent to underlying mineralization in the footwall felsic volcanic (Fig. 6).

Metal Zonation - Cross Section

Two cross-sections were chosen for study: (a) 1160N coincident with the thickest part of the massive sulphide, passing through the southern Zn/Pb/Ag zone and the stringer pipe and (b) 1080N passing through the southern copper-rich zone on the contoured metal plan.

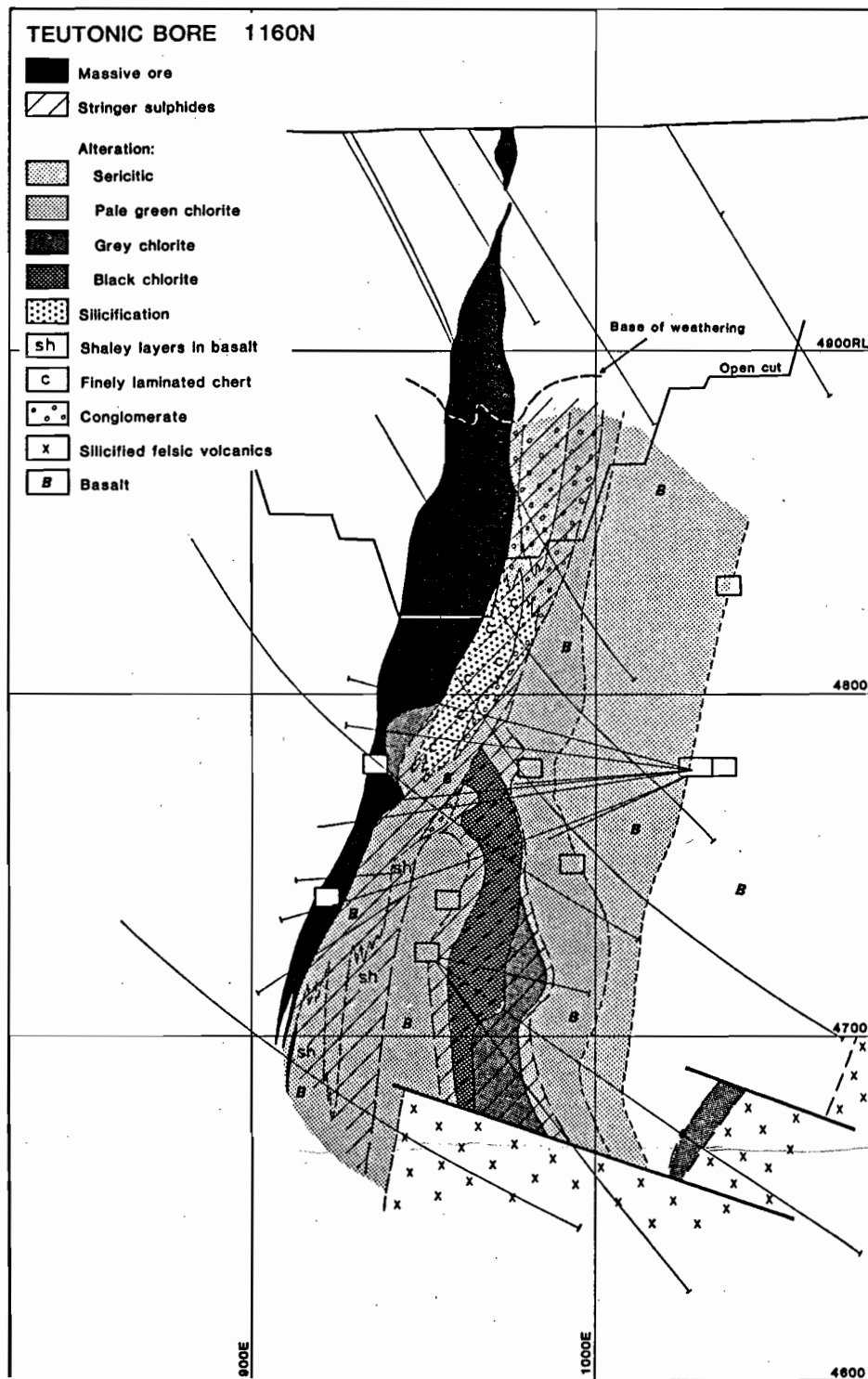
The metal distribution on both sections is similar (Figs. 14 and 15). Zn, Pb, Cu and Ag grades closely follow the boundaries of the massive sulphide. Maximum contour intervals are Zn >30%, Pb >3%, Cu >15% and Ag >500 ppm. Cu (>1%) and Ag (>30 ppm on section 1160N) follow the distribution of the stringer zone. Sporadic Zn and Pb highs with associated Ag and Cu in the stringer zone, are related to lithological boundaries. A sharp pinching of the massive sulphide lens on section 1160N is reflected in the metal contours. This pinch structure is occupied by black chlorite altered basalt with >50% stringer sulphide. The zone lies directly above the centre of the alteration/stringer pipe.

Acknowledgements

Access to all the Teutonic Bore data by B.P. Minerals was very much appreciated. The loan of a vehicle and accommodation at Teutonic Bore was of great help. Thanks to Mike Woodhouse for his patience and assistance in Perth.

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TEUTONIC BORE 1160N

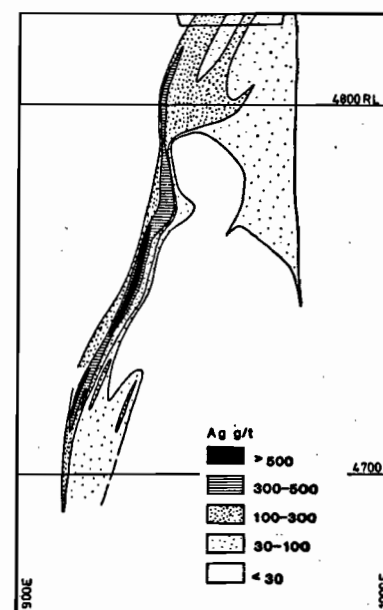
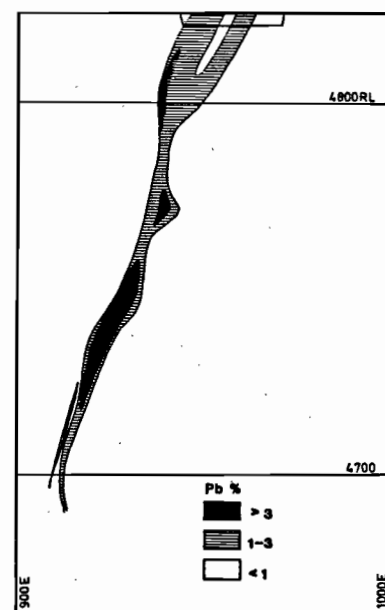
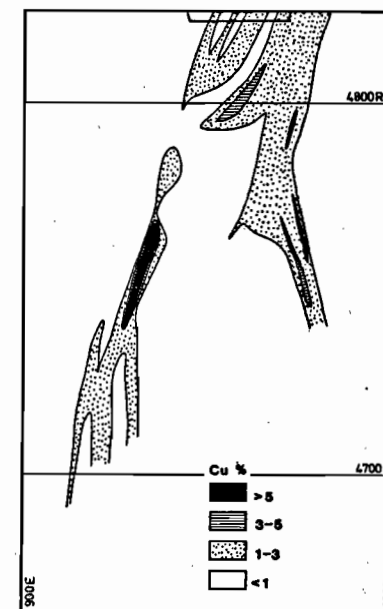
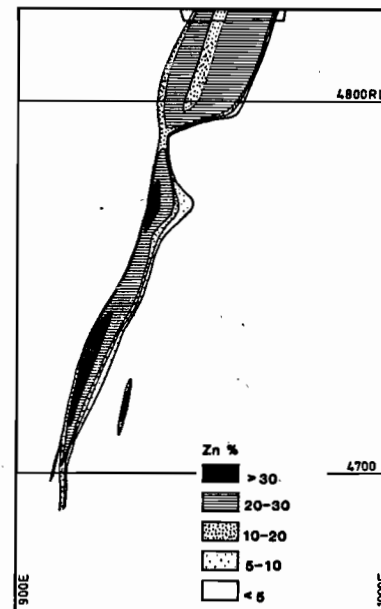


FIG. 14. Section 1160N. Geology and metal contours,
A.Zn - %, B.Pb - %, C.Cu - %, and D.Ag - ppm.

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A PRELIMINARY DESCRIPTION OF THE STATIGRAPHY AND STRUCTURE OF THE BALCOOMA PROSEPECT, NORTHERN QUEENSLAND

David L. Huston

Work Completed Since April, 1986

The author has now completed two field seasons at the Balcooma prospect, returning from the field in early September. The fieldwork included the logging of 26 additional drill holes to make a total of 49 holes, and the mapping of the prospect area at a scale of 1:500. Fieldwork emphasized the gathering of structural information.

Major Conclusions

(1) The hypothesis of two distinct ore horizons has been substantiated, and the possibility of a third horizon exists. Evidence for multiple horizons include: (1) facing evidence in holes containing both major horizons, and (2) different lithologic associations for each horizon. Figure 1 is a working stratigraphic column showing the position of the mineralized horizon.

(2) Four distinct phases of deformation (see Fig. 2) have been recognised, with D_2 and D_3 being the dominant phases. Evidence for D_1 has been destroyed by the later events.

(3) The first three of the four deformation events are probably coaxial (poles to S_0 , S_1 and S_2 all plot on the same great circle), and have fold axes at $20^\circ/220^\circ$, which corresponds well with the plunge of the Balcooma copper shoots.

(4) Two general areas which have significantly different structural styles are present in the prospect area. The first, which is bounded to the east at 1950 mE and to the south by a fault at 8800 mN, is characterised by a tight, overturned syncline-anticline pair (see Fig. 3). In the second area, to the west and south, the structure is characterised by an open, upright anticline.

Discussion and Interpretation

Given the above constraints, several structural models were developed in consultation with R. Berry; the preferred model is shown in Figure 4. In this model, a D_2 recumbant fold is refolded by open, upright D_3 folds (i.e. the syncline-anticline pair is recumbent and refolded by the open anticline to the west). Such a folding style fits a compressional stress field which is consistent with thrusting as proposed by Chevron

geologists.

The above model requires a synformal anticline further to the west and anticlinal folding of S_2 over the broad western syncline as shown in Figure 4. Further mapping to the west and a more detailed examination of existing structural data should be a good test of the model.

Research Program over the Next Six Months

Given the structural model and stratigraphy presented, research will be directed over the next six months at solidifying these interpretations by further structural analysis and construction of additional cross sections.

Given this stratigraphic and structural model, the metal zonation of the Balcooma deposit may be described and the controls on precious metal mineralization may be evaluated in both copper and zinc-lead mineralisation.

Acknowledgements

CEC and Metallgesellschaft provided accomodation and support throughout my stay in northern Queensland. I wish to thank in particular J. Fabray, T. Taylor, B. Stainfort, R. Hall and F. Wellmer of these two compaines and R. Berry of the University of Tasmania for useful discussions during may research and acknowledge the excellent early work by K. Harvey and M. Mulroney and other CEC geologists.

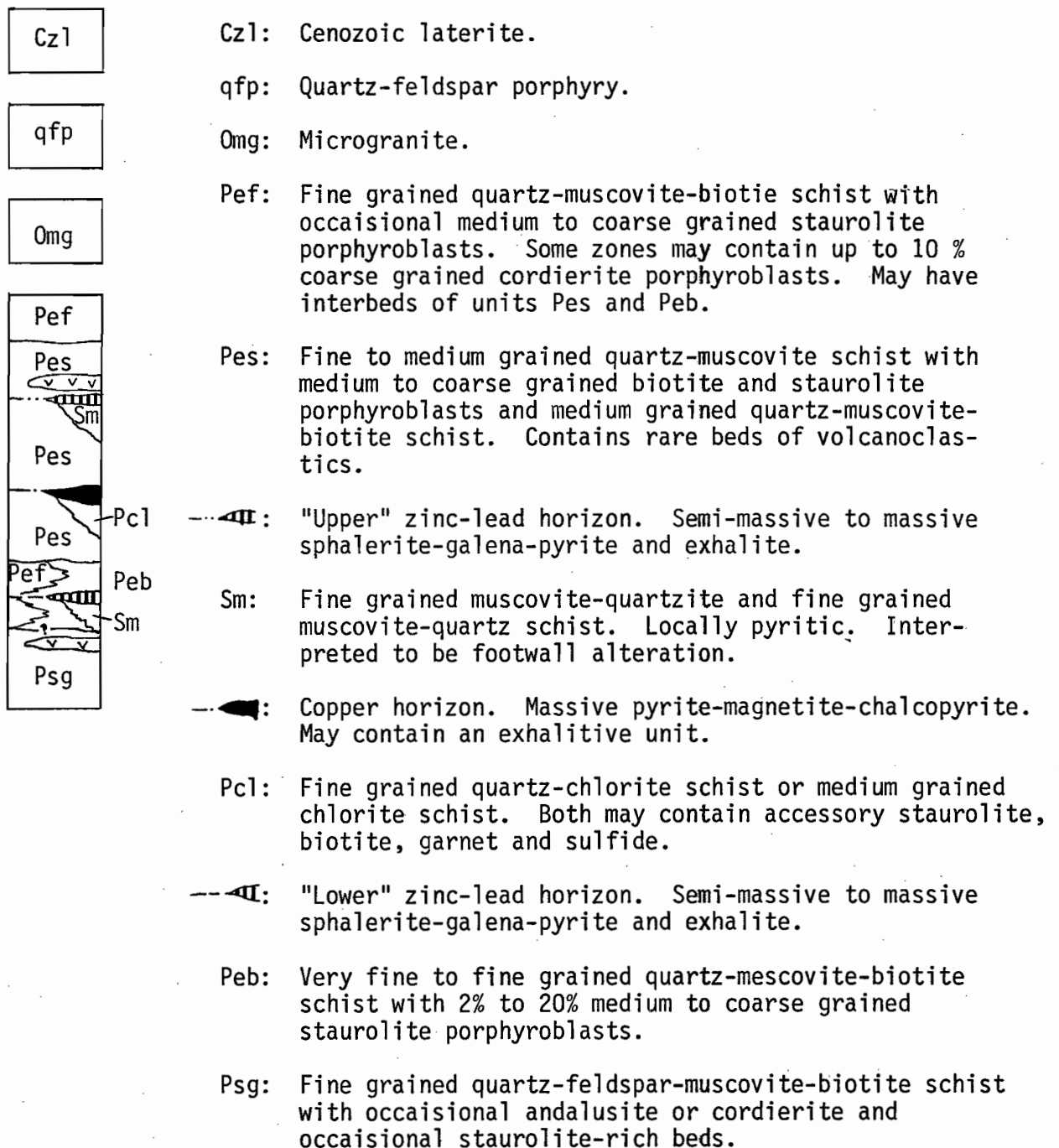


Figure 1: Working stratigraphic column for the Balcooma Prosepect.

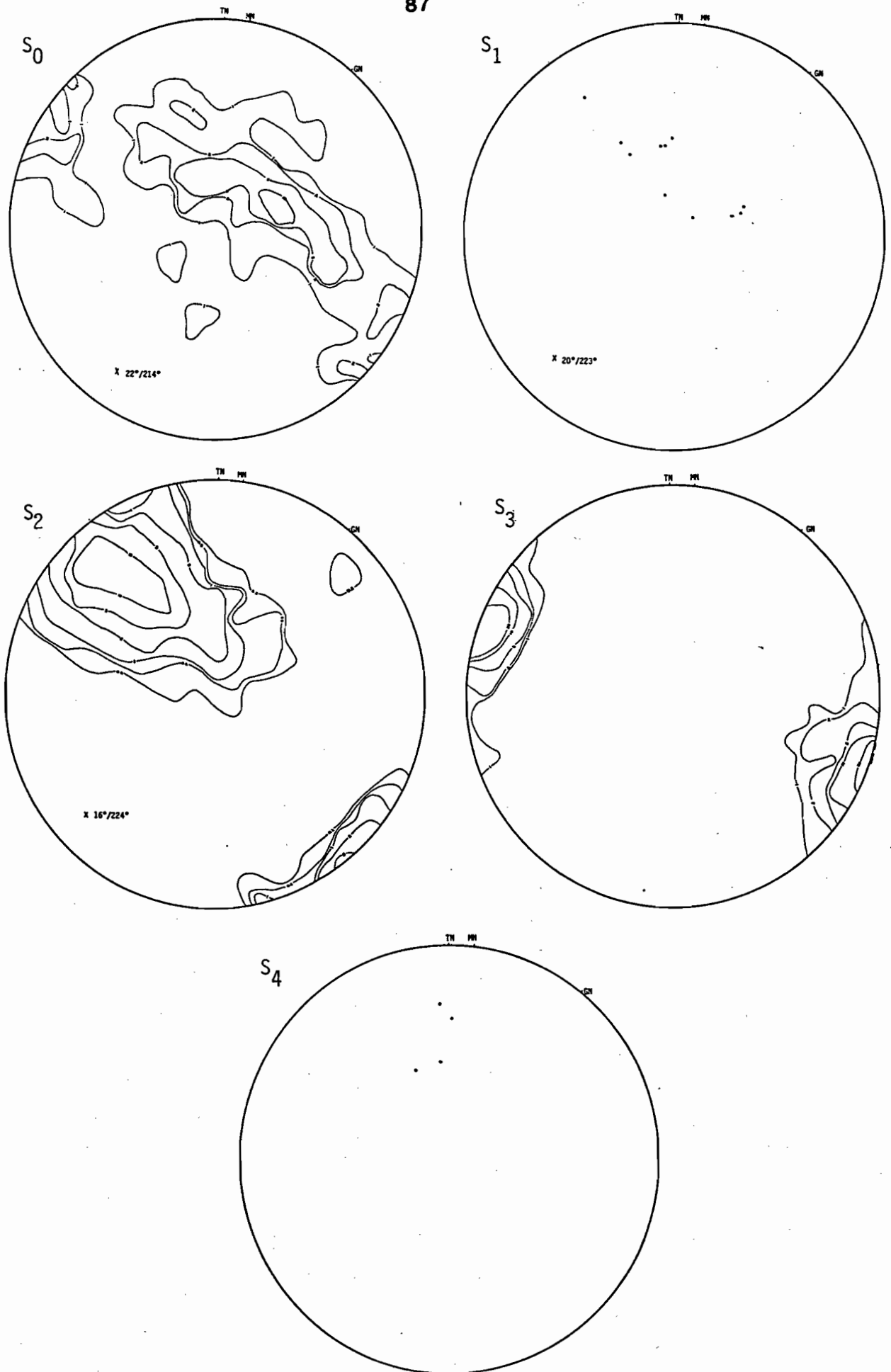


Figure 2: Poles to S_0 , S_1 , S_2 , S_3 and S_4 . Contours in %/area. "x" indicates the pole to the great circle.

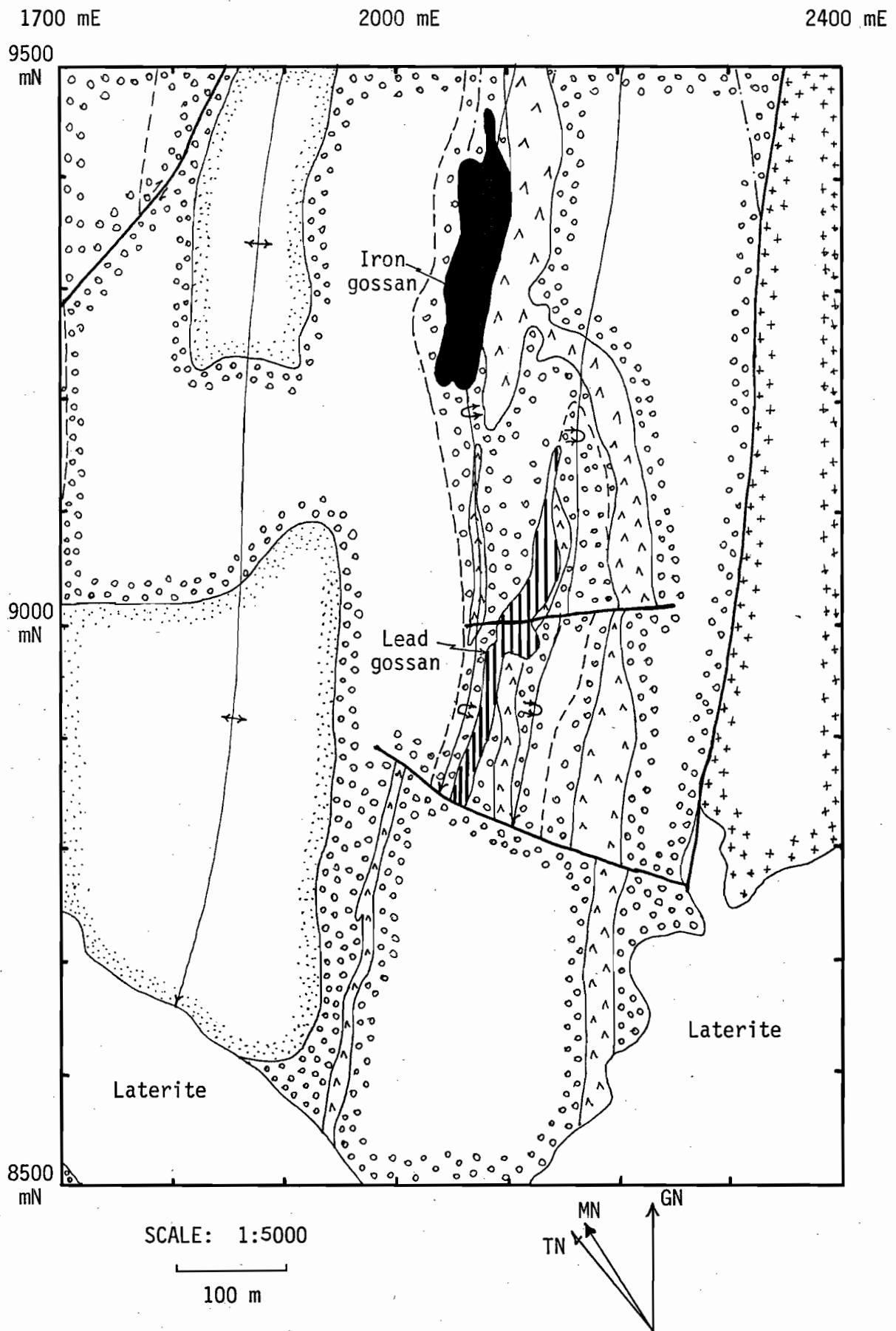


Figure 3: Interpretive geologic map of the Balcooma prospect. Symbols as in Figure 4.

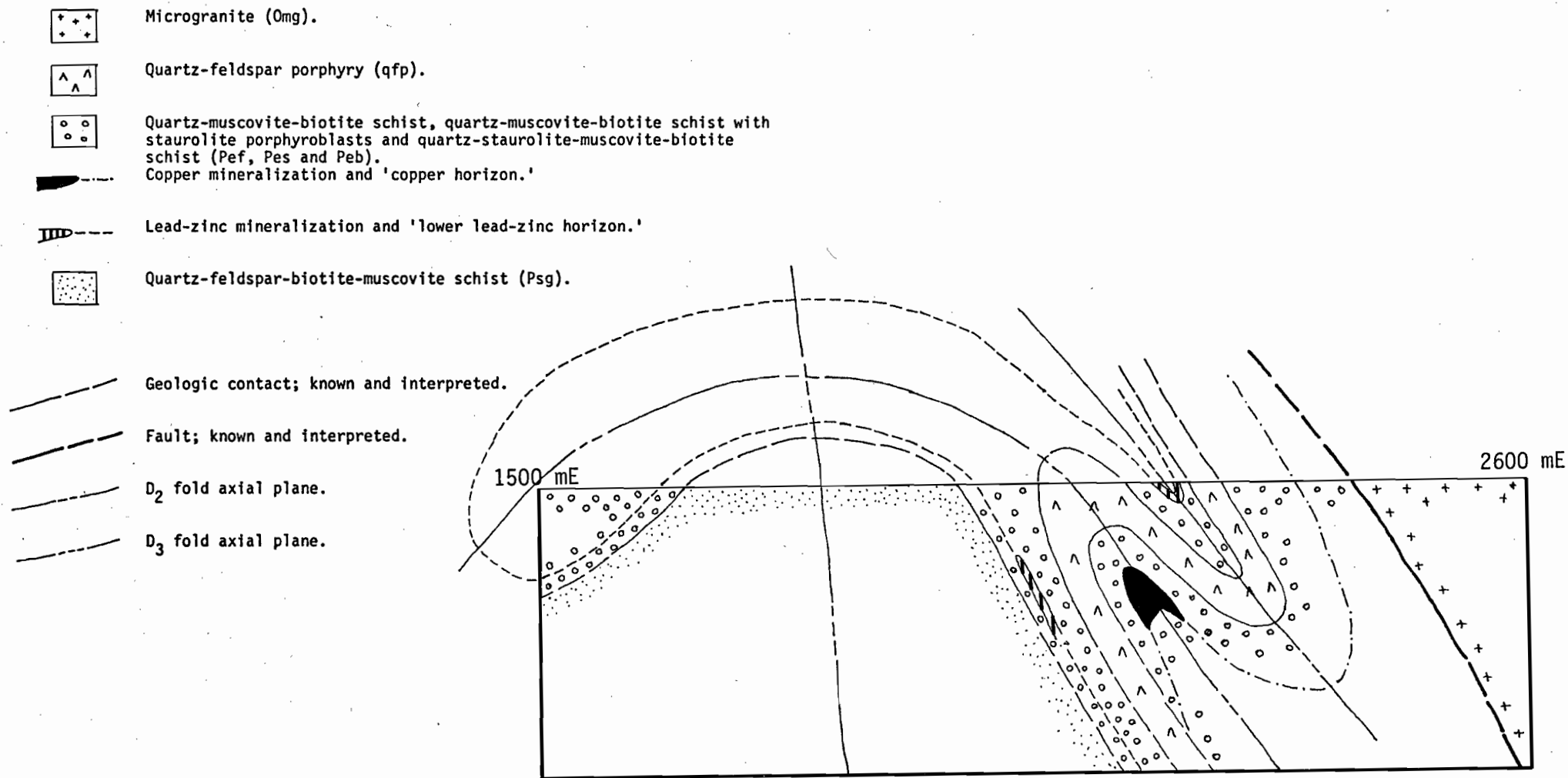


Figure 4: Structural model of the northern part of the Balcooma prospect.

GOLD AND SILVER RELATIONSHIPS IN AUSTRALIAN MASSIVE SULPHIDES

Ross R. Large

Preliminary investigations on the massive sulphides under study in this project, suggest some fairly simple relations between average gold and silver grades (see Fig. 1).

- 1) The Tasmanian massive sulphide deposits are particularly enriched in both gold and silver.
- 2) Most of the massive sulphide bodies have a Ag/Au ratio of about 50/1. There are two major exceptions;
 - the Mt. Chalmers and Mt. Morgan deposits which are enriched in both copper and gold with Ag/Au ratios of about 10/1 and 2/1 respectively.
 - the Teutonic Bore deposit which is significantly depleted in gold with a Ag/Au ratio of about 1000/1.
- 3) The stringer sulphide zones in all deposits have a much lower Au and Ag content than the massive sulphide ore, and they commonly have a lower Ag/Au ratio.

A plot of gold versus zinc from the Que River PQ lens assay data shows some very interesting features (Fig. 2). Mineralisation with less than 7% Zn shows no obvious relationship between zinc and gold, with gold varying from 0.1 to 2.0 g/t. However above 7% Zn, there is an exponential rise in gold grade for increasing zinc, in the pattern

10% Zn	1 g/t Au.
15% Zn	3 g/t Au.
20% Zn	5 g/t Au.
25% Zn	10 g/t Au.

The average ore reserve grades for the other Australian VMS deposits plotted in Figure 2 show a similar pattern of increasing gold with increasing zinc. Mt. Chalmers and Teutonic Bore are again the exceptions, lying on the boundaries of the trend lines. This relationship at high-zinc values, may suggest that the high grade ores are deposited from solutions saturated in both zinc and gold, and that chemical mechanisms controlling zinc deposition lead to concurrent gold deposition. However for low-zinc ores, the lack of a definite relationship suggests either

- the zinc and gold were not transported and deposited together,
- or
- the solutions were undersaturated in gold.

The low-zinc relationship (< 7% Zinc) generally corresponds to stringer type mineralisation (eg. Scuddles stringer, Mt. Lyell and Que River S lens, see also McGoldrick and Large, this volume) where it is probable that gold and copper were transported and deposited together.

Thermodynamic studies on the transport mechanisms of gold relative to the base metals, funded by the ARGS, are presently under way, and aimed at developing a thermodynamic model for gold and base

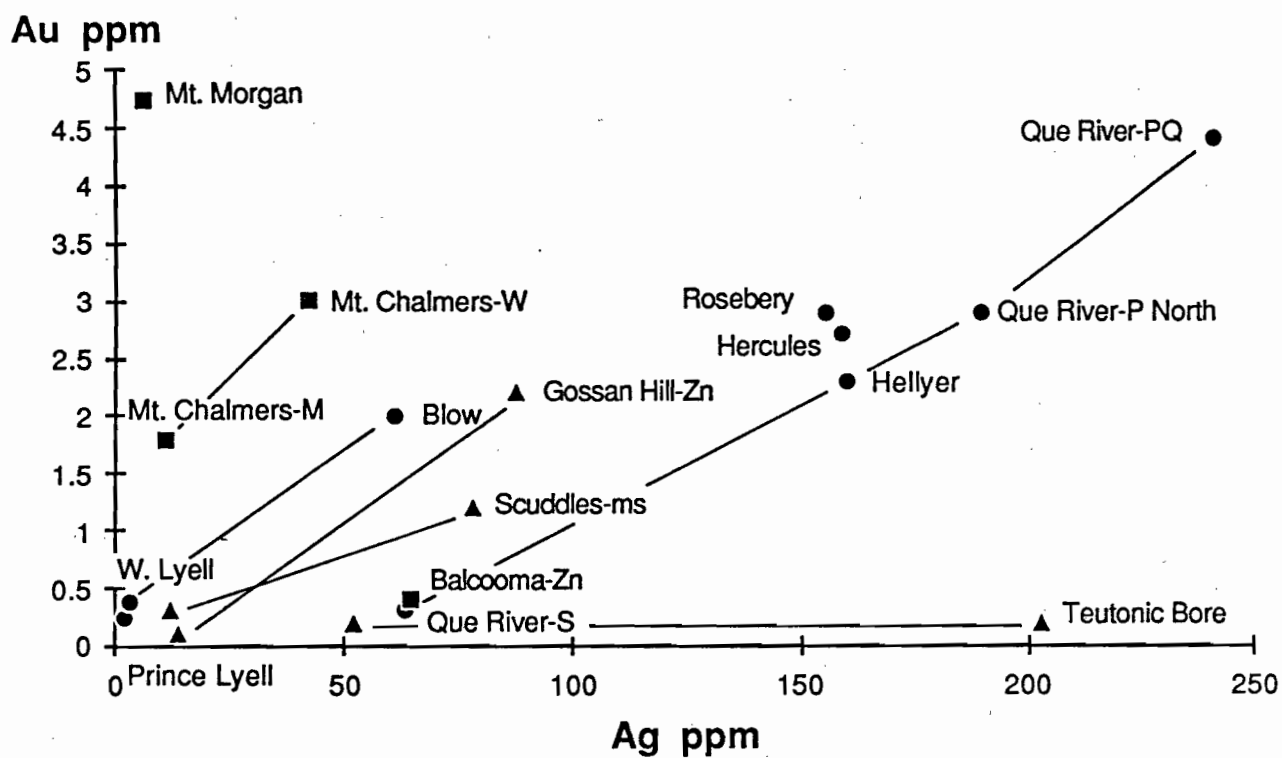


Fig.1 : A gold versus silver plot for the ore deposits studied in this report (plus Hellyer, Mt. Lyell, and Mt. Morgan). The lines join massive sulphide and stringer type mineralisation from the same hydrothermal system.

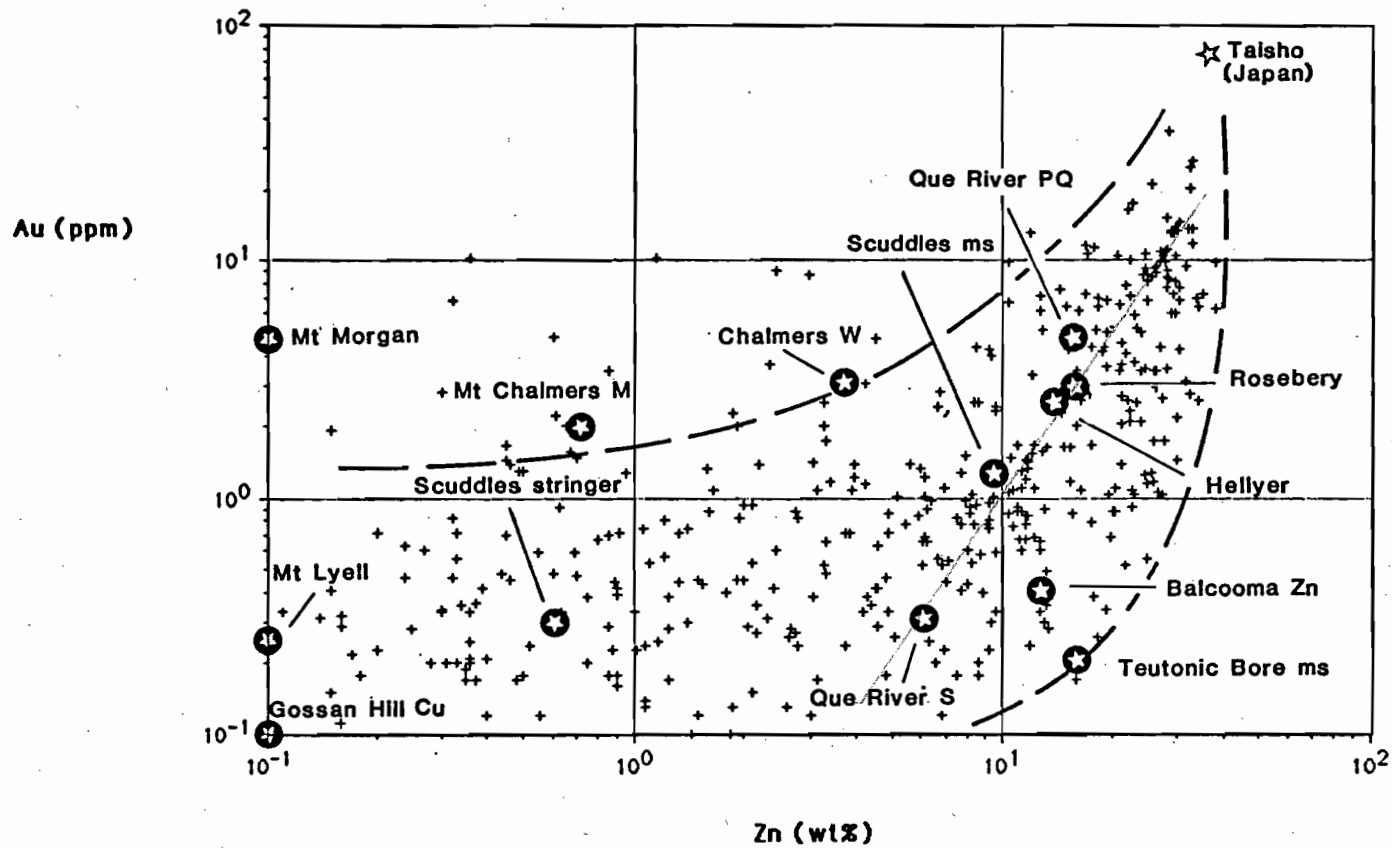


Fig.2 : *gnc*
Gold versus ~~silver~~ plot for drill hole assays on Que River 7550N section (+). Average ore grades for the deposits included in this study are also shown. Note the two patterns in the data. Below 7 % Zn there is no obvious correlation between gold and zinc. Above 7 % Zn, the gold grades increase exponentially with increasing zinc grades.

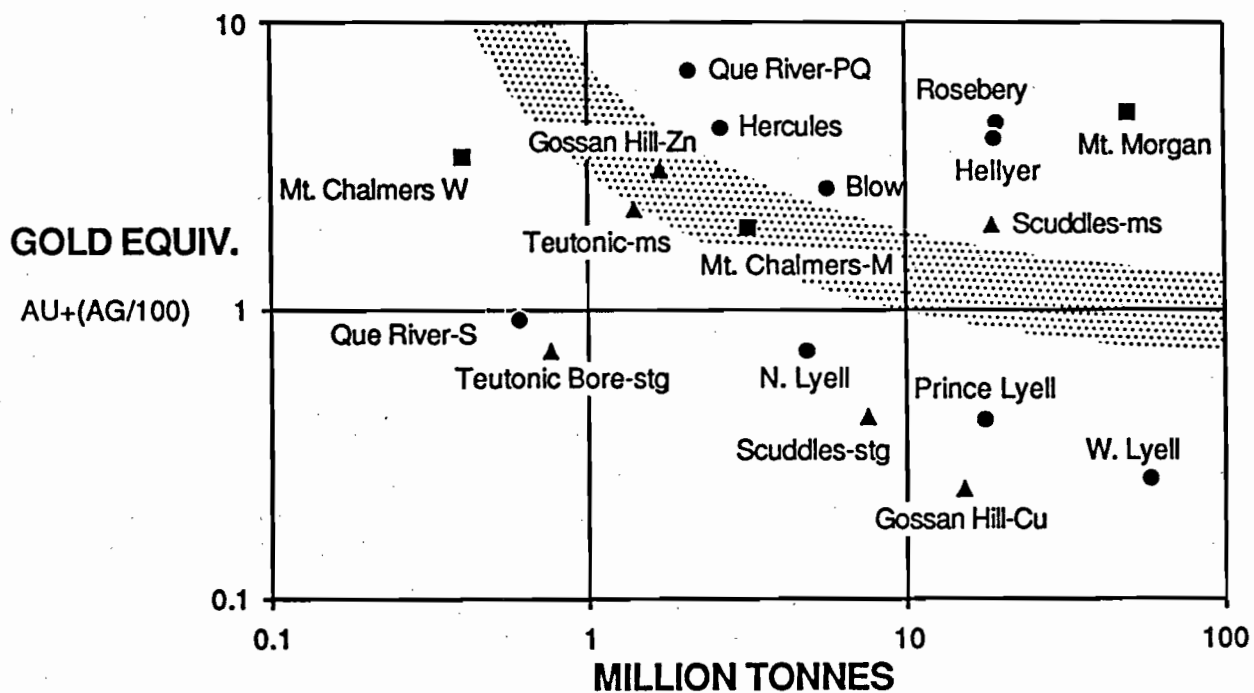


Fig.3 : Tonnage versus grade plot for gold and silver in the massive sulphides under study.

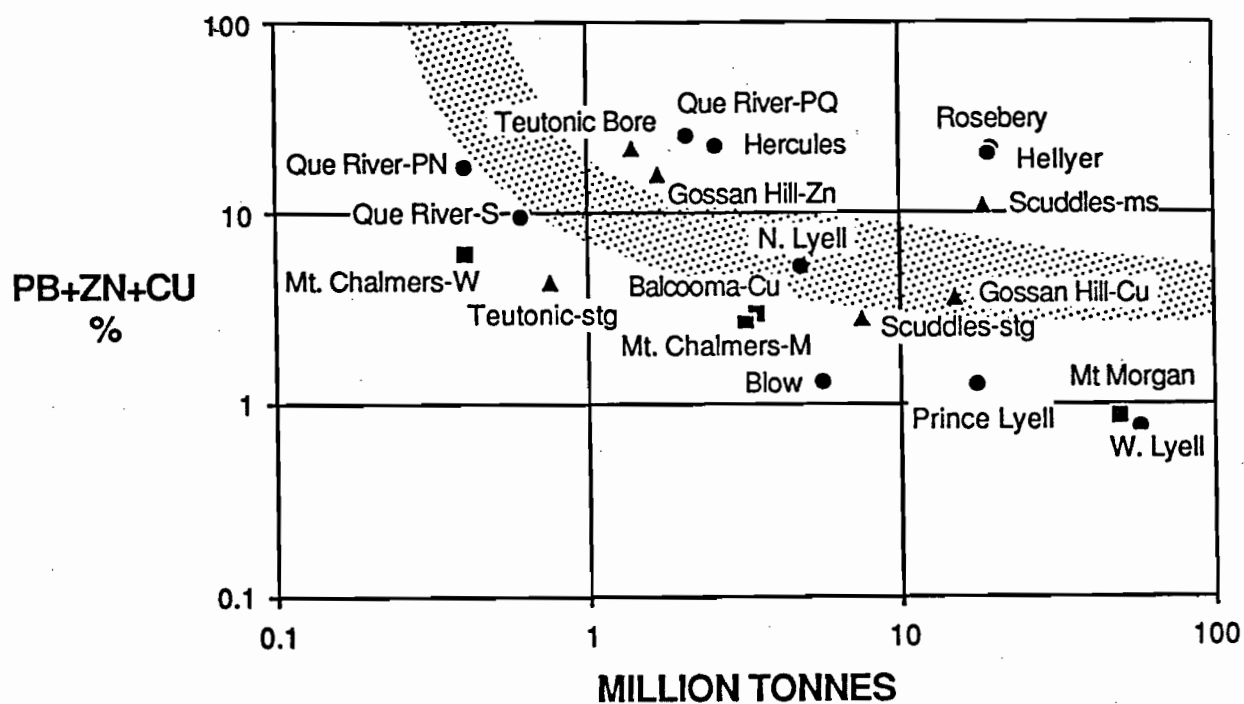


Fig.4 : Tonnage versus grade plot for the base metals only in the massive sulphides under study.

metal deposition in an evolving massive sulphide system.

Tonnage - Grade diagrams

Tonnage-grade diagrams for the deposits included in this project, are shown in Figures 3 and 4 (using data from Table 1,). Using roughly interpreted economic trend lines (Fig. 3) it is apparent that 7 of the 18 deposits are economic based on gold and silver alone (assuming 100% recovery). Many of these same deposits also plot in the economic field in the base metal-tonnage diagram (Fig. 4). All the deposits showing sub-economic gold-silver grades also appear to be sub-economic based on their base metal grades. Teutonic bore is the exception.

Exploration Implications

In the majority of cases the zinc-rich (and lead-rich) massive sulphide deposits have the best gold and silver grades. At the high-zinc end of the scale, minor increases in the zinc grade can be accompanied by significant increases in the gold grade. Except for Mt. Morgan, the copper-rich VMS deposits (and stringer zones) usually contain low precious metals and are marginally economic or uneconomic.

APPENDIX I

GOLD IN WESTERN TASMANIA

A paper prepared for the Australian Institute of Mining and Metallurgy

Bicentennial Volume

GOLD IN WESTERN TASMANIACONTRIBUTORS

Ross Large	)	
David Huston	)	University of Tasmania
Peter McGoldrick	)	
Gary McArthur	)	Aberfoyle Resources
David Wallace	)	
John Carswell		Mt. Lyell Mining Co.
Gerald Purvis		J.G. Purvis and Associates.
Bob Creelman	)	C.S.I.R.O. Division of Mineral Physics
Tony Ramsden	)	and Mineralogy.

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GOLD IN WESTERN TASMANIAIntroduction

The volcanogenic massive sulphide deposits of western Tasmania contain significant amounts of precious metals, resulting in considerable by-product production and reserves of gold (see Table 1). The major deposits at Rosebery, Que River, Hellyer and Mt. Lyell lie within the Mount Read Volcanic Arc of Cambrian age (Fig. 1). In 1985 the Rosebery Mine was ranked eleventh on the Australian gold production list (Fig. xx, Tyrwhitt, this volume), with an annual output of 40,000 ounces (1.25 tonnes).

Table 1. Production and current reserves of gold from western Tasmanian massive sulphide deposits.

Mine	Production of gold (tonnes)	Geological Reserves of gold (tonnes)
Rosebery*	22.7	19.9
Que River*	4.1	5.3
Hellyer	-	35.8
Mt. Lyell	38.7	9.7
Total	65.5	70.7

* calculated at 60% recovery.

The presence of gold in these deposits was the key factor which lead to the initial discovery of Mt. Lyell (in 1883) and Rosebery (in 1893) by conventional stream sediment panning. The recent discoveries at Que River (in 1974) and Hellyer (in 1983) have come about 100 years later by the application of geophysical techniques (principally E.M.) and stream/soil geochemical surveys for copper, lead and zinc (Webster and Skey, 1979; Staff, Aberfoyle Resources Ltd., this volume). A comparison of gold and silver grades in the western Tasmanian ores, with other Australian volcanic and sediment hosted massive

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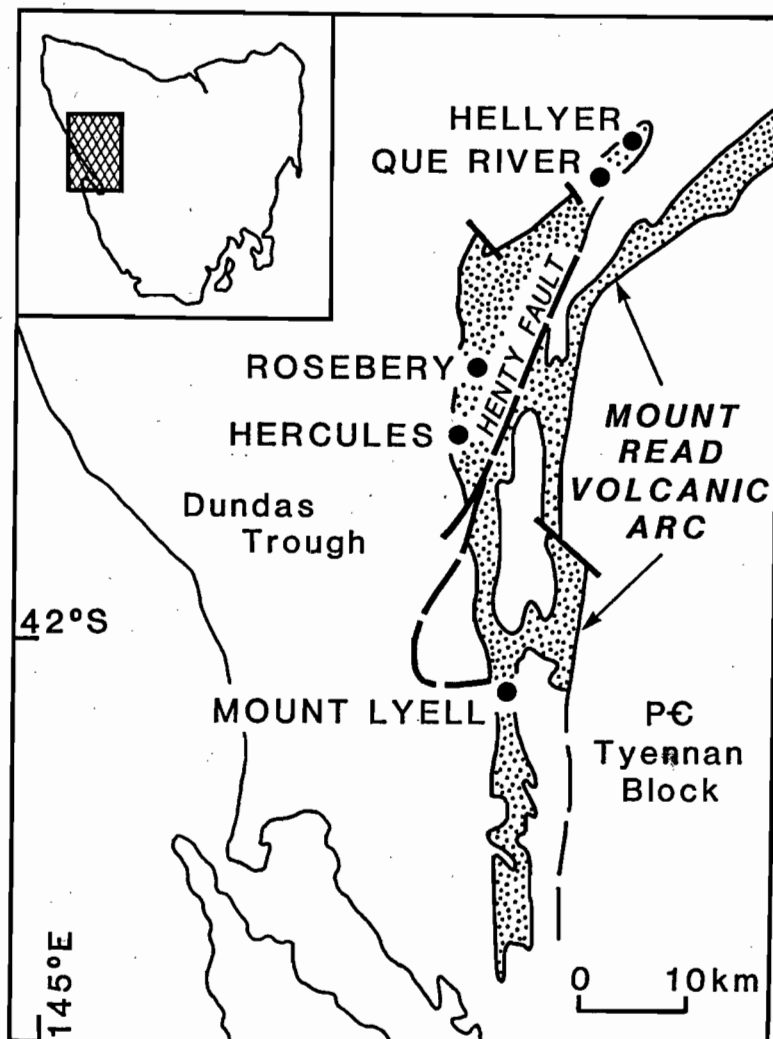


Figure 1. Location of gold bearing massive sulphide deposits in the Mount Read Volcanic Arc.

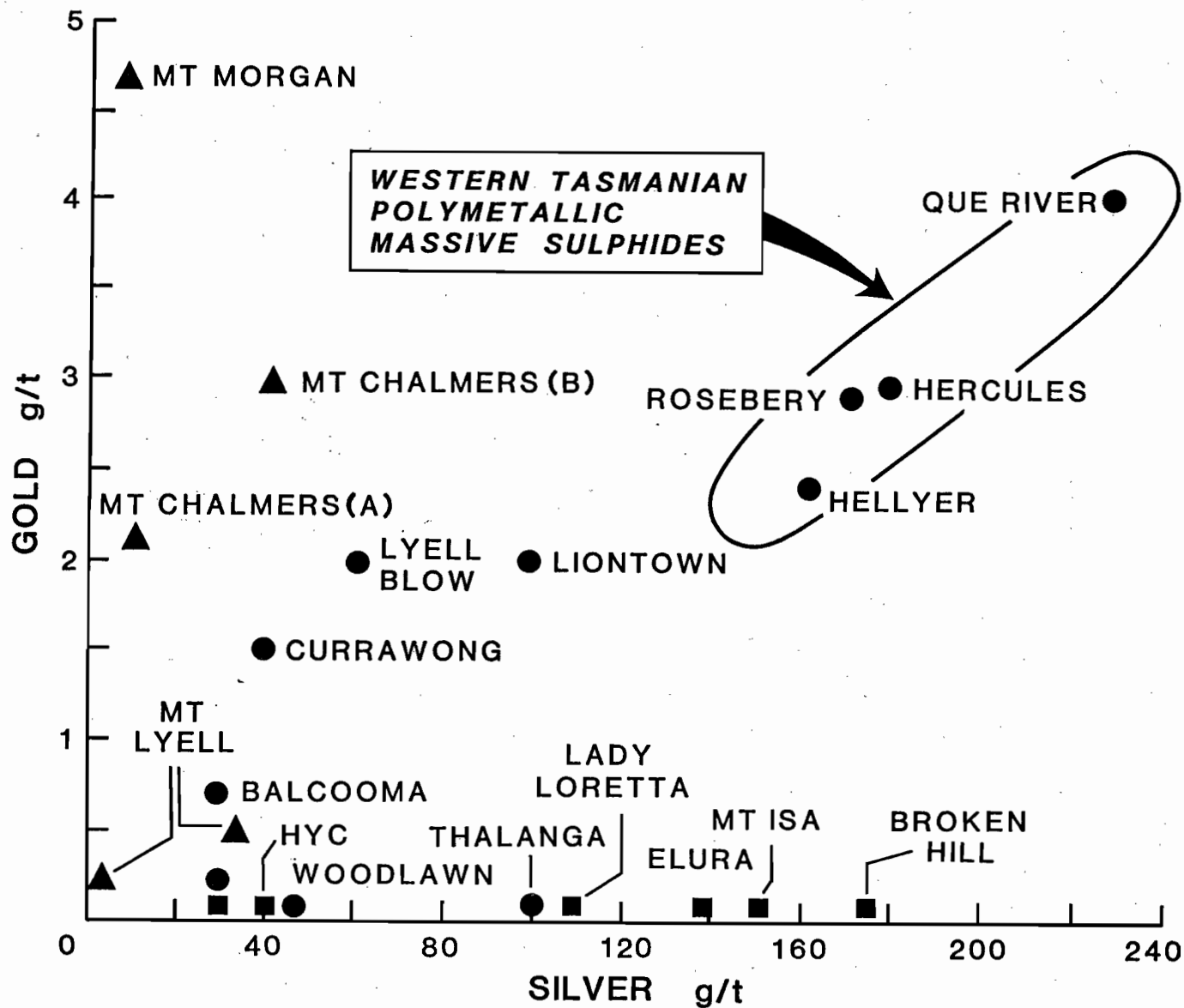


Figure 2. Gold versus silver plot for some Australian volcanic hosted and sediment hosted massive sulphide ores (modified from Large et. al., in press).

sulphides is shown in Figure 2, and highlights the concentration of precious metals in the Tasmanian ores.

Gold at Rosebery

The Rosebery massive sulphide deposit was discovered by a prospector, Jimmy McDonald in 1893, by following a trail of alluvial gold and lead-zinc sulphide boulders on the slopes of Mt. Black (Blainey, 1954). Production and reserves to December 1985 are given below, and details on the geology and lead-zinc mineralisation are provided by Lees (this volume).

	<u>Tonnes x 10⁶</u>	<u>wt%Cu</u>	<u>wt%Pb</u>	<u>wt%Zn</u>	<u>g/T Ag</u>	<u>g/T Au</u>
Production	13.0	0.74	5.1	16.6	169	2.8
Reserves	6.4	0.75	4.7	15.6	129	3.0

Northern ore lens

A recent study (Huston and Large, 1986) of the spatial and mineralogical distribution of precious metals in the Rosebery north-end orebody indicates that both silver and gold are concentrated in the upper parts of massive sphalerite-galena-pyrite ore and barite mineralization (Fig. 3). Both gold and silver tend to decrease in grade toward the fringes of the sphalerite-galena-pyrite ore, with highest concentrations above pyrite-chalcopryrite rich lenses. These lenses may represent localized vents or sulphide mounds. However, both metals may concentrate at the fringes of mineralization in areas of low base metals, and gold has several other occurrences.

Mineralogically, silver occurs in tetrahedrite-tennantite and argentiferous galena. Microprobe analyses of tetrahedrite indicates an increase of silver content with antimony and that remobilized assemblages contain nearly pure tetrahedrite with high silver contents (up to 26 weight percent).

Six styles of gold mineralization have been recognized: (1) in massive zinc-lead ore (the dominant occurrence), (2) in massive barite mineralization, (3) in the upper parts of pyrite-chalcopryrite lenses (in general pyrite-chalcopryrite lenses are poor in gold), (4) in distal pyrite mineralization (at the edges of sphalerite-galena-pyrite mineralization and in the overlying host rocks), (5) in footwall mineralization (poorly sampled and little understood), and (6) in remobilized quartz-carbonate veins probably of Devonian age.

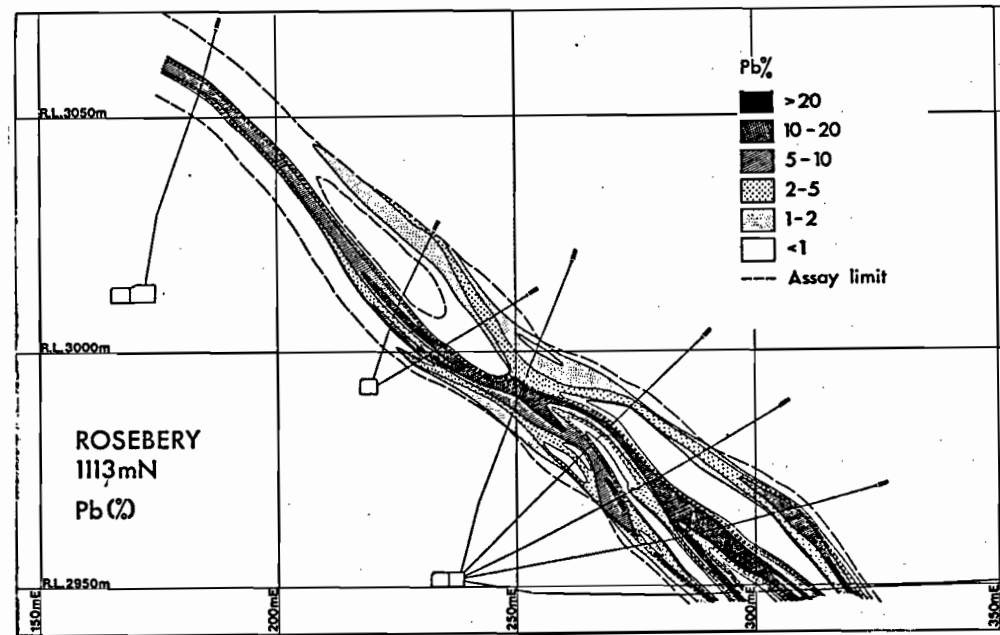
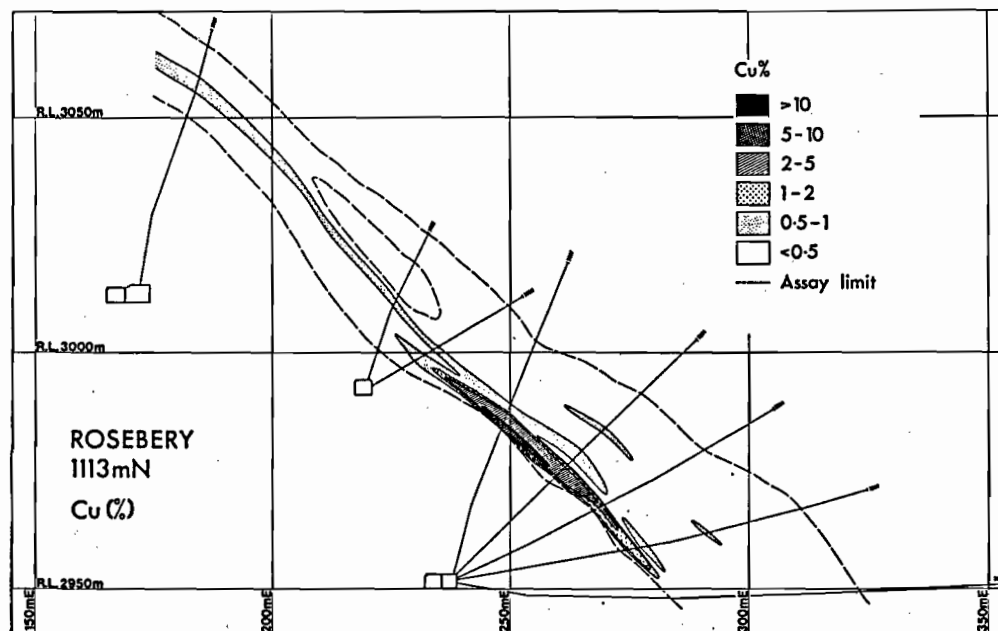
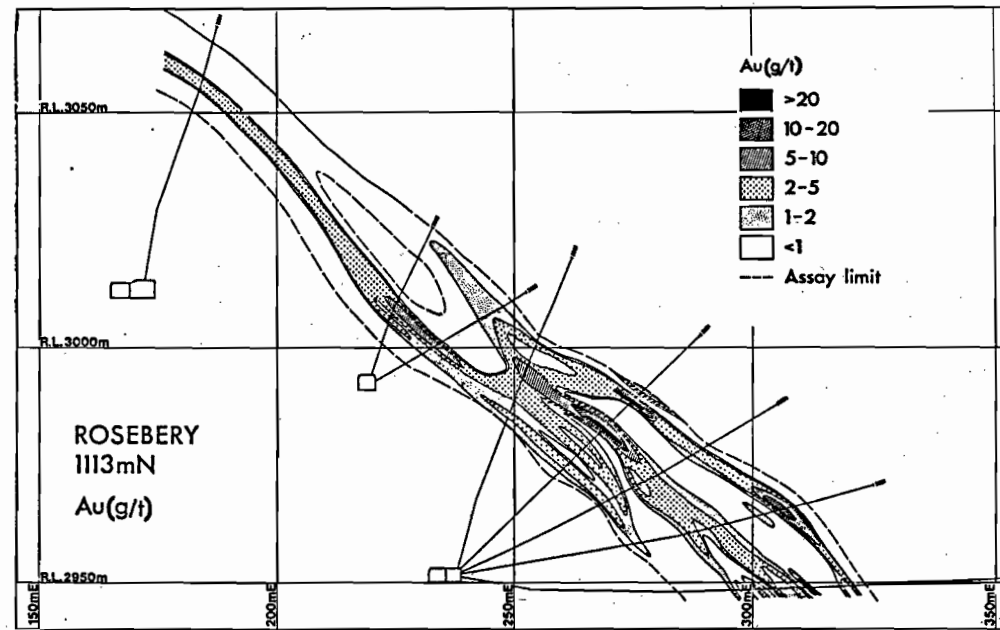
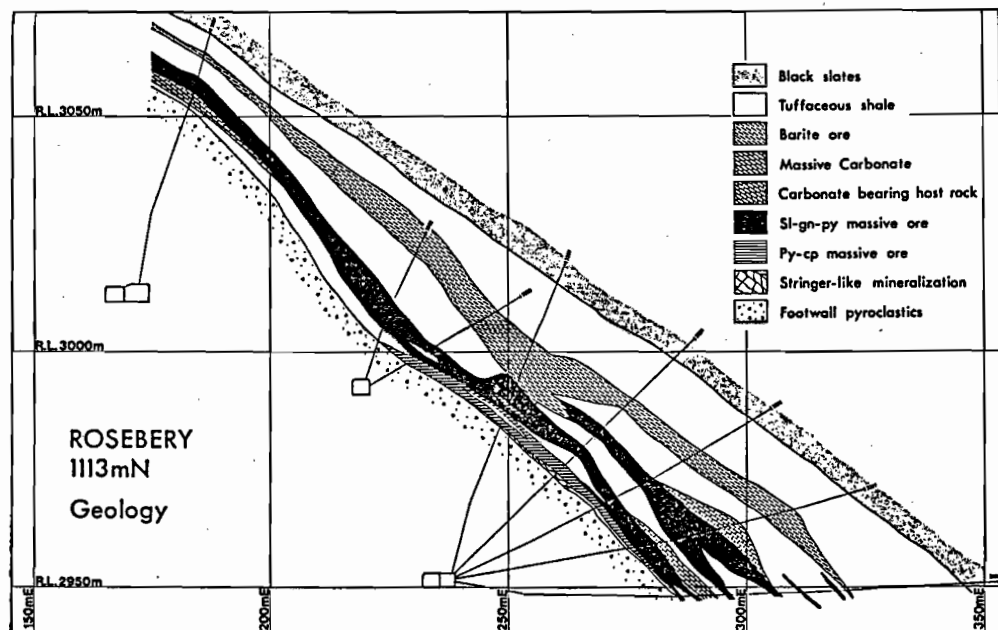


Figure 3. Rosebery cross section through centre of the northern ore lens showing geology, gold contours, copper contours and lead contours.

Gold occurs as electrum or as free gold dominantly associated with pyrite in sphalerite-galena-pyrite ore and distal pyrite mineralization. In the sphalerite-galena-pyrite ore, gold may also occur in tetrahedrite pools, while in the barite mineralization, gold may be associated with chalcopyrite, galena or by itself. The gold has been mobilized locally into cracks and inclusions in pyrite grains; most of the gold grains have average dimensions of less than 25 microns. This explains the poor mill recoveries and the high concentrations of gold in pyrite from the tails.

Southern ore lenses

Gold distribution in the southern ore lenses is generally similar to that described above for the northern lens, being concentrated principally in the lead-zinc-silver rich massive sulphides. However the southern most ore lens (F lens) has the highest gold content in the mine and displays some differences in mineralogical association. Towards the southern end of F lens the gold grade of the basemetal ore increases to an average over 6 g/T Au, with widths up to 13m as high as 9 g/T Au. In this area the massive base metal sulphide body splits into hangingwall and footwall lodes. South of Section 235m S between 15 and 17 levels, the main (hangingwall) lode is replaced by an assemblage comprising predominantly pyrrhotite and pyrite with lesser quartz-chlorite-tourmaline-chalcopyrite-magnetite-gold (see Lees, this volume). This iron sulphide body contains 75,000 tonnes grading 9 g/T Au (Farquhar 1983). The gold occurs as microscopic spherical inclusions (mean diameter 10-40 microns) in the marginal areas of pyrite grains and to a lesser extent chalcopyrite, with some gold (often in association with chalcopyrite) as thin films filling microfractures in pyrite and pyrrhotite. Distribution is erratic and in places the iron sulphide body is almost barren of gold.

The contact between the iron sulphide body and the base metal ore is sharp, discordant and transgresses folding in the latter. This replacement character of the iron sulphide body, along with its mineralogy, has led Solomon et. al. (in press) to propose that there may have been a Devonian gold-mineralising event at Rosebery. However, as already noted the normal base metal ore in the southern part of F lens attains the same grade as the iron sulphide body - 9 g/T Au, and it is clearly not necessary to postulate an influx of 'new' gold to account for the gold grades. The elevated gold content at the southern end of the Rosebery deposit thus may be a feature of the primary syngenetic deposition.

Zones of massive and semi-massive pyrite (lacking significant base metals) occur within and on the margins of the base metal orebodies. These are sometimes highly auriferous. They lack the replacement character of the iron sulphide body at the southern end of F lens, and are simply areas in which syngenetic sulphide deposition was dominated by pyrite. They are probably equivalent to the distal pyrite gold occurrence in the north-end. Grades range up to 12 g/T Au for blocks up to 20,000 tonnes and occasionally the free gold content is sufficient for these pyritic areas to be mined. (Note, the Rosebery mill recovers only free gold and gold included in the ore minerals, which together make up 60% of the total gold in the ore. The 40% of gold lost to tailings is almost entirely that included in pyrite).

Gold at Que River

The Que River volcanogenic massive sulphide deposit was discovered in 1974 by diamond drilling a coincident airborne EM and C horizon soil geochemical anomaly (Webster and Skey, 1979). Production commenced in 1981 and is currently around 300,000 tonnes per year. Production and reserves to December 1985 are given below.

	<u>Tonnes</u>	<u>%Cu</u>	<u>%Pb</u>	<u>%Zn</u>	<u>g/T Ag</u>	<u>g/T Au</u>
Production	1,000,000	0.45	8.3	14.8	227	4.0
Reserves	1,600,000	0.4	6.8	11.7	190	3.2

The deposit is a structurally complex multi-lensed massive sulphide system with an inferred synclinal axial plane dipping sub vertically through the major ore lens and dacite wedge.

The host rocks at Que River are dominated by the altered footwall andesitic volcanoclastics and lavas with intercalated epiclastic facies while the hangingwall rocks are altered dacitic lavas and volcanoclastics. These altered rocks are classified on their Zr/TiO₂ and Nb/Y ratios (Whitford et al in prep.). A more detailed description of the geology is included in the Pb-Zn section of this volume.

Gold is present in all the Que River ore lenses and also in the immediate footwall to P/Q lens. In all cases the precious metal is associated with iron and base metal sulphides.

In Figure 4 the distribution of gold is compared to that of copper and zinc on section 7550 through the centre of the PQ-P north lens system. On this section the massive sulphide lens is folded into an isoclinal W-fold structure. Copper mineralisation is concentrated in the base of the deposit above a zone of intense stinger pyrite, and below the zinc-rich zone. Gold grades of greater than 10 g/T are localised along the synclinal axes of the W-fold structure (Fig. 4), whilst values of 1 to 5 g/T extend throughout the remainder of the massive sulphide, and laterally into the stinger Pb-Zn mineralisation. The prefolding zonation of gold with respect to the other metals is shown in Fig. 5.

A plot of gold versus zinc for the PQ lens at Que River (Fig. 6) indicates two important features of the gold mineralisation.

1. Below 5% zinc, the gold grade varies from about 0.1 to 1 g/T and shows no correlation with zinc grade. These samples correspond to weakly mineralised footwall volcanoclastics and stringer pyrite-galena-sphalerite mineralisation.
2. Above 5% zinc, the gold grades increase roughly exponentially with zinc grades in the following approximate fashion;

Zinc grade	Gold grade
10 wt%	1 g/T
15 wt%	3 g/T
20 wt%	6 g/T
25 wt%	10 g/T
30 wt%	30 g/T

These grades are typical of the variation within the massive base metal sulphide ore.

Native gold appears as large (up to 400 μm) grains associated with galena; as elongate inclusions in sphalerite, typically 100-200 μm long and 20-30 μm wide; as small (<10 μm) inclusions in pyrite and as even smaller (<5 μm) intergranular particles along pyrite-pyrite grain boundaries.

The gold-galena association is the commonest and is characteristic of the coarse grained (i.e. recrystallised) lenses and nodules in the ore. The gold grains range from 50 to 400 μm and are either enclosed in or occur at the boundary of galena. Gold in sphalerite is not common.

Visible gold in pyrite is the least common mode of occurrence. Small grains (<10 μm) occur in fractured and partly recrystallised pyrite and have

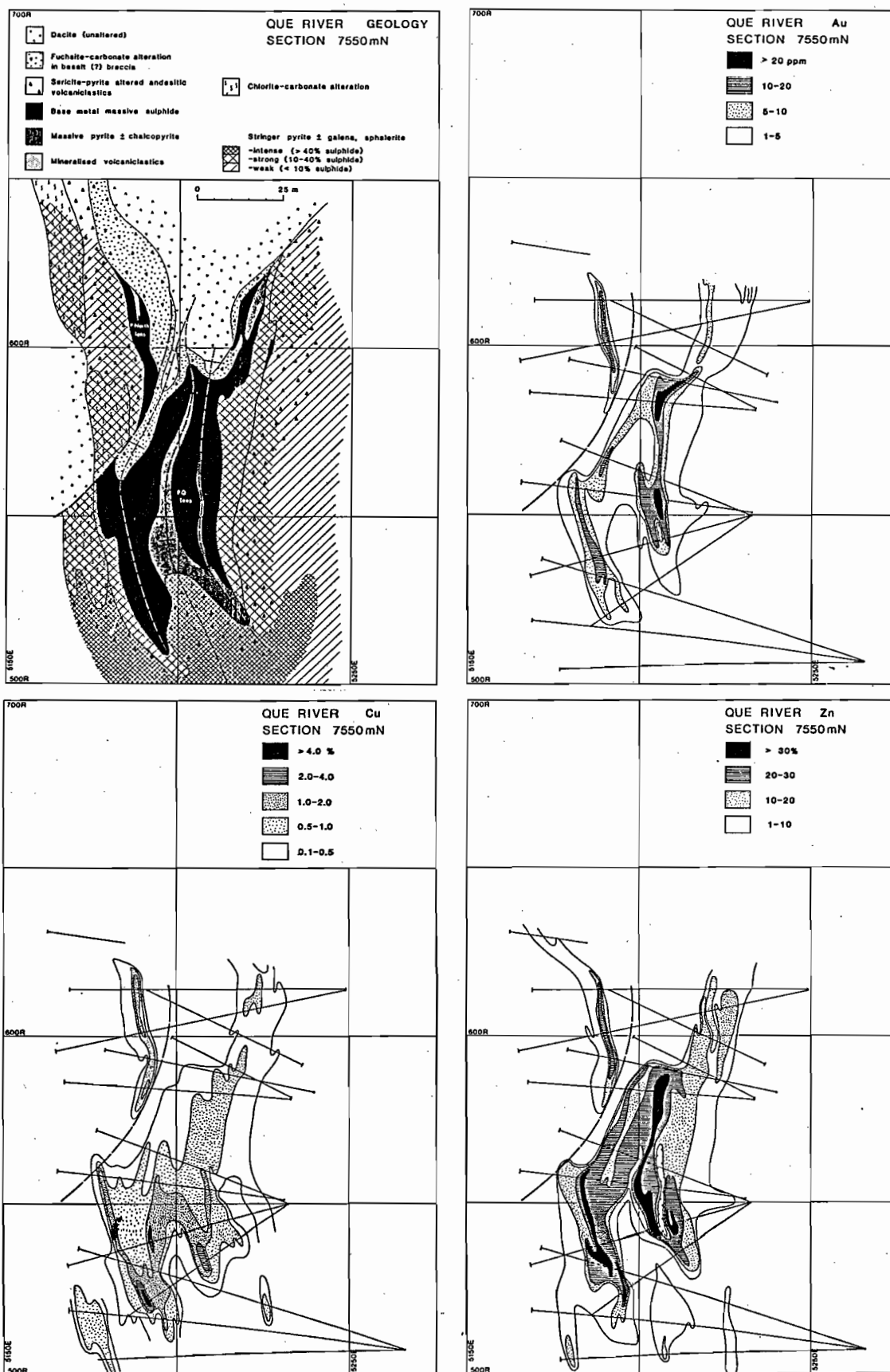


Figure 4. Que River Mine: cross section 7550N, through the centre of the PQ lens showing geology, gold contours, copper contours and zinc contours.

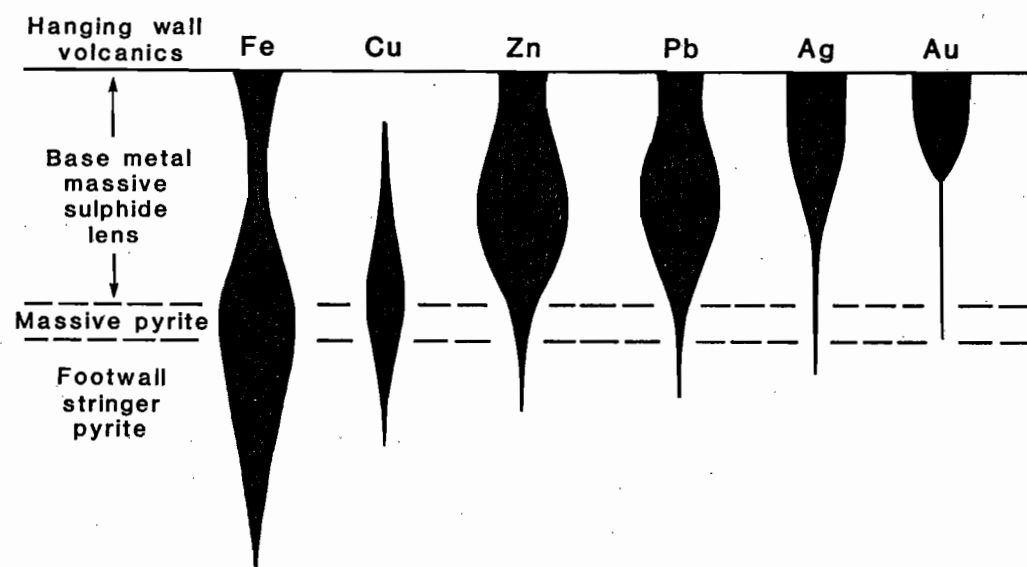


Figure 5. Diagrammatic representation of metal zonation in the Que River PQ lens (pre-folding).

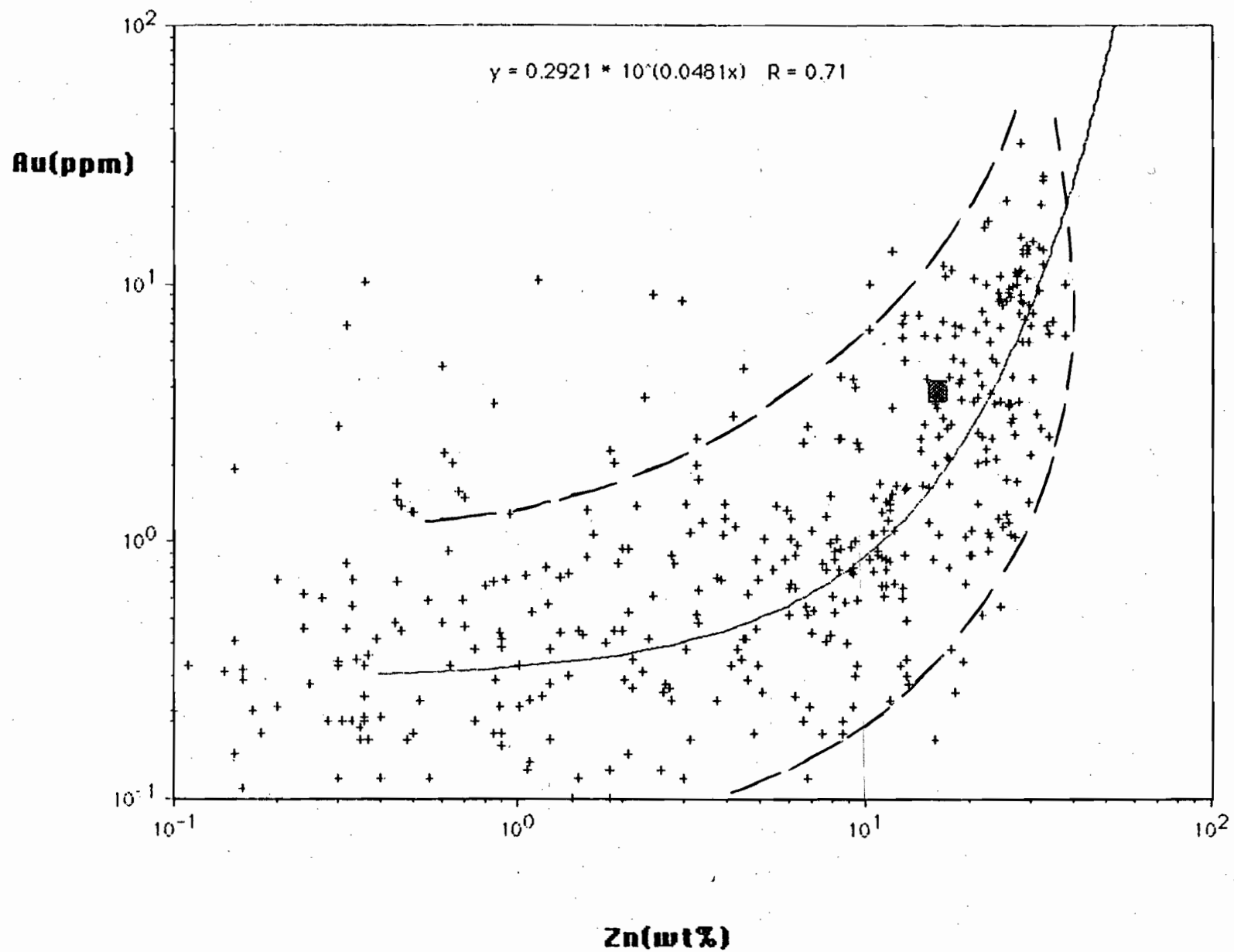


Figure 6. Plot of gold versus zinc for drill core samples from Que River PQ lens (7550N section). The black square denotes the average production grade.

also been observed along pyrite-pyrite grain boundaries. Such particles probably range down to sub-micron size but scanning electron microscopy has failed to reveal ultra-fine particles in the pyrite.

Electron microprobe analyses of particulate electrum shows a wide range in composition from 55% Au to 82% Au with a mean composition of about 72% Au. Large variations can occur even within single grains. Coarse-grained gold associated with galena tends to have the highest Au-content, typically greater than 80% Au, and fine grained gold associated with pyrite (and in one instance tennantite) the lowest, typically less than 60% Au. Gold associated with sphalerite tends to have a Au-content less than 72% Au. Electron microprobe analyses for trace gold in arsenopyrite and pyrite suggest that both are carriers of significant gold.

In summary, it is concluded the the existence of native gold in Que River ores, is largely a consequence of the tectonic deformations that have affected the orebody. Arsenopyrite and, to a lesser extent, pyrite are believed to have been the initial gold bearing minerals. As a result of recrystallisation "lattice" gold is believed to have migrated first to grain boundaries (where it occurs as minute granules in pyrite) and then concentrated along with the ductile galena during continued deformation.

Gold at Hellyer

The Hellyer massive sulphide deposit was discovered in 1983 by diamond drilling a coincident EM and hanging wall soil geochemical anomaly. The resource as currently outlined is tabulated below:

Resource	Tonnes x 10 ⁶	%Cu	%Pb	%Zn	g/TAg	g/TAu	%Ba	%As
Indicated	15	0.4	7	13	160	2.3	3	1.0
Inferred	4							

The deposit is located within the axial plane zone of a broad north-northeast shallow plunging anticline at a favourable stratigraphic horizon between footwall andesites and hanging wall basalts. The single massive sulphide body is characterized by sharp terminations and a complete lack of internal barren rock. It is known to measure at least 800m north-northeast and 200m east-southeast with an average true thickness of 40m. A major north-south vertical fault (the Jack Fault) cuts the deposit displacing the eastern block

130m northwards. Vertically beneath the massive sulphide, a footwall alteration zone within the andesites contains a pyrite stockwork with minor subeconomic base metal veins. Figure 7 is a typical Hellyer cross-section illustrating these geological elements.

The gold and silver is enriched consistently in the hanging wall half of the massive sulphide along with lead, zinc, barium and arsenic. Locally, some enrichment occurs towards the footwall. Figure 7 shows the gross Au zonation within the massive sulphide and Figure 8 displays the variation in average gold grade through the orebody stratigraphy. The highest gold grades are found in an uppermost thin siliceous layer that caps the barite zone over the central part of the deposit. This "glassy silica cap", which contains average grade silver and is low in base metals may be analogous to the ferruginous quartz cap, the tetsusekiei, observed in many of the Kuroko deposits of Japan.

Lateral zonation of gold is not well understood due to insufficient data. However, two areas of above average grade are indicated in the south and north-west, some 200m apart (Fig. 9). These gold rich areas do not exactly coincide with those areas rich in base metals. Some gold (generally less than 1 g/T) is found within the footwall alteration zone correlating broadly with the base metals.

Although total gold assays from the Hellyer deposit are almost as high as at Que River, native gold has not been seen despite intensive search using both light and scanning electron microscopy. As at Que River, electron microprobe analyses show the presence of gold in the range 100 to 400 ppm within fine grained arsenopyrite (to 10 μ m) found along pyrite boundaries and in sphalerite. The general trend to higher Au with increasing As displayed by the majority of massive ore samples (Fig. 10) provides further support for the suggestion that arsenopyrite is an important host mineral for gold. In some intersections the gold content of the arsenopyrite closely follows the total gold assay indicating that it is the dominant source for these intervals. Trace gold is also detected in 10% of the pyrite. Although several generations of pyrite can be distinguished by their arsenic contents, which range from <220 ppm to 4%, there is no correlation between gold and arsenic contents of individual grains.

Arsenopyrite is therefore probably an important carrier of gold but the failure of special laboratory flotation tests to appreciably upgrade the gold content when concentrating arsenopyrite suggests that either arsenopyrite is not

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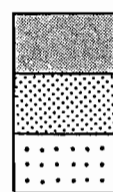
JACK FAULT

FAULT

JACK WEST

FOOTWALL ALTERATION
ZONE

0 100
METRES



4g/t Au

2g/t Au

IN MASSIVE SULPHIDE

Cross section A-A' at 10750N at Hellyer
SHOWING GOLD DISTRIBUTION

FIGURE

7

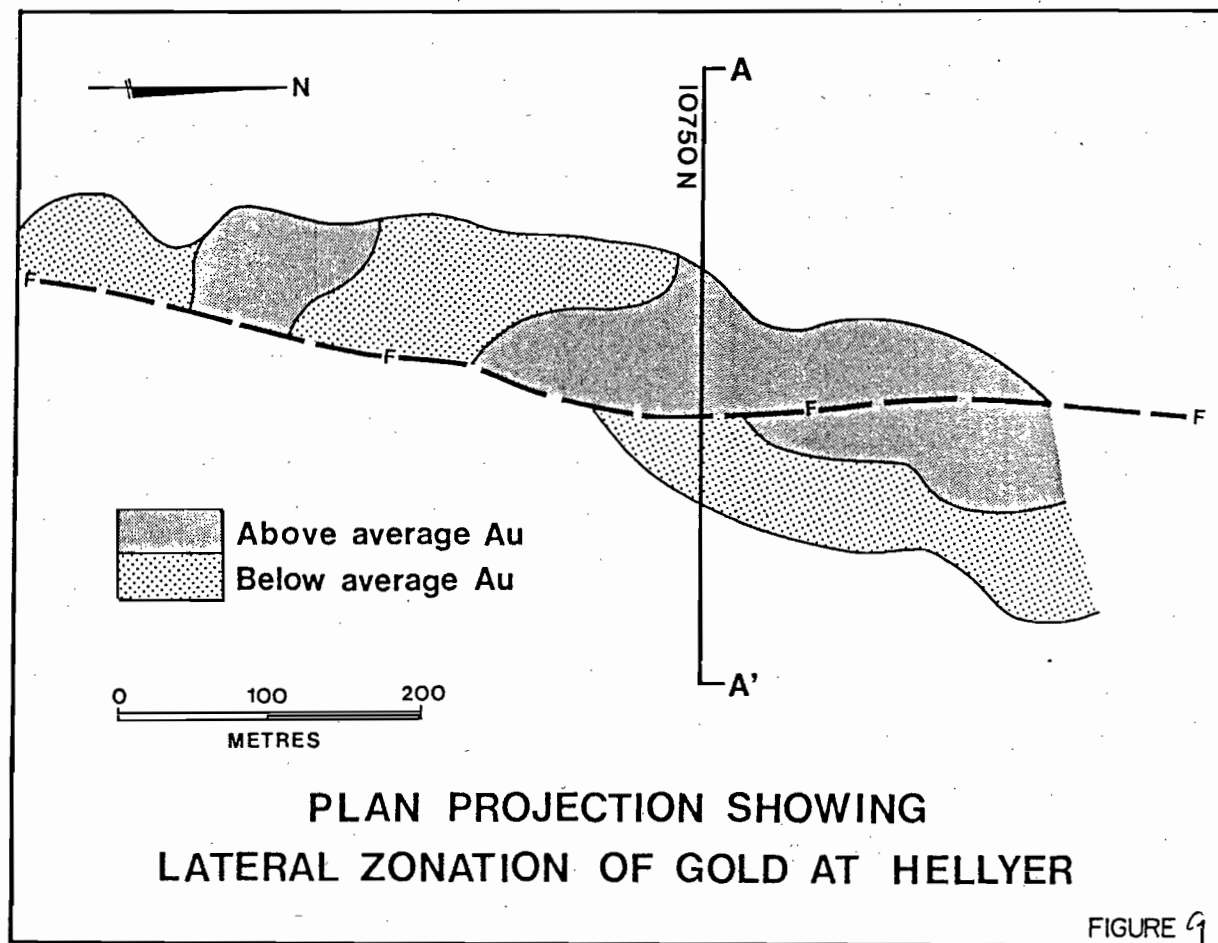


Figure 9. Plan projection showing lateral zonation of gold at Hellyer.

HELLYER BASE METAL SULPHIDES

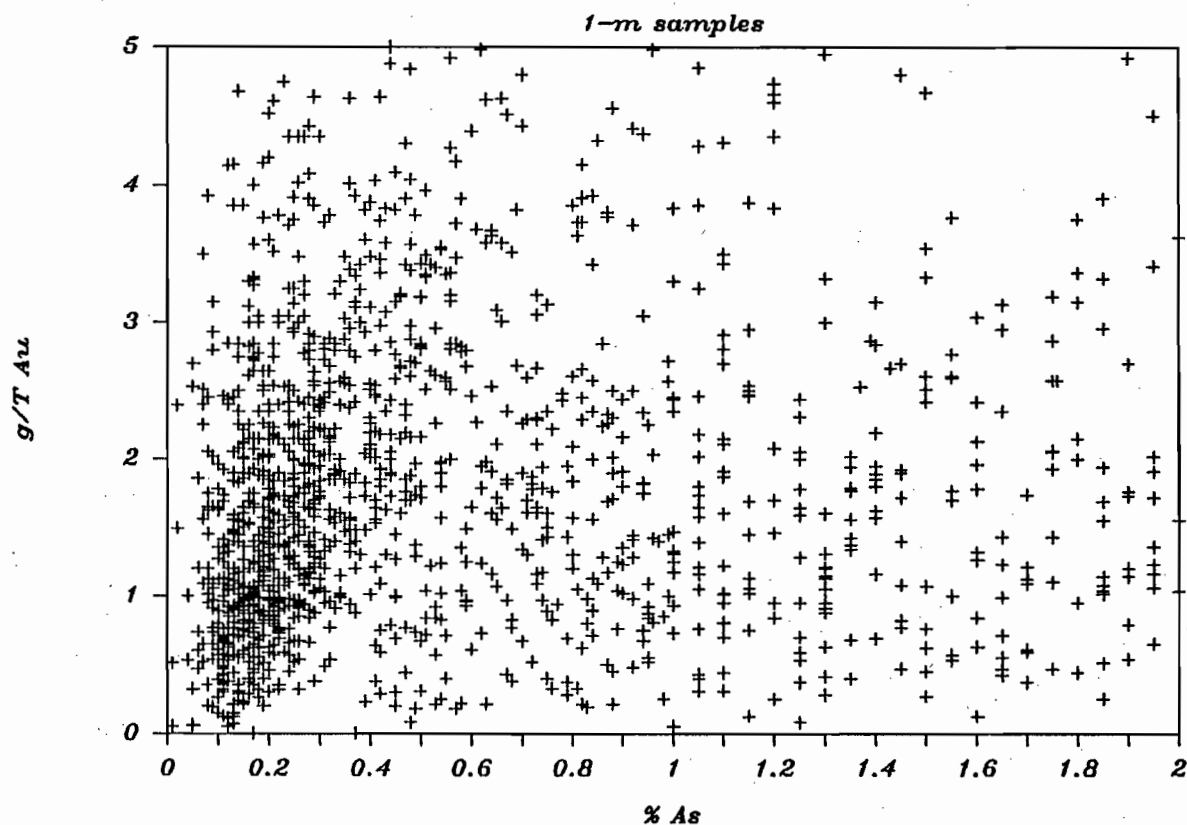


Figure 10. Plot of gold versus arsenic for 1m core samples, Hellyer massive sulphide ore.

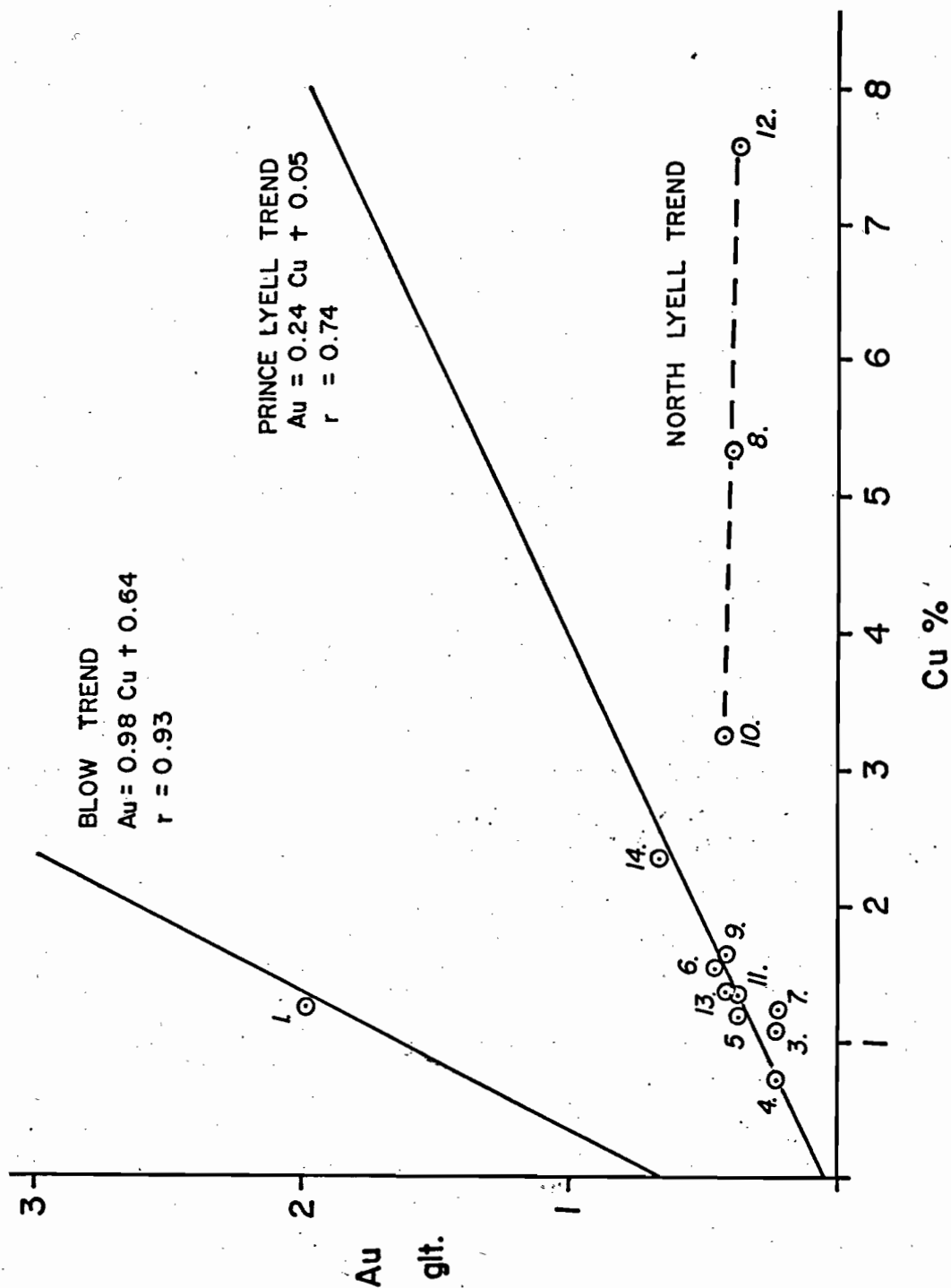


Figure 11. Plot of gold versus copper for the Mt. Lyell ore bodies (see text for details). The numbers relate to ore bodies listed in Table 2.

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the only important source or some generations of arsenopyrite are gold-deficient. Routine electron microprobe techniques, however, have detection limits of the order of 100 ppm, too high to investigate the possibility that other major minerals may carry trace gold at very low levels.

The lack of detectable native gold at Hellyer compared to Que River is considered to be purely a function of lack of recrystallization at Hellyer where very little deformation of the sulphide is evident.

Gold at Mount Lyell

Alluvial gold was discovered at Mount Lyell in 1883 and was mined sporadically along with eluvial gold and the auriferous gossan cap of the Mount Lyell (Blow) orebody until 1895 when the Blow was developed as a copper mine. There has been continuous copper production since then, with significant precious metal by-production.

In the period 1895 to 1985 gold production totalled 38.7 tonnes, silver production 705.0 tonnes and copper production 1.15 million tonnes in 98.57 million tonnes of ore.

TABLE 2 - Production History 1895 - 1985 of Mt. Lyell ores.

	MINE	TONNES	wt%Cu	g/T Au	g/T Ag
1.	Mt. Lyell (Blow)	5,586,000	1.29	1.99	61.22
2.	South Lyell	Included with Blow production			
3.	Razorback	233,000	1.10	0.24	1.48
4.	West Lyell Open Cut	58,315,000	0.72	0.24	1.66
5.	Prince Lyell/A' Lens	17,452,000	1.20	0.38	2.90
6.	Royal Tharsis	1,557,000	1.54	0.47	2.38
7.	Lyell Tharsis	1,505,000	1.26	0.23	3.64
8.	North Lyell	4,803,000	5.33	0.39	33.34
9.	Crown Lyell No. 1	469,000	1.65	0.42	7.93
10.	Crown Lyell No. 2	238,000	3.24	0.42	22.40
11.	Crown Lyell No. 3	3,131,000	1.38	0.36	4.05
12.	Twelve West	117,000	7.59	0.37	39.00
13.	Cape Horn	3,831,000	1.39	0.42	3.30
14.	Lyell Comstock	1,337,000	2.38	0.67	5.23
15.	Tasman Crown Lyell	Included with Lyell Comstock			

TOTAL	98,574,000	1.17	0.39	7.15
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Gold has three known modes of occurrence:

- i) associated with copper sulphide and/or pyrite mineralization,
- ii) in metamorphic quartz veins derived from i) and,
- iii) in alluvial/eluvial deposits and gossans derived from i and ii.

Background values in the mine sequence volcanics away from copper orebodies are of the order of 0.05 g/T, but vary widely from below detection limit (0.008 g/T) to 0.3 g/T with odd values up to 3 g/T. The variability is related to coincident variability in pyrite and low-grade base metal mineralization and possibly to intensity of hydrothermal alteration.

The bulk of gold with grades in excess of 0.2 g/T is, however, associated with copper mineralisation. The gold is present as discrete very fine grains of native gold and minor electrum, occurring as inclusions in, and along grain boundaries between, chalcopryite, bornite and pyrite grains. There is a remarkable relationship between copper and gold grades, and therefore gold distribution, on three trends each related to the major styles of copper mineralization (Fig. 11).

- a) a massive sulphide (Blow) trend. regression of annual copper and gold production grades for the life of the Blow Mine exhibit high correlation and, gold grades of 0.64 g/T in copper-barren massive sulphide.
- b) a disseminated chalcopryite (Prince Lyell) trend, determined from drill hole sampling from a section of the Prince Lyell orebody, on which all of the disseminated chalcopryite/pyrite orebodies fall; the correlation may have been modified by other styles of mineralization particularly the presence of massive sulphide units within the disseminated orebodies.
- c) a bornite trend including the North Lyell, Crown Lyell No. 2 and Twelve West orebodies in which bulk grades are consistently about 0.4 g/T irrespective of copper grade; annual production grades, however, vary from 0.05 g/T to 1.0 g/T independently of copper grade so an erratic distribution of gold in the orebodies can be assumed; the distribution of copper mineralization in each of the ore types and orebodies is well documented in Reid (1975).

Coarse grained gold has been reported from quartz tension veins from a number of orebodies. The gold is hosted by coarse grained remobilized quartz, chalcopyrite, bornite, pyrite, siderite and chlorite. The extent of this style of gold mineralization is obscured by a nugget effect in sampling. For example, only one sample from the Bonanza shoot at the Blow detected gold and assayed 1350 g/T.

There is no record of gold production from alluvial workings, but reports suggest that grades were erratic and recoveries poor due to the fine-grained nature of the gold. Grades of up to 450 g/T were reported from the Blow gossan but were also erratic.

Silver has a similar distribution pattern to gold generally being confined to, and evenly distributed in the copper orebodies. The Blow and North Lyell orebodies, and minor massive pyrite units in the disseminated orebodies have elevated silver contents and the disseminated orebodies have low bulk grades. Silver occurs in tetrahedrite, stromeyerite, hessite, betechtinite, electrum and in galena and a range of copper sulphide minerals.

The orebodies at Mount Lyell are considered to be Cambrian volcanogenic, partly exhalative and partly shallow hydrothermal replacement. The ore, particularly the bornite ore, has undergone varying degrees of remobilization during Devonian tectonism (Arnold and Carswell, this volume). Precious metal distribution is consistent with this model.

Summary

The gold mineralisation in western Tasmania massive sulphides is stratiform and syngenetic forming part of the overall metal zonation commonly displayed by this class of deposit. Gold and silver are concentrated in the uppermost parts of the lead zinc-rich ore lenses and extend into the barite zones at Rosebery and Hellyer. Studies by Large et. al. (in prep.) have shown that there is a consistent relationship between gold grades and lead + zinc grades in the Que River deposit, which is also seen in other volcanogenic polymetallic ores world wide. This relationship strongly suggests that the gold, lead and zinc were transported together and deposited together to form the ores. In the relatively unmetamorphosed Hellyer deposit the gold is submicroscopic, and intimately associated with arsenopyrite, pyrite and possibly also in As-Sb sulphosalts, which form part of the galena-sphalerite zone. In the folded and recrystallized ores at Que River and Rosebery the gold mainly

occurs in free grains of electrum commonly in cracks in pyrite or pools in other metal sulphides. This metamorphic liberation of the gold has important metallurgical implications. The copper-rich massive and stockwork pyrite ores at Mount Lyell are depleted in both gold and lead-zinc compared to the polymetallic massive sulphide ores.

Other Tasmanian Gold Deposits

In addition to gold in the massive sulphides, there are five other styles of gold mineralisation in Tasmania.

1. Copper-gold stockworks and disseminations associated with chlorite-quartz-hematite-magnetite alteration in potassium-rich rhyolite domes in the Mount Read Central Volcanic Sequence (eg., Red Hills, Jukes Pty.).
2. Gold with minor base metals in siliceous pyritic volcanoclastics and cherts, commonly along strike from or peripheral to small high-grade massive sulphide lenses (eg., Pinnacles, Red Hills and Henty Fault Zone Prospect).
3. Minor gold in quartz-carbonate-base metal veins of Cambrian age cutting carbonate altered volcanoclastics in the Mount Read Arc (eg., Voyager 24 Prospect, Elliott Bay).
4. Gold-arsenic mineralisation in quartz $\pm$ tourmaline and/or pyrite-arsenopyrite-pyrrhotite veins hosted by rocks ranging in age from Cambrian to Silurian, and genetically related to the emplacement of the Devonian granites (e.g. Sterling Valley, Moina, Beaconsfield and Mathinna goldfields).
5. Alluvial gold $\pm$ osmiridium commonly derived from alluvial re-working of Tertiary gravels (e.g. Corrina and Jane River gold fields).

Of these types the only significant producers have been the Devonian granite related vein systems.

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APPENDIX II

FIELD EXCURSION GUIDES

**Que River
Anthony Road**

NOTES FOR A VISIT TO QUE RIVER MINE, 18TH NOVEMBER, 1986

Peter McGoldrick and Ross Large

During the course of this visit sponsors representatives will be able to view three drill-holes (QR 405, QR 417 and QR 278) from 7550 N section (Figs 1 and 2). A fourth drill hole (QR 631) from 7700 N section (Fig. 3) will also be on display and a surface inspection of S lens will be carried out. We would like to take this opportunity to thank the geological and technical staff at Que River Mine for making this inspection possible. In particular, frank discussion of various aspects of the mine geology with Peter Bertram, Ed Dronseika, Gary McArthur, Steve Richardson and Dave Wallace have been particularly valuable. It should be noted, however, that all responsibility for the material presented in these reports is taken by the authors.

Rock Types

The following section provides a brief description of the common rock types observed in the mine sequence at Que River. Our classification does not adhere to that used by Que River geologists. Less emphasis is placed on the detailed alteration mineral assemblages (eg., abundance of fine sericite, the lack of recognizable primary clastic textures in the altered footwall rocks) to subdivide different lithologies. Because the extent of alteration in the footwall rocks reflects both the alteration intensity and the precursor lithology more emphasis was placed on the obvious effects of the transient mineralizing solutions (eg., modal pyrite and base metal sulphide contents, the extent of stringer development). Other rock names correspond to the Que River Mine rock classification.

Andesitic volcanics:

Monomict and polymict volcanoclastic rocks of andesitic provenance that form the footwall to the PQ - P north massive sulphide bodies and host the stringer and footwall precious metal zone (PMZ) mineralization (Fig. 4) are hydrothermally altered for a large distance around the massive sulphides (Fig. 5). Volcanic fragments are recognizable in the coarser grained lithologies but finer rock types and the matrix of coarser units are commonly altered to a sericite - silica - sulphide $\pm$ carbonate assemblage. Alteration intensity is variable, pyrite and base metal sulphides occur as disseminations and discrete stringers and commonly increases moving toward the massive sulphides orebodies. Some rocks are dominantly a fine grained sericite - carbonate - sulphide assemblage, these may have been coarser original rocks that have been so intensely altered that clastic textures are not recognizable, alternatively they may represent fine grained primary lithologies. The PMZ rocks are very similar to the rest of the footwall rocks except for a characteristic, patchy, creamy-white alteration. The strongest development of this alteration corresponds well to the highest Au grades in the PMZ (D.B. Wallace, pers. comm., 1986).

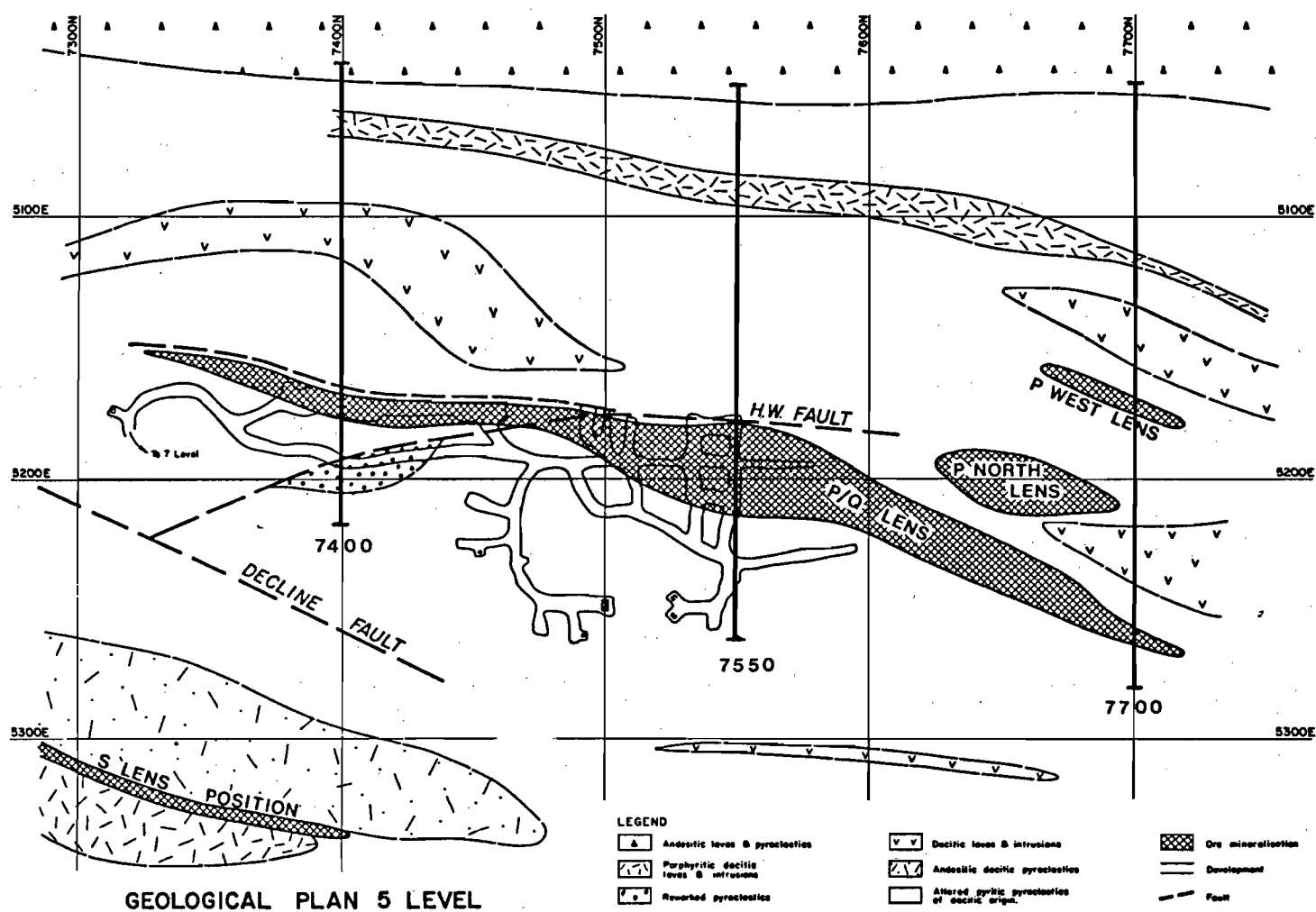


Fig. 1 Geological plan of 5 level, Que River Mine.

Chlorite-carbonate-pyrite rocks:

These massive, fine grained, black rocks occur in some parts of the footwall of PQ - P north orebodies. They are irregularly distributed but appear to have formed peripherally to the thickest massive sulphide mineralization and strongest stringer development. They may be localized by an unusual primary lithology or, alternatively, represent zones of strong alteration formed at the seafloor.

Base-metal massive sulphide:

Four types of massive sulfide can be distinguished in drill core:

1. Fine grained uniform to thinly laminated sphalerite-rich base metal sulphides. These ores may be preserving the primary chemical and/or sedimentary layering of the ores.
2. Banded massive sulfide (a more coarsely layered ore type than 1.). Layering is defined by varying proportions of different base metal sulphides and pyrite. Sulfides (especially galena) may show evidence of recrystallization and annealing.
3. "Disturbed" base metal massive sulphide. This ore type is not obviously layered and may cross-cut the other ore types. It is commonly transitional from the banded massive sulphide and may replace the laminated massive sulphide.
4. Fragmental massive sulphides. While some examples are polymict and represent broken up and redeposited massive sulphide, others may be due to network veining of laminated or layered massive sulphide. Some of these ores may contain significant amounts of sericitic gangue.

Fuchsite-carbonate breccia:

This unit overlies the folded massive sulphides of the PQ - P north system. It is a polymict volcanic-derived conglomerate or breccia. A dark, amygdaloidal rock type (basalt?) forms the main clast type, but dacitic fragments are locally important and rare clasts of massive sulphide (pyrite/sphalerite) are also present. The rock is characterized by its pale green colour (due to the presence of fuchsite) and abundant carbonate alteration. Fuchsite may be concentrated in this unit because the original rock type may have contained anomalous amounts of Cr (in spinels and/or pyroxenes) that was subsequently incorporated in the fuchsite during hydrothermal alteration.

Dacite:

The Que River dacites are buff to grey coloured massive and flow banded fine grained lavas and volcanic breccias. Although they are extensively carbonate altered and locally contain small chlorite veins and

patches, they are essentially devoid of base metal sulphides and only rarely contain pyrite.

700R

QUE RIVER GEOLOGY SECTION 7550mN



Dacite (unaltered)

Fuchsite-carbonate alteration
in basalt (?) brecciaSericite-pyrite altered andesitic
volcanoclastics

Base metal massive sulphide



Massive pyrite ± chalcopyrite



Mineralised volcanoclastics



Chlorite-carbonate alteration

Stringer pyrite ± galena, sphalerite



-intense (> 40% sulphide)

-strong (10-40% sulphide)

-weak (< 10% sulphide)

0 25 m

QR 405

600R

QR 417

QR 278

5150E

500R

5250E

Fig. 2

Summary Logs

QR 405

0 - 10.9 m	sericite-pyrite altered volcanics; no definite stringers	
10.9 - 23.3 m	sericite-pyrite altered fine grained (?)volcaniclastic with bands of strongly disseminated to massive pyrite; some pyrite stringers	
23.3 - 24.9 m	low grade stringer/disseminated Zn-Pb mineralization in volcanics	
24.7 - 24.9 m	fragmental massive base metal sulphide (bms)	} PQ lens
24.9 - 28.6 m	massive pyrite	
28.6 - 31.8 m	grey pyritic siliceous ore	
31.8 - 33.6 m	pyritic fuchsite-carbonate breccia	
33.6 - 37.5 m	dacite	
37.5 - 39 m	dacite breccia (pyritic)	
39 - 52 m	dacite	
52 - 60.4 m	fuchsite-carbonate breccia	
60.4 - 61.6 m	fragmental bms	} P north lens
61.6 - 62.6 m	massive pyrite	
62.6 - 65 m	fragmental bms	
65 - 77.5 m	strongly sericite-pyrite altered volcaniclastic (pyrite decreases towards EOH)	
77.5 - 79.5 m	chlorite-carbonate-pyrite rock	
EOH		

QR 417

0 - 4.9 m	siliceous sericite-pyrite altered volcaniclastic; minor Zn-Pb sulfide stringers
4.9 - 7 m	strong Zn-Pb sulphide stringers in fine grained sericite-pyrite (?) volcanics
7 - 9.6 m	siliceous and sericitic volcaniclastic with minor carbonate veining
9.6 - 19.8 m	strongly sericite-pyrite altered volcaniclastic with abundant stringer and semi-massive bms
19.8 - 22.4 m	bms (mixture of disturbed and fragmental types)
22.4 - 24.7 m	banded bms
24.7 - 25.2 m	massive pyrite (chalcopyrite)
25.2 - 33.8 m	banded bms
33.8 - 37.4 m	massive pyrite (chalcopyrite)
37.4 - 46.3 m	banded bms with disturbed zones (disturbed zones are pyrite-rich)
46.3 - 51m	interlayered banded and fragmental bms
51 - 56 m	low grade fragmental bms/volcanics
56 - 57 m	sericite-pyrite altered volcaniclastic

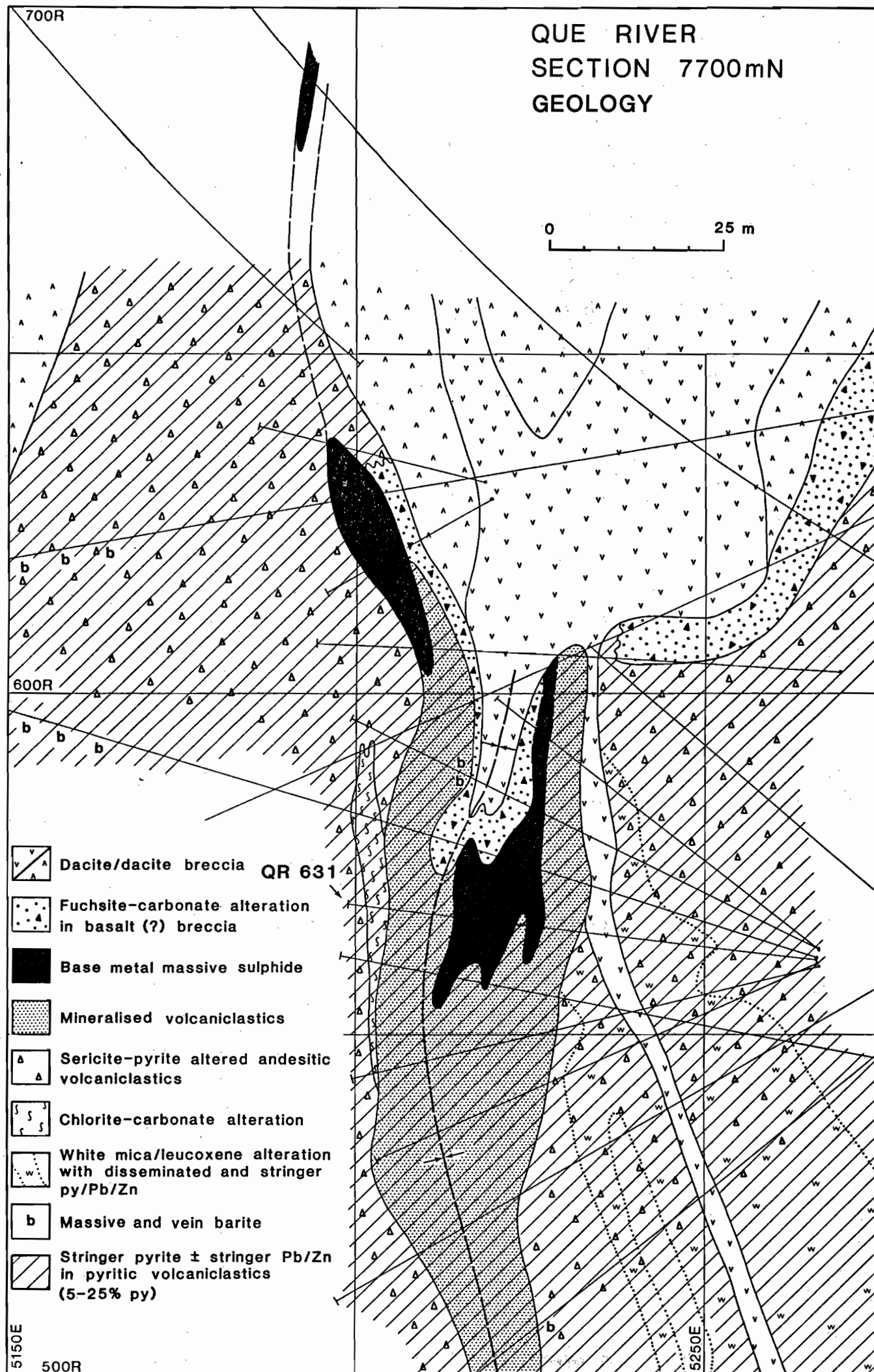


Fig. 3

57 - 58 m chlorite-carbonate-pyrite rock
 58 - 65.5 m dacite breccia with strong carbonate and minor pyrite veining
 EOH

QR 278

0 - 8 m siliceous sericite-pyrite altered volcaniclastic
 8 - 69.5 m intense pyrite stringer development in (siliceous) sericite-pyrite altered volcaniclastics; stringers increase down hole; minor chalcopyrite is present in some stringers
 69.5 - 75.9 m fragmental bms with minor patches of barren altered volcaniclastics
 75.9 - 97.2 m intense pyrite stringer with semi-massive to massive pyrite bands and cross-cutting veins developed in altered volcaniclastics (fragmental textures are preserved in some places)
 EOH

QR 631

0 - 13.7 m siliceous sericite-pyrite altered coarse volcaniclastics
 13.7 - 28.9 m disseminated and minor stringer base metal sulfides in siliceous sericite-pyrite altered coarse volcaniclastics (PMZ) with well developed creamy-white alteration patches
 28.9 - 33.7 m dacite dyke
 33.7 - 39.6 m disseminated and minor stringer base metal sulfides in siliceous sericite-pyrite altered coarse volcaniclastics; locally semi-massive bms
 39.6 - 49.6 m bms; contacts between this intersection and preceding and subsequent intersection are gradational
 49.6 - 58.8 m semi-massive and disseminated base metal sulfides in pyrite-sericite-carbonate altered fine grained (?) volcaniclastics
 58.8 - 63 m highly altered pyrite-sericite rock
 63 - 65.2 m chlorite-carbonate-pyrite rock
 65.2 - 66.7 m siliceous pyrite-sericite altered rock with Zn-Pb sulphide stringers
 EOH

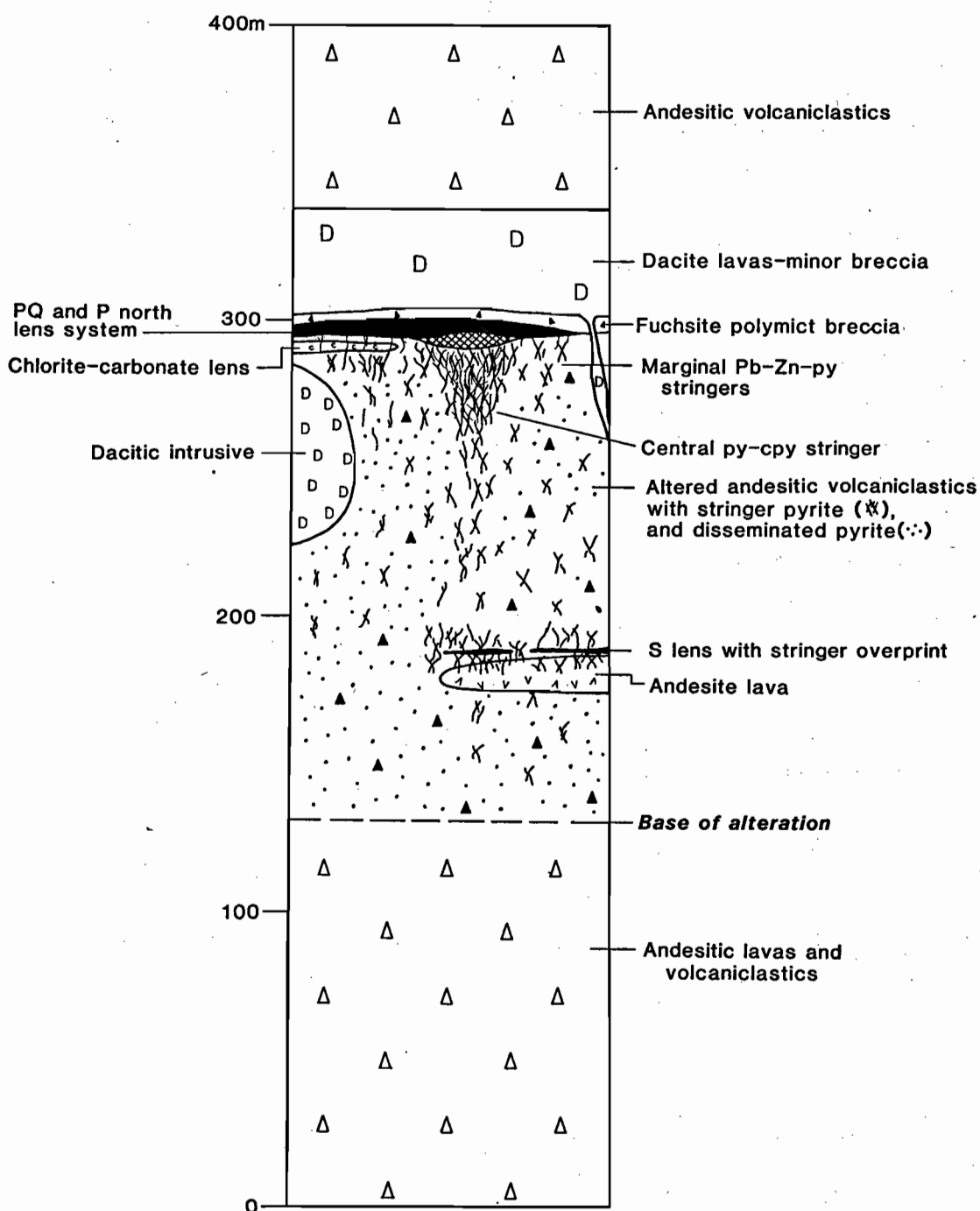


Fig. 4 Idealized stratigraphic column for Que River showing major rock types, massive sulphide bodies and alteration.

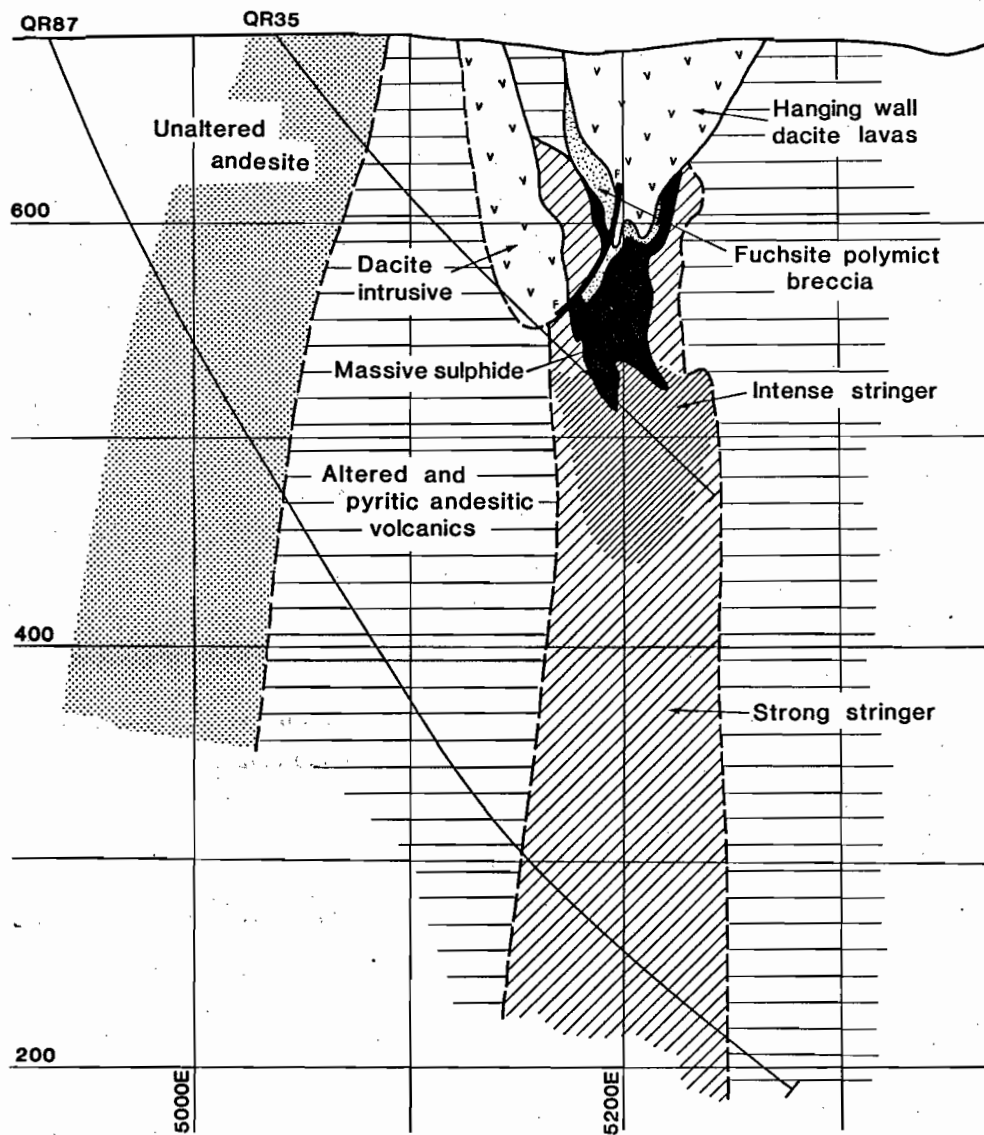
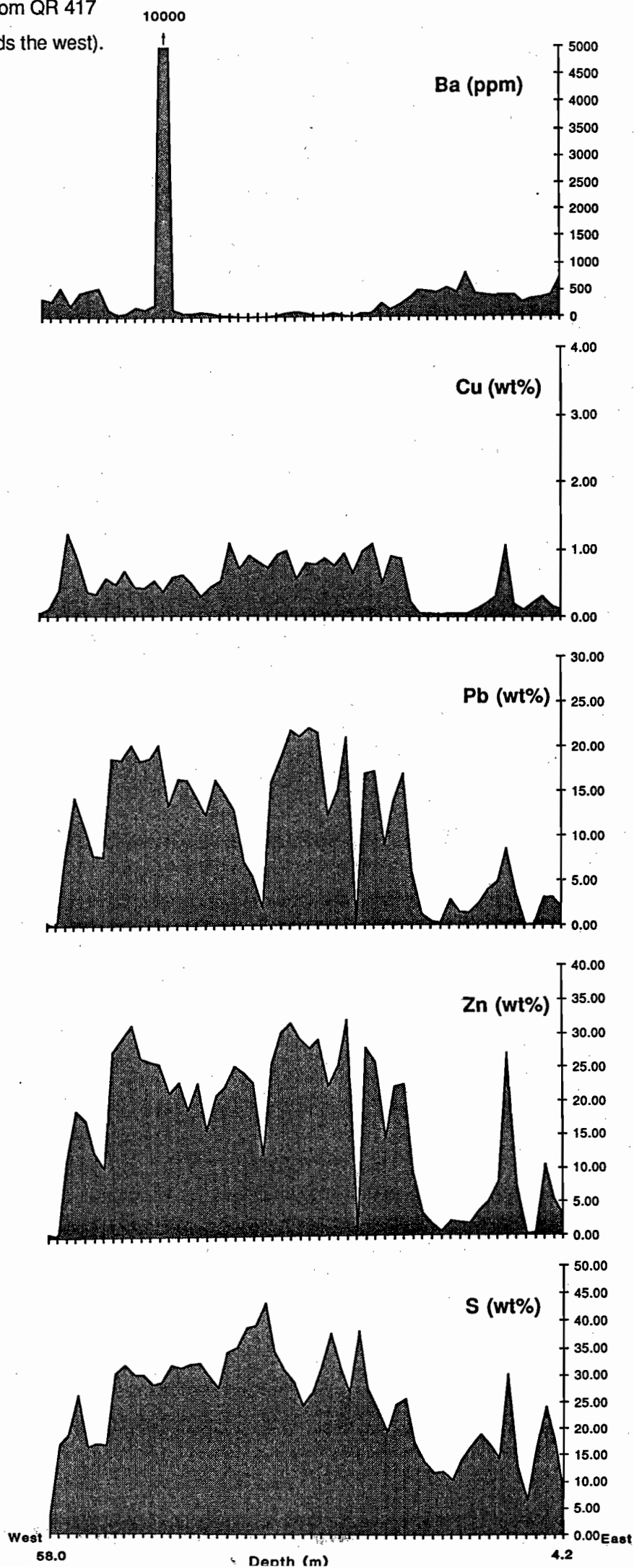


Fig. 5 Geological section from 7550 N, Que River Mine, showing the extent of alteration beneath the massive sulphide.

Fig. 6 Down hole element variations from QR 417
(hole was drilled from east towards the west).



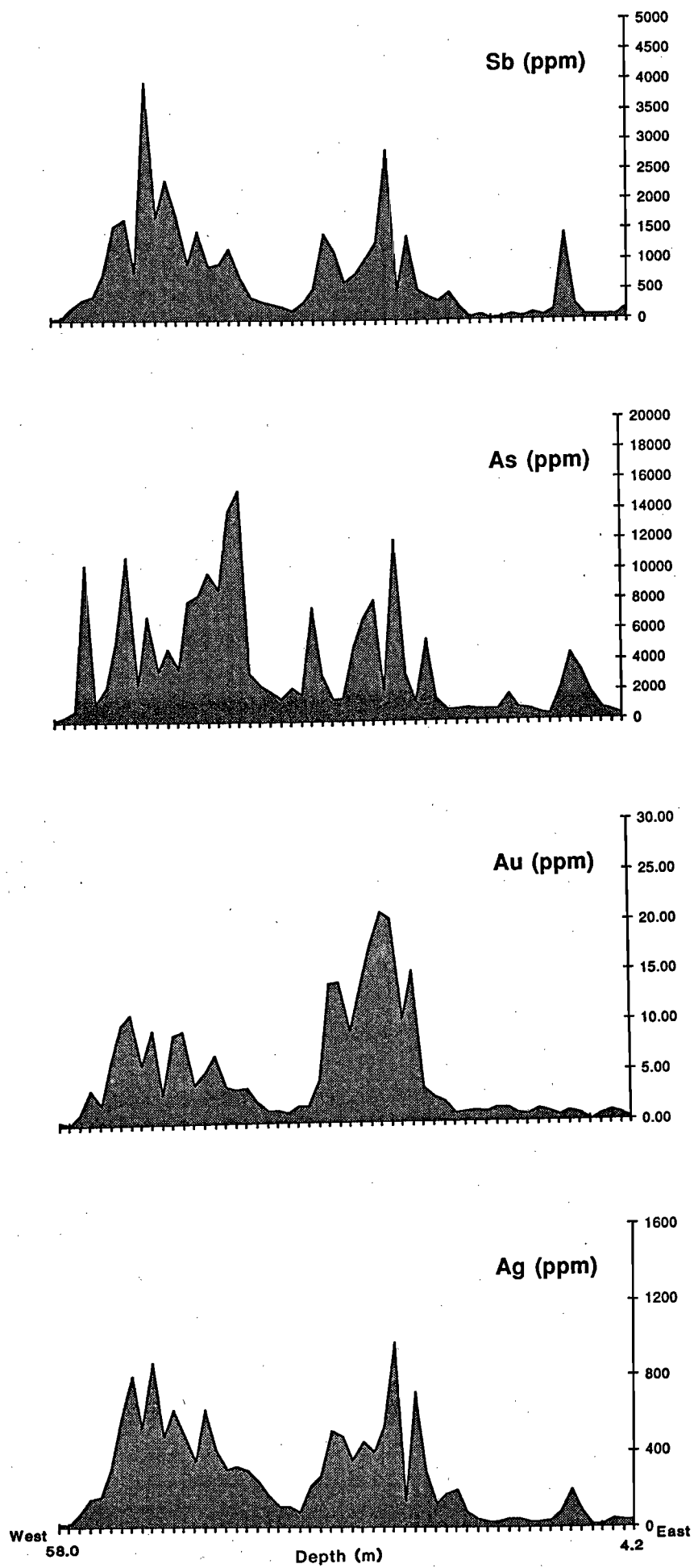


Fig. 7 Down hole element variations from QR 405 (hole was drilled from east towards the west).

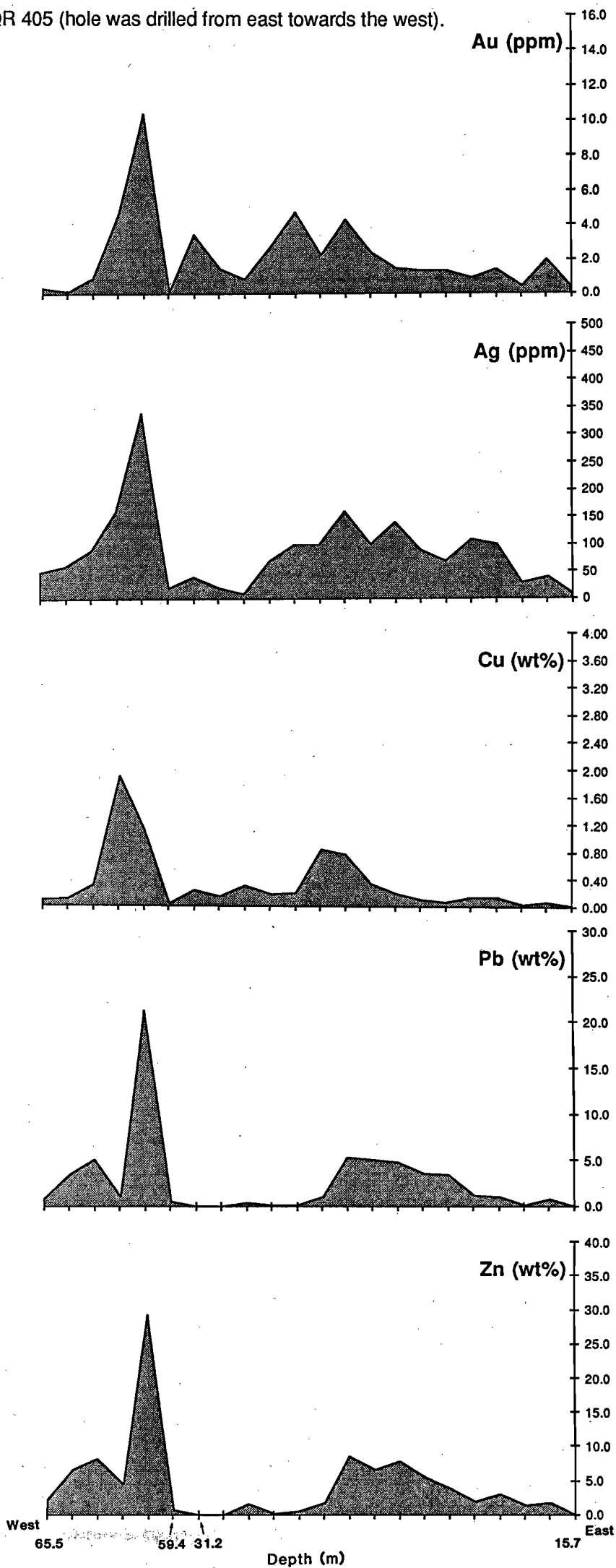


Fig. 8

Down hole element variations from QR 278 (hole was drilled from east towards the west).

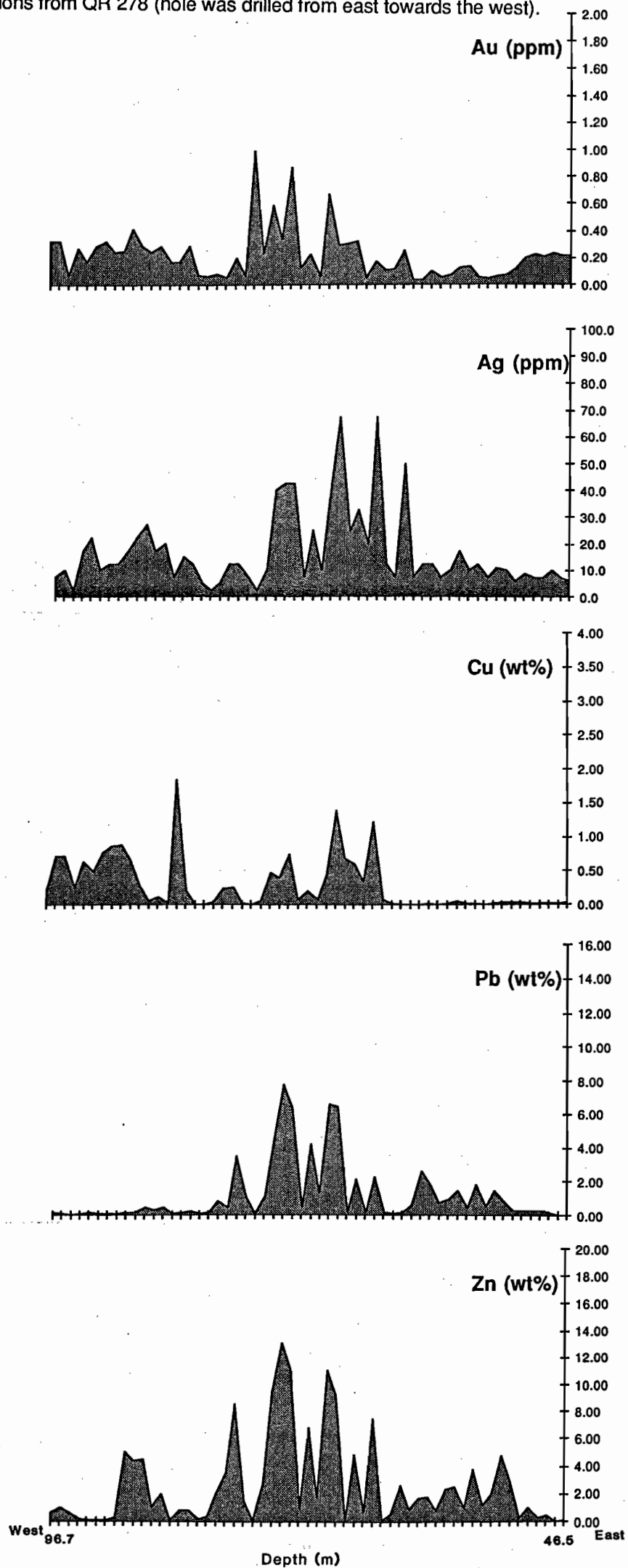


Fig. 9 Down hole element variations from QR 631

(hole was drilled from east towards the west).

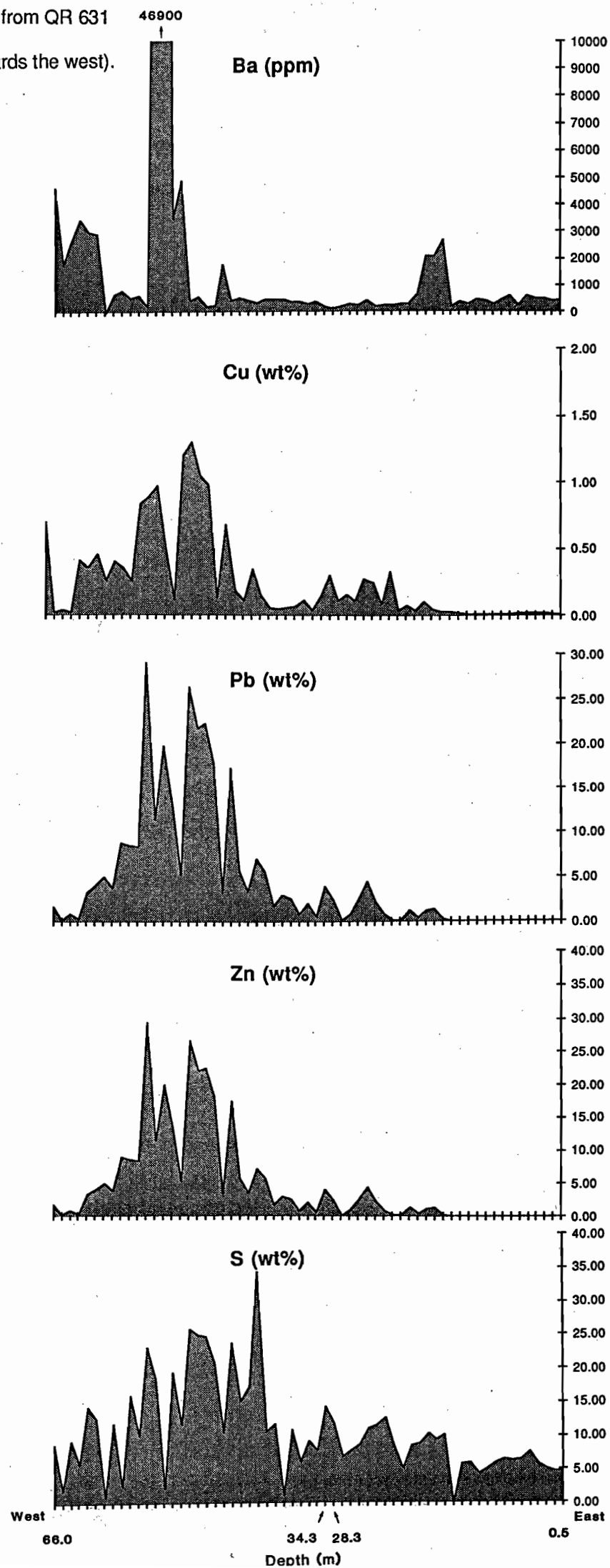
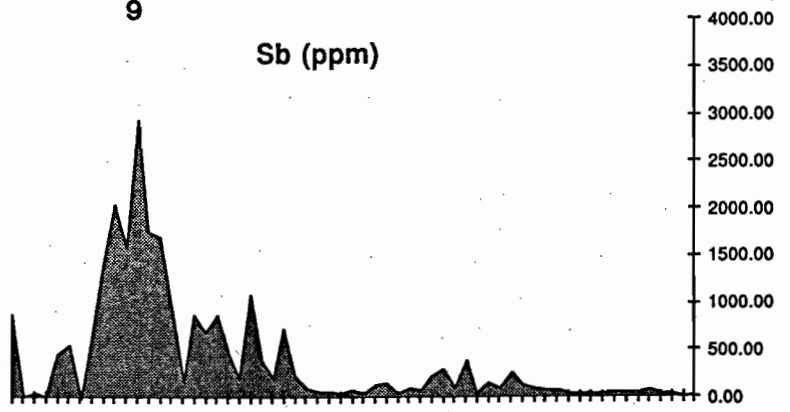


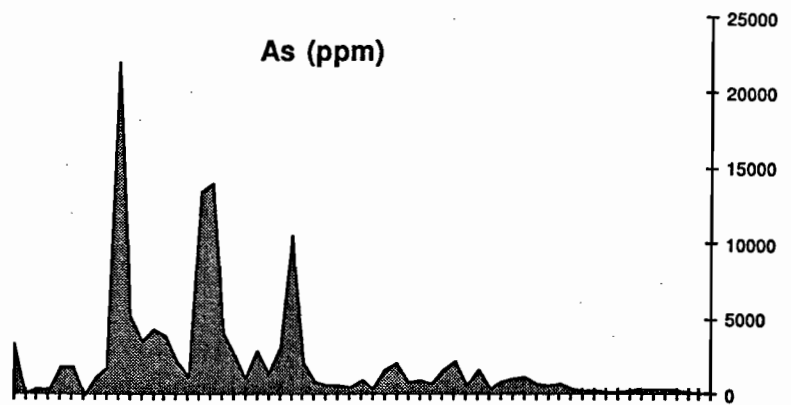
Fig. 9 cont.

9

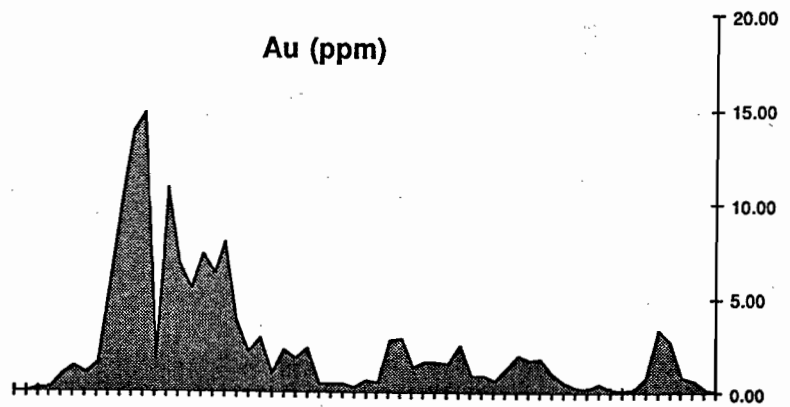
Sb (ppm)



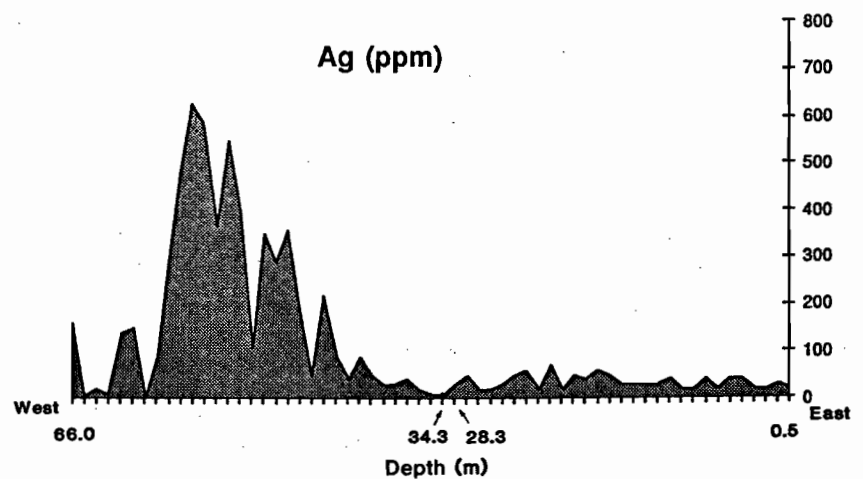
As (ppm)



Au (ppm)



Ag (ppm)



ANTHONY ROAD NORTH EXCURSION

AR1. Murchison Volcanics: Mineralised Rhyolite.

This exposure is a 20-30 metre thick fine grained silicified ?rhyolite lava. At this locality the Henty Fault is about 1km to the west. The unit is sheared and faulted in places. There is disseminated mineralisation (mainly pyrite) throughout the unit. This mineralisation is concentrated in sheared zones (?volcaniclastic layers) within the lava, although it is weakly pervasive throughout the entire unit.

Tension gashes filled with a Qtz-K feldspar-tourmaline assemblage occur throughout the unit, especially to the north-east of the exposure. These are related to Devonian deformation (and ?granites), and are significantly later than the mineralisation.

AR2. Murchison Volcanics: Quartz Porphyry Intrusive.

This unit is a high level intrusive body. The outcrop extent is about 400 metres as the road here is subparallel to regional strike. True thickness is probably much less. The unit is quartz-phyric throughout, and is quartz-feldspar phyric towards the base (south). Hydrothermal breccia zones up to 20cms thick occur in places. These contain fragments of the intrusive rock in a chloritic groundmass.

AR3. Murchison Granite:

This outcrop is in the "centre" of the body. The rock is a medium grained granodiorite. The mineralogy is dominantly quartz - K feldspar-plagioclase-hornblende-biotite. The granite has been altered by regional metamorphism; plagioclase --> sericite + clay, biotite + hornblende --> chlorite.

The granite is strongly magnetic. Whether the magnetite is primary, or due to alteration is being examined. At this stage it is suggested that the magnetite is primary.

AR4 Murchison Granite: Aplite Dykes.

These dykes are abundant towards the top of the intrusive body. The pink colour is due to very fine grained hematite pervasive through the K-feldspar. The contacts of these dykes are usually sharp.

The mineralogy is dominated by quartz and K-feldspar, with some plagioclase and chlorite (after biotite).

AR5 Murchison Granite: Dykes and Alteration.

There are two basic rock types to be observed here. The pink dykes are similar to those at the previous locality. The contact of these dykes have some interesting textures associated with them. They appear pod-like, with 'blobs' of aplite forming in the fine grained green rock.

The green rock at this locality is interpreted as an extremely altered phase of the Murchison Granite. In outcrop the rock is mainly textureless, though in thin section this is not the case. Phenocrysts of euhedral zoned plagioclase crystals occur throughout, and are visible in outcrop to the south of the exposure. These plagioclase crystals are beautifully zoned, probably indicating a magmatic origin. The groundmass of the rock is dominated by fine grained recrystallised quartz, with some chlorite and feldspar. The rock has been strongly silicified under conditions such that the entire rock, excluding the original zoned plagioclase, has been broken down and recrystallised.

AR6. Cambrian-Ordovician Unconformity:

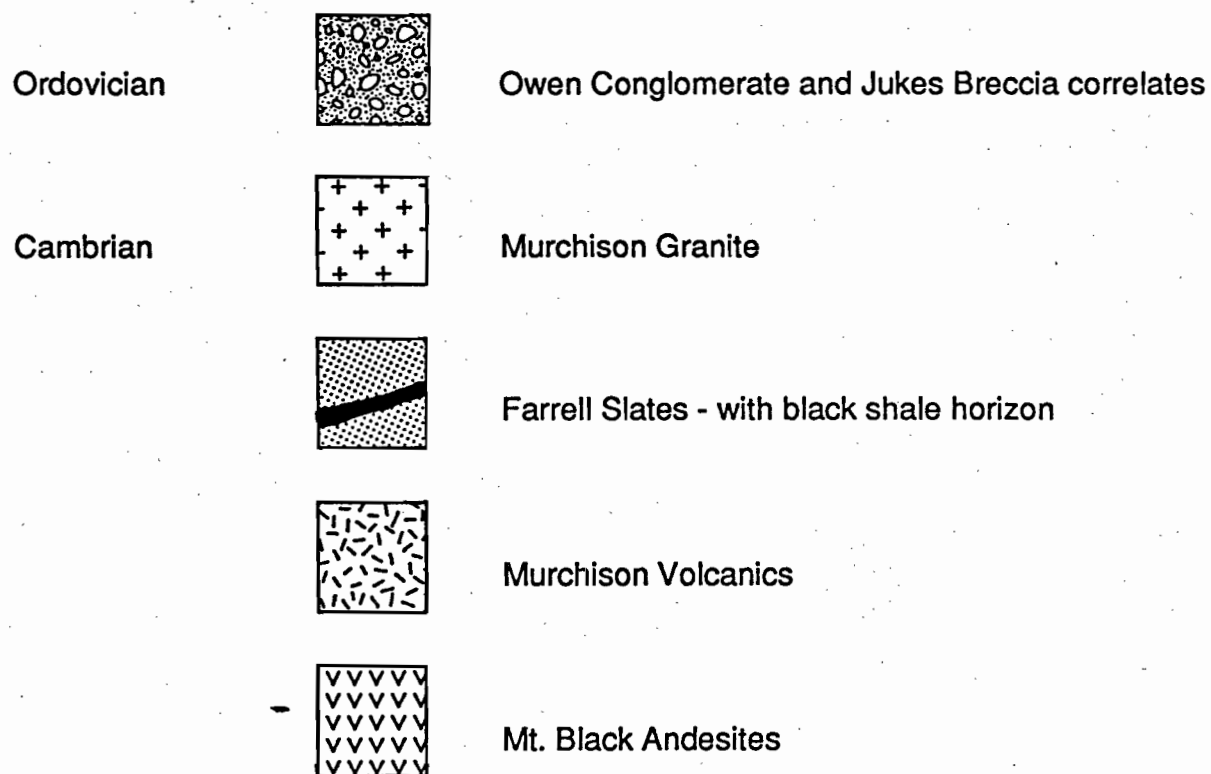
The contact in this exposure is between cleaved Cambrian volcanics and relatively flat lying Ordovician Owen Conglomerate. Post Owen faulting has caused a vertical displacement of the contact to the right of the outcrop. Some quartz veining is associated with this fault. The unconformity surface south of the fault is irregular, possibly folded.

The volcanics underlying the Owen Conglomerate are purple in colour, due to a high hematite content. This may be due to exposure at the surface prior to deposition of the Owen, or may be hematite leached from the adjacent conglomerates since deposition.

Interpreted Geology Of The Sterling Valley Area



0 1 2km



Note: Quaternary deposits have been omitted for clarity.

 Prospects

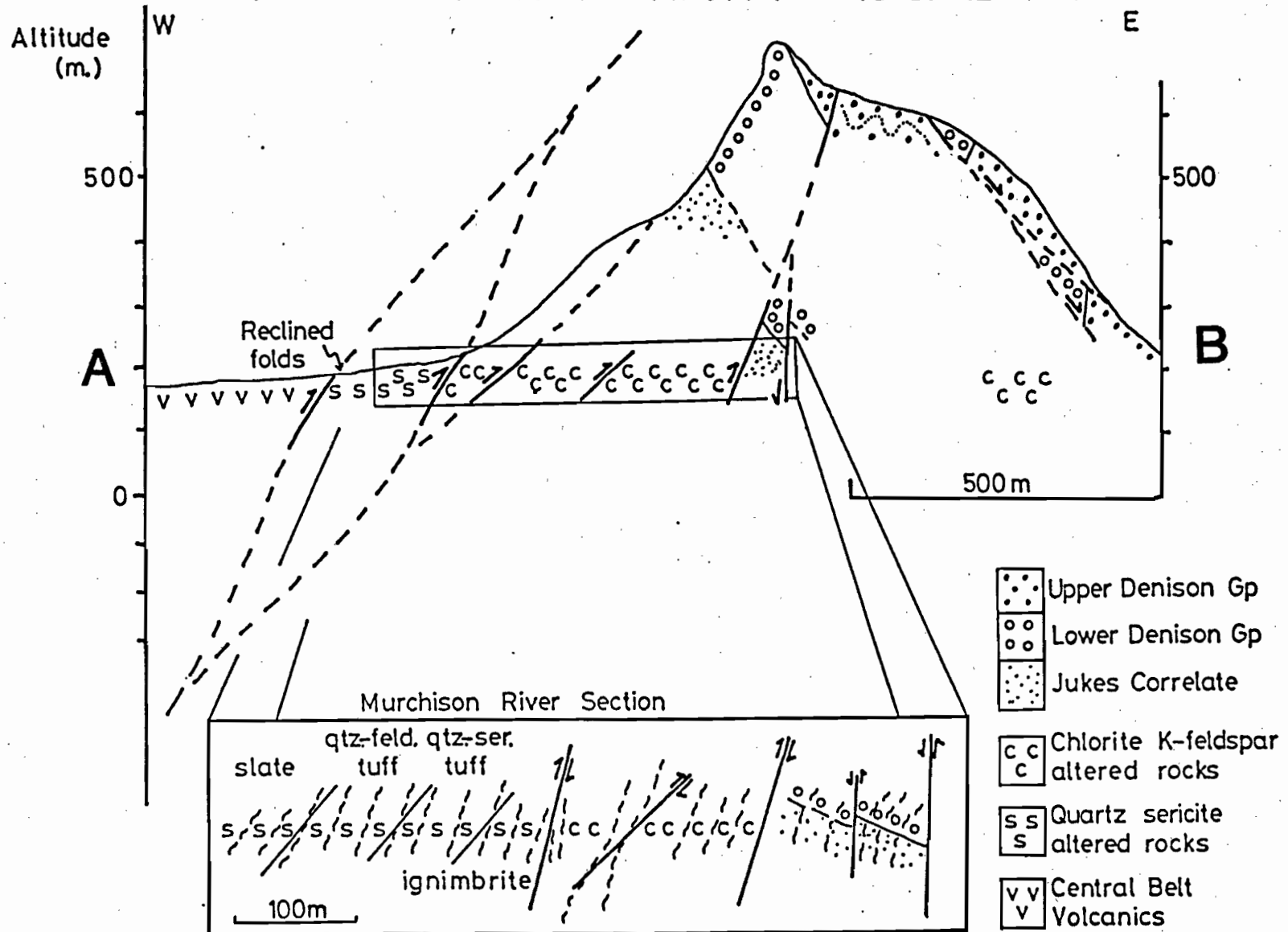
 Drillholes

Figure 1: Interpreted Geology Of The Sterling Valley Area, Western Tasmania.

compiled from field work by A. McNeill, D. A. Polya and I. F. Gordon.

drawn by I. F. Gordon 1986

CROSS SECTION OF HENTY FAULT ZONE



R. Berry

