97-4071

270001

ABERFOYLE RESOURCES LIMITED

ZEEHAN TIN DEPOSITS

TASMANIA

97-4071

ABERFOYLE RES.LTD - ZEEHAN
TIN PROJECTS - RL 9705
C H YOUNG

Prepared by: C H Young
April 1990

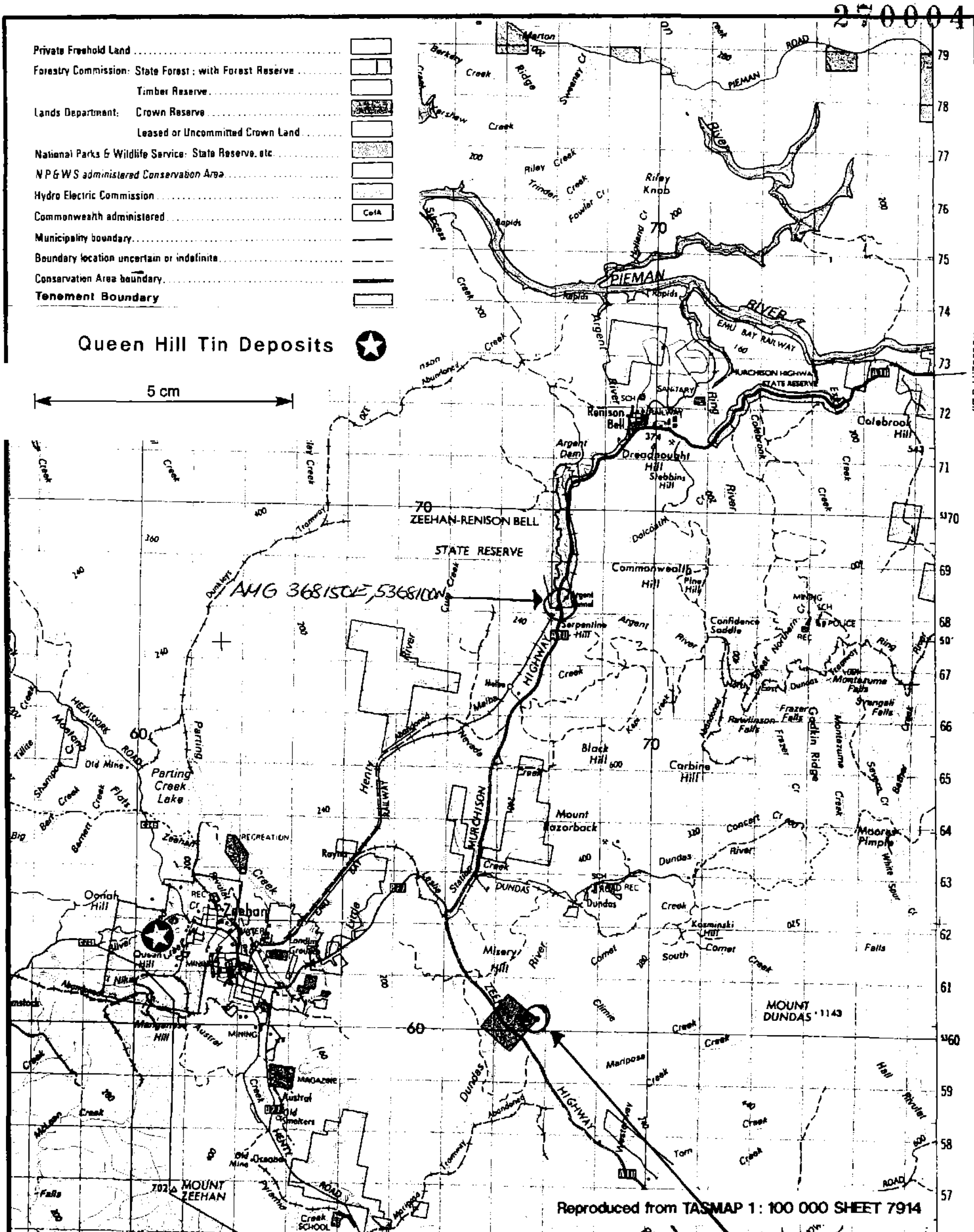
AMG REFERENCE POINTS ADDED

270002

TABLE OF CONTENTS

LIST OF PLATES

270004



Aberfoyle Resources Limited

AMG 367850E, 5360220N

EXPLORATION DIVISION

AMG REFERENCE POINTS ADDED

North West Tasmania

ZEEHAN TIN DEPOSITS
LOCALITY PLAN AND LAND TENURE

Compiled :	CHY
Drawn :	
Traced :	JAB
Checked :	GLC
Plate No. :	QH 251

Location Code :

Scale : 1:100,000

Date : APRIL 1990

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Fig. 1

1. INTRODUCTION AND SUMMARY

1.1 Location

The Zeehan tin deposits are located in the vicinity of Queen Hill at the western edge of the town of Zeehan in western Tasmania. Zeehan is situated between the Renison Bell tin mine 13 km to the NW and the Mt Lyell copper mine some 45 km to the SW (Figure 1).

Renison Goldfields Consolidated Ltd is mining and treating sulphide-cassiterite ores from an underground operation at Renison and tin production has reached an all time high of 7,800 tonnes per annum.

1.2 Tenure

The property consists of CML 36M/81 of 564 ha. which was granted for 21 years from 1st August, 1981. The tenement is registered in the names of Aberfoyle Exploration Pty Ltd and Gippsland Oil and Minerals NL. Exemption from the labor covenant of 141 men is current.

The tin deposits are situated centrally within the tenement and also within the boundaries of the town of Zeehan.

Aberfoyle manages the Zeehan project in accordance with the Aberfoyle/Gippsland Oil and Minerals joint venture agreement. Aberfoyle may earn up to 70% equity in the project by completing an acceptable feasibility study. A written commitment by an acceptable institution, to lend not less than half of all costs to be met by Gippsland for the development is essential to acceptance. Costs during development shall be born according to equity. On commencement of production, 75% of Aberfoyle expenditure on behalf of Gippsland after project expenditure of $153,000 and up to completion of the feasibility study, will be reimbursed from proceeds of the mining operation, provided that Gippsland borrowings are repaid first. Simple interest on the above expenditure is credited to Aberfoyle.

Aberfoyle's expenditures on the project towards the Zeehan Joint Venture to April 1990 total $2,851,095.

1.3 Mining History

The Zeehan silver-lead mining field was discovered in 1882 and worked until about 1913. The most productive area was covered by the Western, Montana, Oonah and Queen leases, immediately to the north west of

Zeehan. Production from the field totalled 2.7 million ounces of silver and 200,000 tonnes of lead. There is little information on small scale prospecting and mining in the area after the main mines closed.

Henderson reported the discovery of cassiterite on the north-west slope of Queen Hill in 1937 and Hill and Blisset (1961) mention that in about 1938 the area was worked by Zeehan Tin Development NL. In 1960 the Queen Hill area was being worked and prospected for cassiterite in an open-cut and adits known as the Stormsdown Mine. Exploration activities in the Zeehan field were renewed in the 1960's and several lodes in the Queen Hill area known for their silver/lead content were found to contain small amounts of tin.

The Queen Hill cassiterite-sulphide mineralisation had been cut by adits running into the adjacent Clarkes Lode, but the extent of the mineralisation and its tin content were not recognised until exploration by Gippsland Oil and Minerals NL, which commenced in 1969.

In late 1970 and during 1971, Gippsland completed 10 diamond drill holes. The first hole, G1, intersected cassiterite in massive pyrite and pyrrhotite, as did G3 and G4. Aberfoyle recognised the apparent conformable nature of the mineralisation with a volcanic/shale contact and possible relation to the Cleveland mine style mineralisation.

Following negotiation of a joint venture agreement with Gippsland Aberfoyle took over management and commenced drilling in August 1971.

It was soon realised that the Queen Hill deposit had metallurgical problems, due to the very fine grain size of the cassiterite (average 20 microns). Stannite mineralisation also contributed to poor recoveries.

Exploration and development drilling continued hand in hand with metallurgical research culminating in the delineation of the Zeehan tin deposits and the successful application of matte fuming.

1.4 The Zeehan Tin Deposits

By June 1982, 89 diamond drill holes totalling 23,004.56 m were completed. On the basis of this drilling a total inferred resource using 0.1% Sn cut-off was 7.3 million tonnes @ 0.69% Sn which includes 3.6 million tonnes @ 1.21% Sn. This resource comprises three separate zones of mineralisation known as Queen Hill, Severn and Montana (Figure 2).

From late 1982 major work on the CML comprised re-assessment of data and re-logging of drill core by J A Anderson and accompanying petrographic and isotopic studies as part of his PhD research of the

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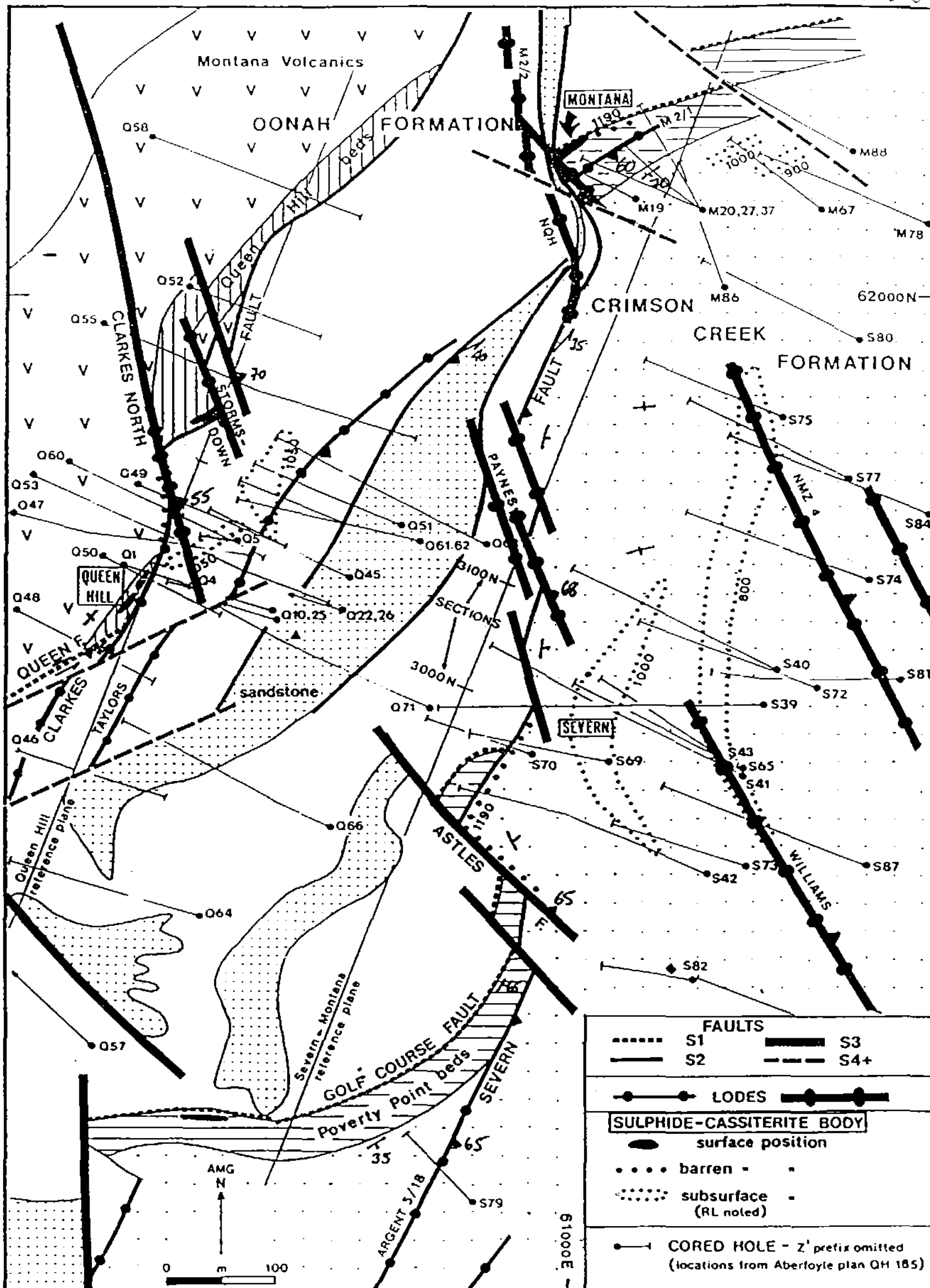

Aberfoyle Resources Limited

EXPLORATION DIVISION

REVISIONS				NORTH WEST TASMANIA ZEEHAN DEPOSITS SURFACE STRUCTURE & PROJECTION OF MINERALISATION	Compiled : JAA
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Zeehan tin field. Anderson has provided substantive evidence of a cupola locus and a structurally controlled and vertically zoned hydrothermal system for mineralsation forming the tin deposits.

Two diamond drill holes completed in 1989 (DDHs ZS 91 and 92) helped define possible mineralisation limits in the area south of Severn.

Results of the research and the recent drilling form the basis of a renewed exploration effort with potential to at least double the size of the existing resource as follows:

Exploration Potential Summary

DEPOSIT	DEPTH METRES	POSSIBLE HIGH GRADE RESOURCE
* Severn Deep	500-800	2.5 - 5 Mt
* Queen Hill Deep	200-500	2.0 - 5 Mt
Montana Deep (Hangingwall Poverty Point Beds)	200-500	0.5 - 1.0 Mt
* Golf Course Deep (Footwall Poverty Point Beds)	50-600	0.5 - 1.0 Mt
* Other Favourable structural positions/ hydrothermal core (Figure 7)		0.5 - 5 Mt

1.5 Metallurgy

Since discovery, metallurgical testwork has incorporated gravity, sulphide and cassiterite flotation, pressure leaching and matte fuming. Before 1980 all testwork was concentrated on samples from near surface of the Queen Hill deposit. More recent work has focussed on ore characterisation on exploration drill core. Significant differences in metallurgical characteristics were confirmed. These differences relate to grain size and sulphide concentration:

ORE SOURCE	D50 UM*	SULPHIDE CONCENTRATION
Severn	65	20 - 50%
Queen Hill Upper	14	50% (some base metals)
Queen Hill Lower	21	30%
Montana	31	50%

*D 50 um is the screen size in microns through which 50% of the grains will pass.

Matte fuming is a proven technology for upgrading Queen Hill Upper material (an 88% recovery to a 30% Sn concentrate was achieved from a head grade of 0.7% Sn during matte fuming pilot plant trials utilising a 2,200 tonne bulk sample) however it is not economic at the low head grade tested. Pre-concentration is required to achieve an economic feed grade to matte fuming.

A new processing philosophy emerged - an integrated "unstressed" circuit incorporating sulphide flotation, gravity and cassiterite flotation circuits with final concentrate upgrading by matte fuming.

Laboratory tests show that using this processing route overall recoveries greater than 75% are possible.

SIMPLIFIED GEOLOGY OF ZEEHAN DISTRICT

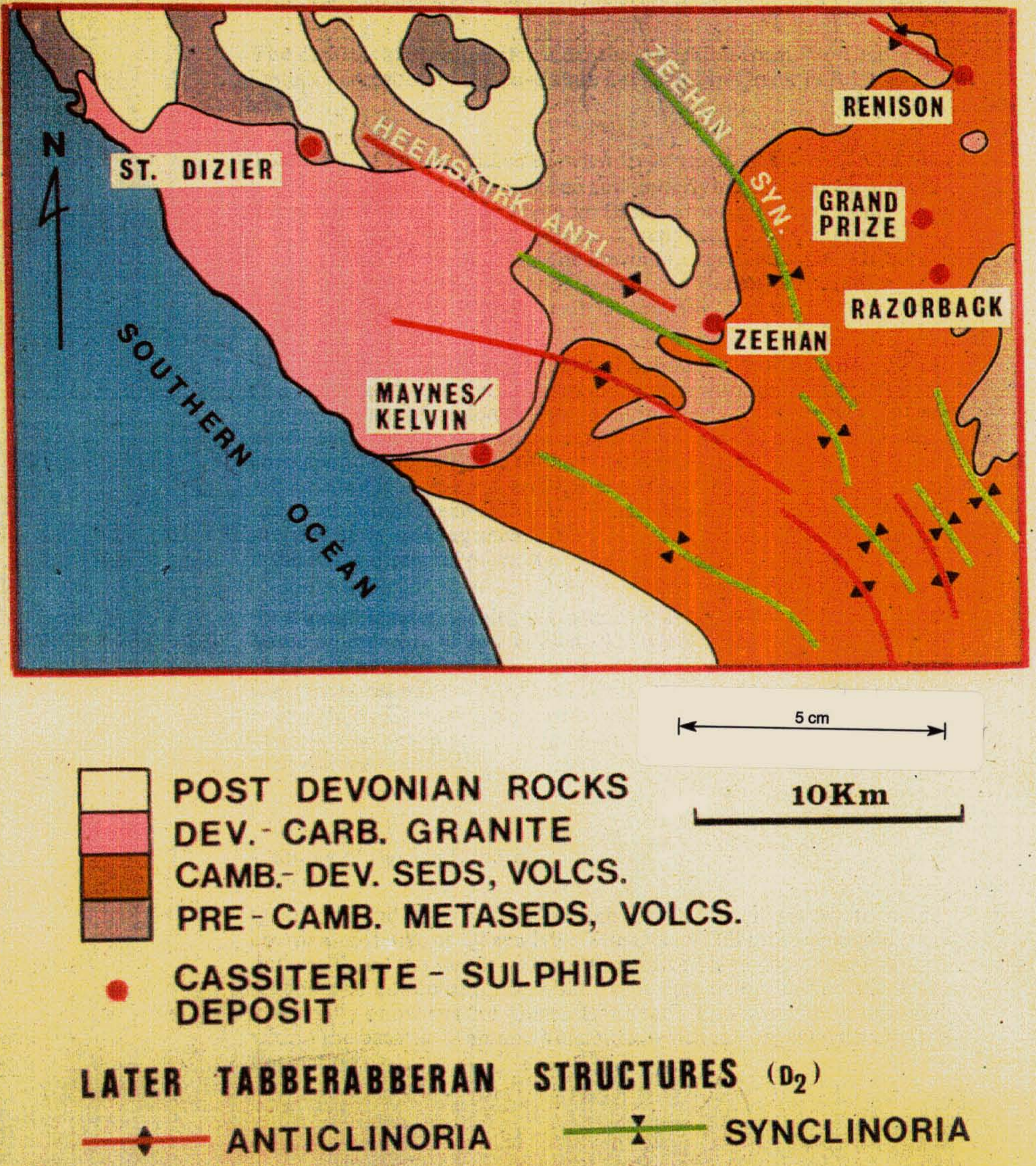

Fig. 3

2. GEOLOGY

2.1 Regional Geological Setting

The Zeehan tin deposits comprise three undeveloped bodies of sulphide-cassiterite mineralisation clustered beneath the flanks of Queen Hill. The Severn deposit contains most of the resources. Both Montana and the Golf Course Lode are stratabound within dolomite.

The deposits are located at or near the transition from Pre-Cambrian Oonah Formation to the eo-Cambrian Crimson Creek Formation (Figure 3).

To the NE of Queen Hill, in the vicinity of the Zeehan town dam, there is Ordovician Gordon Limestone and underlying the majority of the Zeehan townsite, Siluro-Devonian Eldon group sandstones and siltstones. The McIvor Hill Gabbro of supposed Cambrian age is situated 3 km SW of Zeehan and the Devonian age Heemskirk Granite outcrops 7 km to the west. An apophysis of the Heemskirk Granite is believed to lie about 1 km beneath Queen Hill.

The structure of the Queen Hill area is complex, with intense folding and faulting on all scales believed associated with the Tabberabberan Orogeny, a major period of deformation. Early folds are isoclinal, with north-easterly plunging and steep SE dipping axial planes. The planes correspond to the attitude of the major lithological units and a series of NE striking faults with steep SE dips. This is the orientation of most of the lodes in the Queen Hill area. Minor folds plunge SE with associated more easterly striking shear faults. Faults also occur striking SSE which is the strike direction of most of the fissure lodes in the Zeehan field.

Stratigraphic relationships at Queen Hill as presently understood are based on the work of A V Brown 1986, Geological Survey Bulletin 62 and J A Anderson's PhD research. These relationships, which involve the uppermost units of the Oonah Formation and the unconformably overlying eo-Cambrian Success Creek Group and Crimson Creek Formation, involve a juxtaposition of stratigraphic units related to a wrench fault regime.

2.2 Geology of the Tin Deposits

Quartzites and slates of the Precambrian Oonah Formation form the crown and flanks of Queen Hill. The Queen Hill mineralisation crops out weakly on the western side of the hill and is superimposed on a sequence of dololutites, sideritised evaporites, cherts and pyritic shales, informally known as the 'Queen Hill Beds'. This sequence is enclosed within the basaltic Montana Volcanics, which are coeval with the Oonah Formation.

SIMPLIFIED GEOLOGICAL COMPILATION

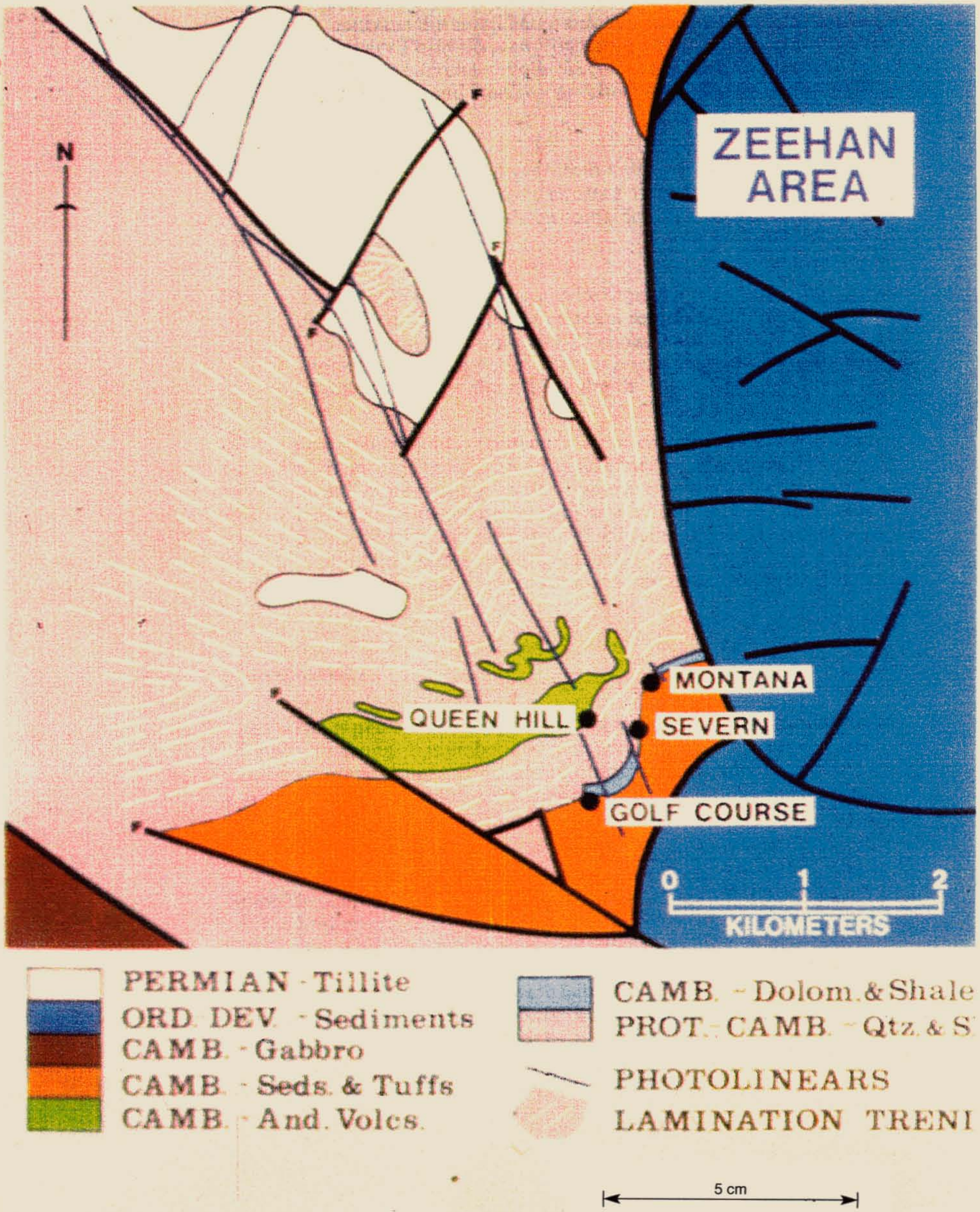

Fig. 4

Volcaniclastic sediments of the Crimson Creek Formation are the main host of the Severn mineralisation in the hanging wall of the Severn Fault zone above a pseudo-conformable contact with the Oonah Formation. A sequence of massive dolomites and psammo-pelites, the Poverty Point Beds, contains the small Montana deposit and the Golf Course Lode. The Povery Point Beds conformably underly the Crimson Creek Formation and are correlated with the Success Creek Group, which embraces the stratabound Renison pyrrhotite-cassiterite deposits (Figure 4).

Although the only confirmed granitoid in the vicinity of Zeehan is a dyke of quartz-feldspar porphyry situated 1 km E of Queen Hill, a cupola model is supported by three coincident features centred on the hill:

(i) The known sulphide-cassiterite deposits
(ii) A 2 x 4 km Rb anomaly in stream sediment samples
(iii) A broad magnetic anomaly ('Zeehan anomaly'). The preferred model for the magnetic source is a contact metamorphic aureole above a cupola at about 1 km depth

Granitoid emplacement is controlled by intersecting NNE-NW fractures, which become the channelway and loci of subsequent hydrothermal mineralising fluids. These are now represented by N to NW-oriented stannite-pyrite veins of which the Clarke's Lode is the best example. Intersection of these easterly-dipping feeder fractures with the N or E striking host sequences, produce the short tabular morphologies and NE-E plunges of the known sulphide-cassiterite deposits (Figure 5).

2.3 Mineralisation

Cassiterite is present as fine-grained disseminations with modal ranges of 20-70 microns. It is embedded in stockworks and masses of fine-grained gangue comprising siderite, chlorite, silica, pyrite and pyrrhotite with variable accessories of sericite, sellaite, tourmaline, topaz, fluorite, phlogopite, apatite, stannite, base metal sulphides and silver sulphosalts.

Sulphide contents of 30-50% and densities in the range 3.3-3.9 are usual for the higher-grade zones, decreasing to 5-30% in the lower-grade envelopes. Although pyrite is the dominant sulphide, micro-textural evidence demonstrates that a major pyrrhotite component was substantially replaced by pyrite and marcasite. The resulting magnetic susceptibilities are greatly variable. Only the pyrrhotitic core of the Severn body retains broad magnetic zones, including cored intervals of 1-5 m with magnetic susceptibilities exceeding 25,000 x 10^{-6} SI units. Stannite is present locally in the upper parts of the deposits.

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ORIENTATION OF THE ZEEHAN LODES

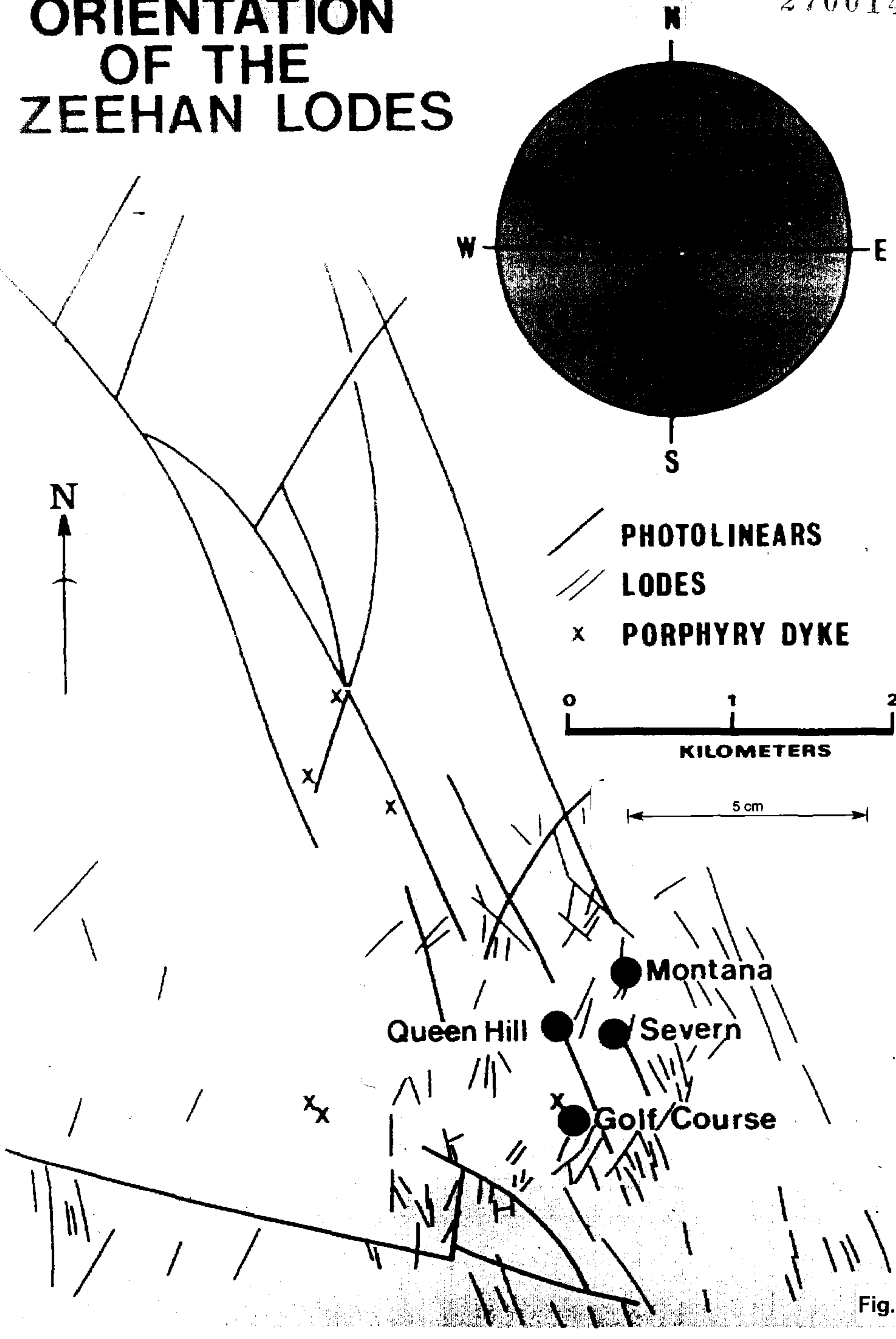

Fig. 5

2.4 Potential

The Severn mineralisation occurs as several parallel and pseudo-conformable lenses of bedding-slip replacements and stockworks within a 130 m wide drag zone in the hangingwall of the Severn Fault zone (Figure 7). This fault zone has an en-echelon pattern based on two fracture sets at 030 degrees and 330 degrees as shown on Figure (6). The mineralisation peaks at the intersections (dilational jogs) of the two fracture sets.

There is a vertical and paragenetic sequence from deeper/ earlier sellaite chlorite pyrrhotite pyrite cassiterite replacement of stockwork-style mineralisation at the Severn deposit, to pyrite stannite + /- cassiterite lodes (eg Stormsdown Lode - Figure 8) and then to slightly younger and shallower siderite sphalerite galena lodes. This and the low temperature mineral assemblage demonstrates that only the top of the Severn cassiterite system has been intersected to date (Figure 7).

Within the deposits zoning to higher grade, coarser cassiterite mineralisation can be expected as deep as granitoid or skarn development at about 1 km below the surface, ie 500 m below the deepest drilling.

At Montana sulphide-cassiterite mineralisation also replaces dolomites of the Poverty Point Beds (correlate of the Success Creek Group. ie host to the Renison mineralisation), which have an apparent strike slip displacement of 500 m across the Severn Fault zone.

Renison-style mineralisation may replace dolomite where the Poverty Point Beds are dragged against the Severn Fault, especially at deeper levels within the hydrothermal system. Near surface, replacement mineralisation in dolomite (Golf Course Lode) is weak but this environment is encouraging for economic developments at depth (Figure 2).

At Queen Hill spatial and paragenetic zoning indicates the deposit lies at the transition from replacement to distal lode style mineralisation. Fluid temperature determinations confirm the deposit is situated at the very top of a hydrothermal system with obvious potential for a major sulphide-cassiterite deposit at depth.

In the known deposits and indeed for those yet to be discovered, tin mineralisation appears to peak where 'dilational jogs' coincide with favourable stratigraphy. Research work by J A Anderson has demonstrated abundant depth potential. Economic drill intersections are likely where structural/stratigraphic targets are tested at depth (Figures 6, 7, 8 and 9).

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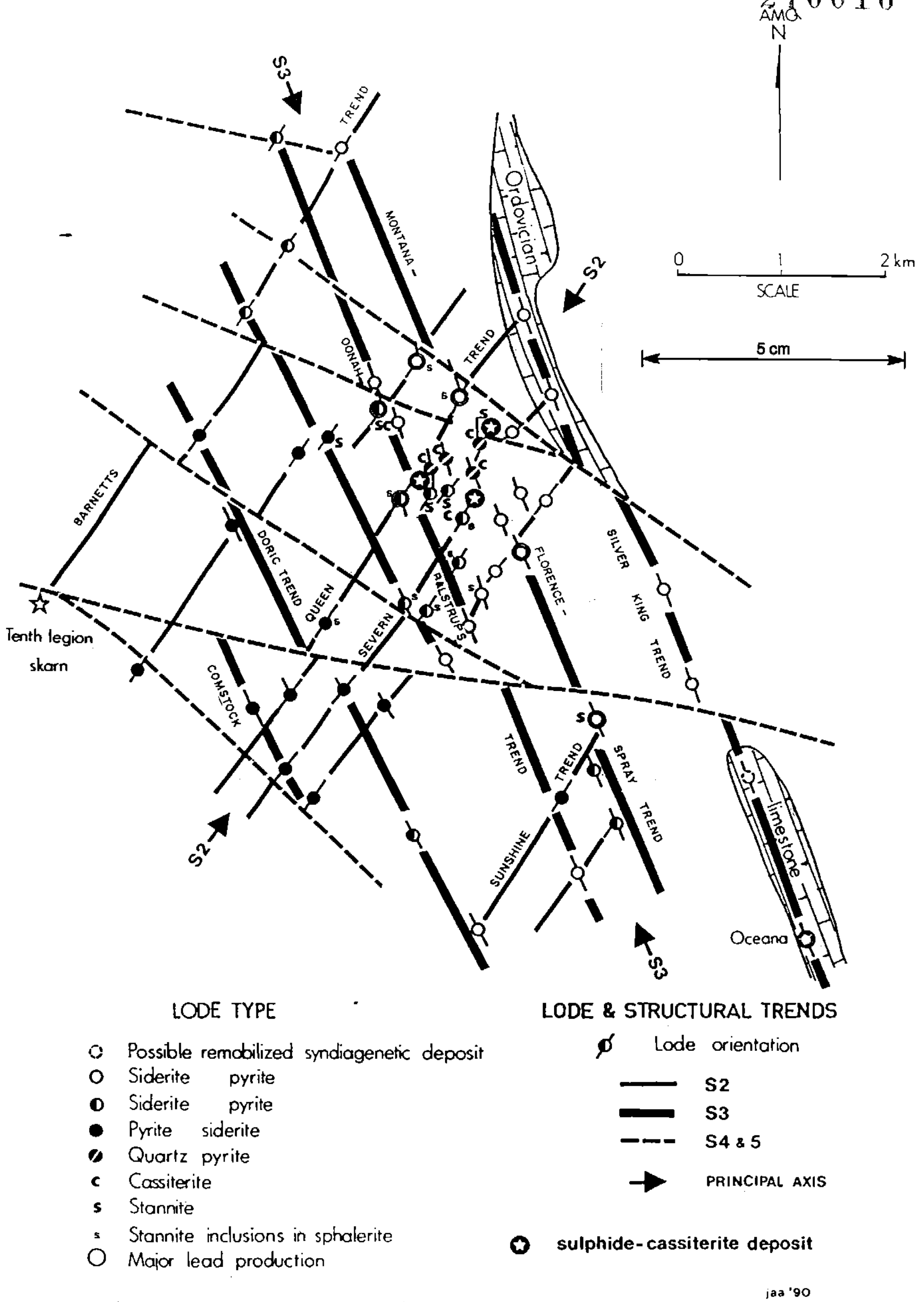
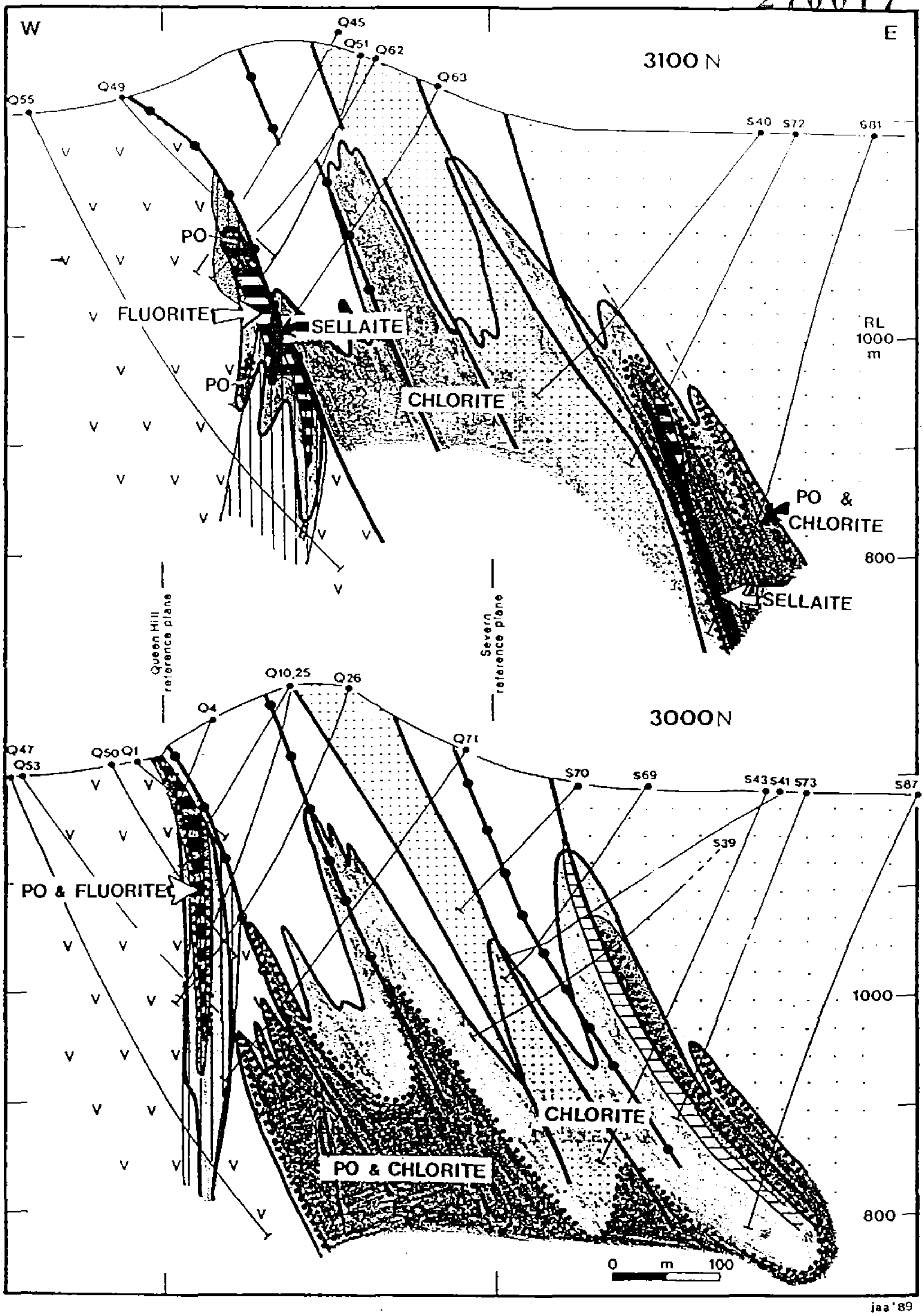


ZEEHAN AREA
Lode and Structural Trends

Fig. 6



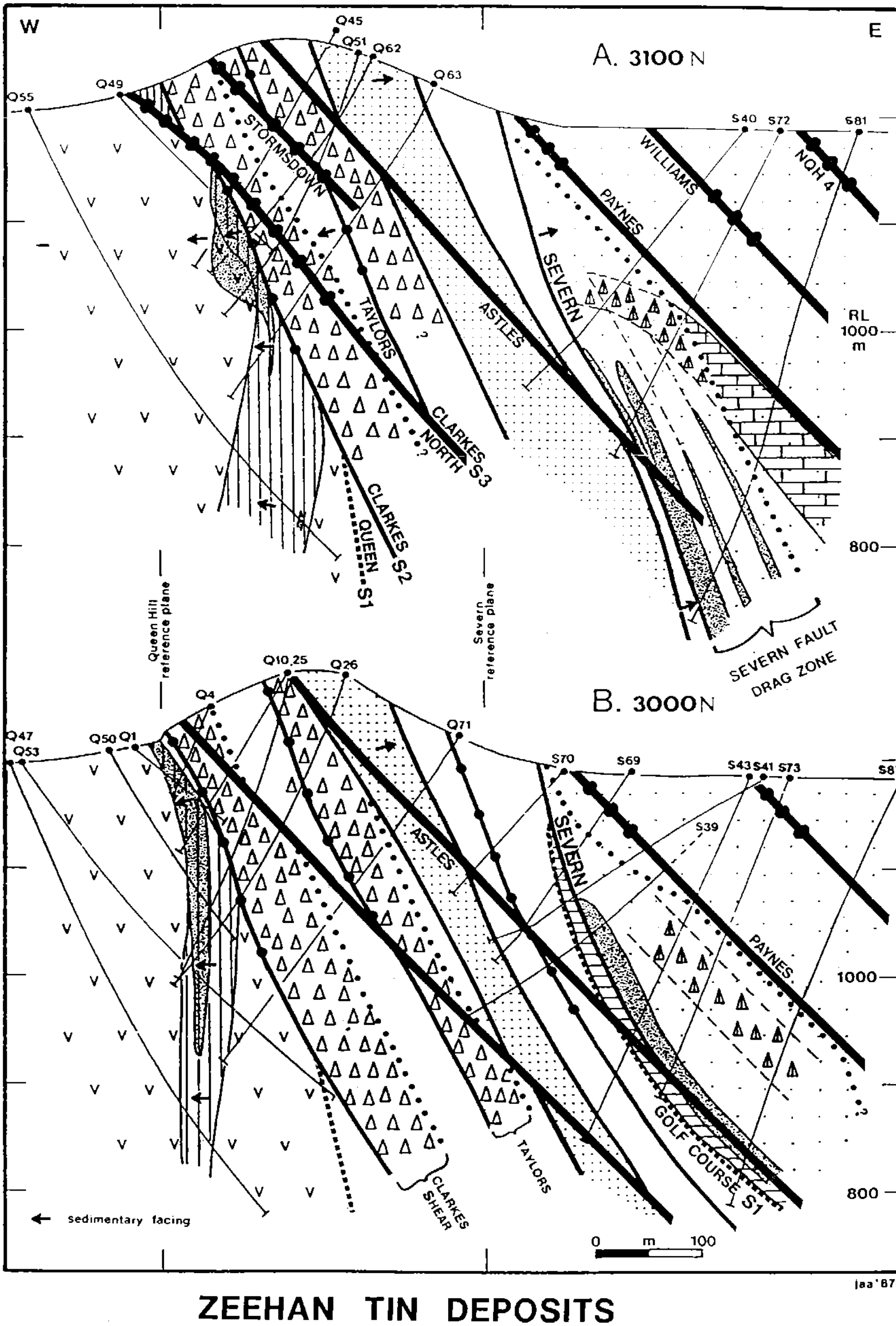
ZEEHAN TIN DEPOSITS

Alteration mineral Assemblage

5 cm

Fig. 7

270018



ZEEHAN TIN DEPOSITS

Idealised Structural Cross Sections

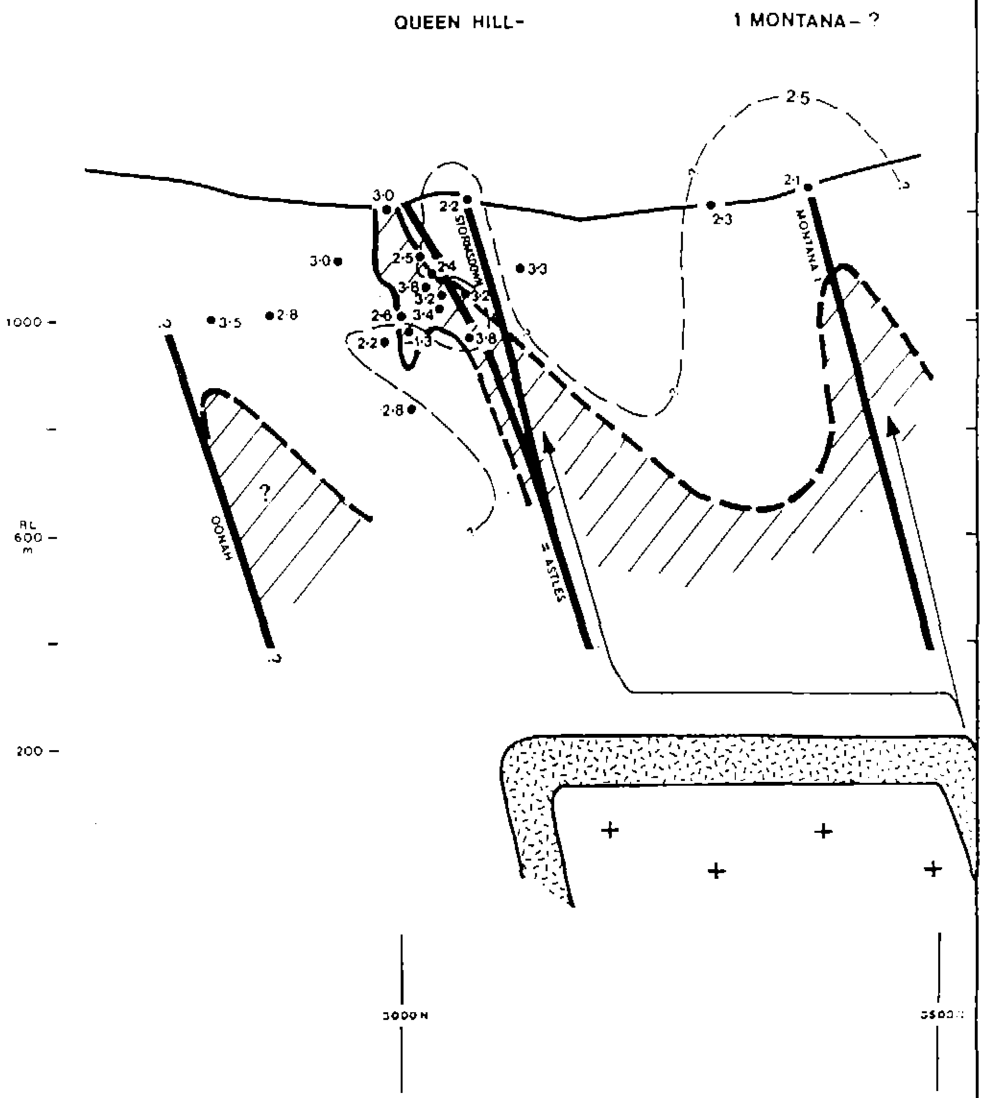
5 cm

Fig. 8

EXPLANATION

AT [illegible], FLUID SULPHUR IS MAGMATIC WITH [illegible] APPROXIMATELY ZERO. ON MIXING WITH [illegible] SULPHUR PROGRESSIVELY AWAY FROM THE [illegible]. $\delta^{34}S$ GRADUALLY INCREASES FROM [illegible] FOR MEASURED SAMPLES. INTERPRETIVE [illegible] AROUND STRUCTURAL INTERSECTIONS ([illegible] PATHWAYS) ENABLES THE POSTULATION [illegible] HYDROTHERMAL HIGHS AND HENCE NEW DRILL [illegible].

5 cm



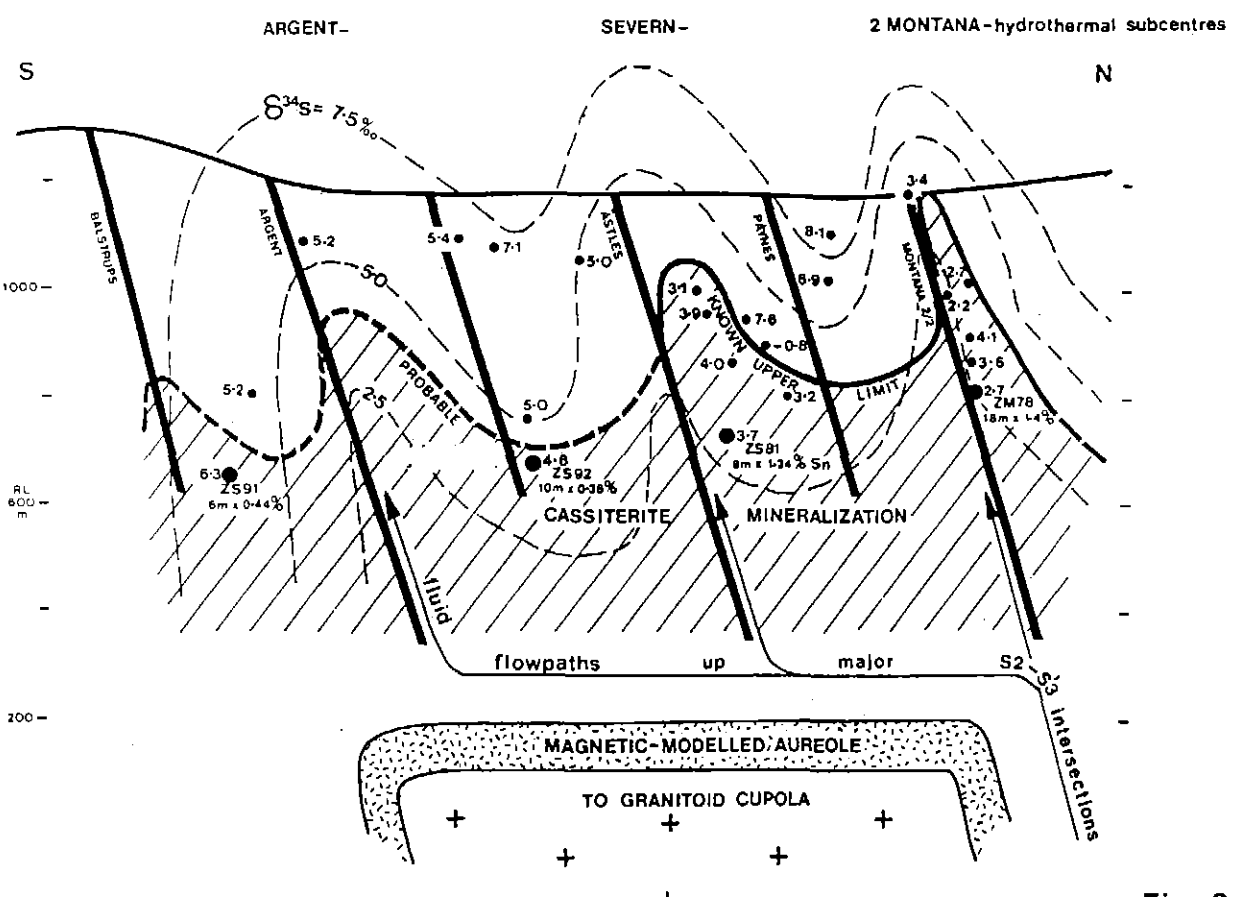


Fig. 9

REVISIONS			
Init.	Date	Init.	Date

Aberfoyle Resources Limited
EXPLORATION DIVISION

Zeehan Tin Deposits, NW Tasmania

SUMMARY LONG SECTIONS OF SEVERN AND QUEEN TRENDS

Structural and S-isotope evidence for New Drill Targets

Location Code :
Scale 1:50,000
Date : April 1990
Compiled : JAA
Drawn : 1990
Traced :
Checked :
Plate No. :

Mineralisation

Sulphide / Cassiterite

eo- Cambrian Crimson Creek Formation

volcaniclastics mudstone and shale

Poverty Point beds

evaporite
massive dolomite
psamno - pelite

Pre- Cambrian Oonah Formation

shale / slate
sandstone / quartzite

Queen Hill Beds

dololutite, sideritised evaporite, chert, pyrite shale

Montana Volcanics

basaltic agglomerite

Structure

Zone of Shearing
Limit of Shearing

Faults

S1
S2
S3
S4

Lodes

3. SUMMARY OF ORE RESOURCES

A comprehensive geological resource assessment of the Zeehan Tin Deposits was made by K G Palmer in 1982, in summary:

- Total Mineralised Envelope (0.1% Sn cut off)

Lens	Category	Tonnes x 10^6	% Sn
Queen Hill	Indicated	1.8	0.82
Severn	Inferred	5.1	0.60
Montana	Inferred	0.4	1.22
TOTAL		7.3	0.69

Within the total mineralised envelope higher grade zones are identified. These resources are:

Lens	Category	Tonnes x 10^6	% Sn	Metallurgy
Queen Hill	Indicated	0.93	1.39	20mu Some stannite
Severn	Inferred	2.37	1.11	+50mu Improves with depth
Montana	Inferred	0.31	1.45	30mu Minor stannite
TOTAL		3.61	1.21	

4. EXPLORATION

1969-1971 - Based on 1965 sampling by Placer Prospecting, which revealed 6 m @ 3.46% Sn in the No 2 adit into Clarkes Lode, tenements over Queen Hill were acquired by Gippsland Oil and Minerals NL who completed 10 diamond drill holes. The first hole, G1, intersected cassiterite in massive pyrite-pyrrhotite sulphides, as did G3 and G4; but other holes were not successful in expanding this zone, although minor mineralisation was intersected.

1971-1972 - Aberfoyle recognised the apparent conformable nature of the Queen Hill mineralisation, and the volcanic/shale contact as analogous to the stratigraphy at the Cleveland Tin Mine. A joint venture was negotiated with Gippsland and Aberfoyle commenced drilling in August 1971.

In November 1972 Seigel Associates carried out down hole IP, resistivity and mass energisation equipotential geophysical surveys on drill holes G6 and G9 (Queen Hill) and reconnaissance IP and resistivity at Montana.

Twenty five diamond drill holes were completed to outline the Queen Hill deposit to 300 m below surface. An 'indicated reserve' of 1 million tonnes of 1.15% Sn was defined.

Additional diamond drilling tested tin occurrences away from the Queen Hill deposit. At Montana, drilling intersected a 6.5 m lode assaying 1.57% Sn. Subsequent drilling delineated a small stratabound resource.

1973 - By recognition of carbonate hosts at both Queen Hill and Montana, the potential for large tonnage targets of the Renison style became apparent.

Assessment of this potential proceeded in 3 ways:

1. Additional drilling at Queen Hill.
2. Metallurgical investigations of the fine-grained ores.
3. A regional exploration programme preceded by the characterisation of the geophysical signature of the deposit.

The metallurgical work was supported by K A Foo's 1974 MSc Thesis (University of London) on 'Process Design Study for the Beneficiation of a Tin Ore from Queen Hill'. This led to the development of matte fuming technology for tin (Foo and Floyd, 1980), which was successfully tested on a 2,200 bulk sample of Queen Hill ores.

Geophysical orientation established the conductivity of the Queen Hill deposit. Geological research was supported by W M Lutley's 1975 MSc Thesis (University of Adelaide) on 'Cassiterite-Sulphide Mineralisation at Queen Hill'.

Regional exploration for additional large conductive targets commenced with a helicopter-borne Scintrex Turair EM and magnetometer survey over a 25 sq km area.

Only disrupted EM and weak magnetic responses were detected over the Queen Hill deposit. However a 50 nT magnetic anomaly was delineated over the eastern flank of the hill, in the vicinity of Severn Street. This anomaly was superimposed on a broader 130 nT anomaly (Zeehan anomaly; Webster 1984).

1975 - It was concluded that the sequence to the east of Queen Hill was highly prospective and capable of producing tin bearing bodies similar to Renison. The Severn magnetic anomaly was characterised by a ground survey as a 300 nT total field anomaly with modelled source parameters of 50 m width, 100 m depth to top and a substantial depth extent. No coincident aerial or ground EM response was obtained.

At the same time orientation IP work was carried out at Queen Hill together with some down hole misse-a-la-masse.

1976 - The source of the Severn anomaly was investigated by a 350 m diamond drill hole (G39). An intersection of 5.65 m averaging 1.95% Sn as cassiterite was achieved 140 m below the surface and within a 111 m interval of pyrite-pyrrhotite-siderite veined sediments.

1977 - A high resolution airborne magnetic survey was flown with a mean terrain clearance of 60 m and a 140 m flight line spacing.

Twenty six stream sediments and 107 soil samples were collected in the vicinity of the known Queen Hill mineralisation as geochemical orientation.

Immediate follow-up of the G39 intersection was delayed during re-organisation of the Aberfoyle companies.

Three subsequent holes intersected the Severn position 40 m above and 100 m on either side of the discovery intersection without encountering ore grades. The fifth hole (G43) intersected 40 m of 0.89% Sn within a 130 m envelope of disseminated pyrite-pyrrhotite mineralisation situated 100 m below the intersection of G39.

The discouraging results of the shallow drill holes dissuaded further drilling at Severn for three years. In that period, surface IP, EM and airborne DIGHEM surveys did not detect any anomaly attributable to the mineralisation.

Bedrock auger sampling delineated linear Pb and Rb anomalies over the position of the Severn mineralisation and a parallel Sn anomaly situated up the flank of Queen Hill.

1978 - South of Queen Hill very noisy results were obtained from a ground magnetometer survey carried out as follow up to an airborne magnetic anomaly at Manganese Hill. Percussion drilling (1 hole completed) suggested a laterite profile, developed over shales and siltstones to be the probable source of the magnetic anomaly.

1979 - By early 1979 the area to the south west of Queen Hill was surveyed by UTEM. No exceptional anomalies were detected and due to power lines the Severn area was not surveyed.

In the same area IP showed major anomalies consistent with formational sources.

The existing Queen Hill ore reserve was reassessed and a lack of adequate drill coverage was identified. Additional drilling was commenced to improve the quality of the inferred resource and delineate gross ore potential.

The Queen Hill/Severn metasomatic aureole was investigated by analysis of core ground samples for Sn, W, F, Rb, As and Bi.

Severn drill core was relogged and a major structural control recognised. Additional drilling was recommended to test the structural plunge of known mineralisation.

Orientation DIGHEM (helicopter EM) was flown at Queen Hill in conjunction with an extensive survey in the Heemskirk/St Dizier area.

1980 - Drill hole G65, designed to test for structurally controlled mineralisation adjacent to G39, intersected tin mineralisation over an interval of 136.31 m which assayed 0.51% Sn and included 4.6 m @ 2.76% Sn in semi-massive pyrrhotite and thus confirmed the interpreted structural plunge.

Since discovery, metallurgical testwork has incorporated gravity, flotation, pressure leaching and fuming. Before 1980 all the testwork concentrated on samples from near surface in Queen Hill. The objective in all these tests was to maximise recovery into a saleable concentrate. Modest recoveries were achieved with cassiterite flotation to a concentrate containing 20% - 30% Sn matte fuming indicated that high recoveries could be achieved.

In 1980 with recognition of the significance of the Severn deposit, ore characterisation was commenced on exploration drill core. Initially drill intersections from Severn were tested but later mineralisation in holes from both Queen Hill and Montana was characterised. Significant differences in metallurgical characteristics were confirmed. These differences relate to grain size and sulphide concentration.

1981 - Drilling proceeded at Queen Hill, Severn, Montana and the Golf Course Lode.

1982 - In June 1982 drilling on the CML ceased and a new resource estimate was completed.

Geoex Pty Ltd conducted Sirotem transient down hole EM geophysics.

1983-1989 - Following a pre-feasibility study work on the property languished apart from the re-assessment of data and re-logging of drill core by J A Anderson as part of his PhD research of the Zeehan tin field.

1989 - To the south of Severn two diamond drill holes were completed to test for a significant expansion of resources. These holes did not intersect high grade mineralisation but added data enabling better prediction of possible structural targets.

The holes were tested with down hole EM and five UTEM loops were surveyed on surface. No conductors considered to be related to sulphide-cassiterite mineralisation were detected. However a very strong conductor of cultural origin obliterated any response anticipated from the main Severn deposit.

5. MINING

Appraisal of Palmer's 1982 resource assessment led to the following observations relevant to mine design of the Zeehan Tin Deposits:

(i) Queen Hill Deposit

Queen Hill can be divided into two parts. The upper section, above RL 1110, is essentially massive sulphide, relatively narrow (3 to 8 metres) but high grade and dips at 50 to 80 degrees. The hanging wall is adjacent to a fault zone coincident with Clarkes lode.

The lower section of Queen Hill (RL 1110 to RL 1010) is a wide zone of mineralisation with relatively narrow high grade zones within the envelope. The southern end is sufficiently wide that long hole stoping may be possible whether bulk or high grade is to be mined.

(ii) Severn Deposit

At 0.5% cut off, the upper part of Severn is narrow and has a short strike length, but is high grade. Both thickness and strike length increase with depth and while grades appear to decrease the yield of tin per vertical metre increases. At RL 1000 the yield is about 2600 MTU's (1 tonne x 1% Sn) per vertical metre and at RL 800 about 6700 MTU's.

(iii) Montana Deposit

Montana is narrow (2.5 to 5 metres) and short in strike length. It may need to be accessed by long crosscuts from Queen Hill. The mineralisation is high grade and massive sulphide, lending itself to visually controlled selective mining.

The most significant factor evident in all deposits and relating to mine production is the concentration of tin in zones at high cut off. In particular the benefits of mining selectively the mineralisation defined by the 0.5% cut-off outweigh any advantages gained by reducing the cut off and bulk mining. Most of the mining widths and attitudes are suited to trackless mining. The major portion of production will come from ore where assay grade control, (e.g. down hole probes) will be essential and where some ground support is needed. Since access will almost certainly be by decline, production is unlikely to commence from the bottom.

It is considered that most favourable mine access would be by decline from the western side of Queen Hill, commencing in the footwall basic volcanics. The volcanics appear to be competent and environmental problems will be minimised. The road to Trial Harbour will probably need to be relocated. The decline will remain in the footwall volcanics to about 1000 RL where it is proposed that it will cut across strike to Severn and continue downwards in quartz rich sediments in the footwall of Severn.

Queen Hill can be mined by cut and fill and by long hole stoping. It is likely that two rib pillars will be required for the lower part of Queen Hill and that above a sill pillar at RL 1110, mining will be by cut and fill, but later in the life of the mine.

Severn can be mined by cut and fill in three major lifts with pillars separating each main stope. Montana can contribute a low annual production, probably by shrink stoping. Its location in relocation to the other deposits indicates high access capital and consequently less favourable economics.

6. METALLURGY

6.1 Introduction

Tin in the Zeehan deposits occurs principally as cassiterite with some stannite in upper levels. Though often visible to the naked eye the cassiterite consists of clusters which readily break up into very fine grains. Initial work on the Queen Hill deposit showed 70% of cassiterite was less than 20 microns in size. Major gangue components are pyrite, silicate, carbonate and fluorite.

The fine grain size of the cassiterite precludes the use of conventional gravity separation or cassiterite flotation as a means of concentration.

6.2 General

Since discovery, metallurgical testwork has included gravity, sulphide flotation, cassiterite flotation, pressure leaching and matte fuming.

Reports on metallurgical programs include:

- A summary of all the work and significance of the results by D R McKay - June 1973.
- Process Design Study for the Beneficiation of a Tin Ore From Queen Hill, Tasmania, by K A Foo MSc Thesis, 1974.
- Queen Hill Upper - Progress Report No 1 by S S Meik October 1982.
- Testwork on Drill Core from Queen Hill, Severn and Montana:- "Zeehan Deposits Progress Report No 1 by S S Meik, November 1982".

6.3 Matte Fuming

Matte fuming is a pyro-metallurgical process which overcomes the limitations of conventional tin concentration and smelting techniques particularly in relation to fine grained tin ores.

In conjunction with the CSIRO, Aberfoyle completed considerable research on the matte fuming process. Encouraging results were obtained from a small pilot plant (50 kg/hour) using the CSIRO developed SIROSMELT technology, and in the latter part of 1979 Aberfoyle made a commitment to spend $3.5 million on the construction of a large scale 4 tonne/hour pilot plant at the Western Mining Kalgoorlie Smelter. This site was chosen because it provided access to an existing sulphur extraction unit (Figure 10).

MATTE FUMING PLANT

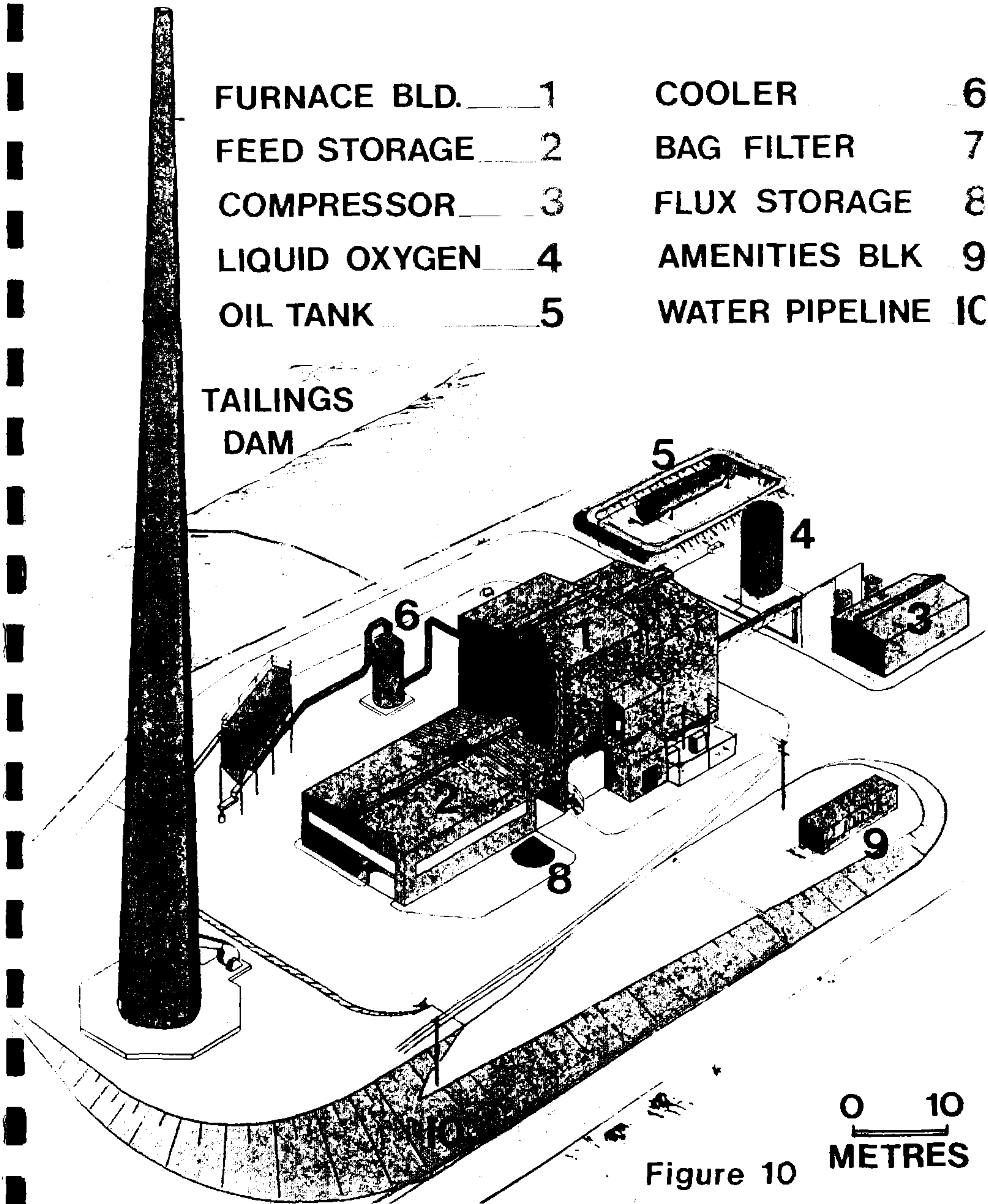


Figure 10

5 cm

The matte fuming process involves the continuous feeding of crushed tin ore to the surface of a molten iron sulphide matte overlain by a thin layer of iron silicate slag at 1200°C. Air is delivered through a lance submerged in the matte and causes an intense reaction. Tin oxide fume is collected in a baghouse.

An exothermic reaction is sustainable with air as oxidant if sufficient iron sulphides are present in the feed. Fuels used in pilot plant have included oil, natural gas and various types of coal.

The Kalgoorlie pilot plant testwork was successful and demonstrated matte fuming could upgrade Queen Hill Upper material (an 88% recovery to a 30% Sn concentrate was achieved from a head grade of 0.7% Sn) however this is not economic at the low head grade tested. Pre-concentration is required to achieve an economic feed grade to matte fuming.

A new processing philosophy emerged - an integrated "unstressed" circuit incorporating sulphide flotation, gravity and cassiterite flotation circuits with final concentrate upgrading by matte fuming.

Laboratory tests show that using this processing route overall recoveries greater than 75% are possible.

7. CONCLUSIONS

The Zeehan tin deposits represent a major tin resource with few hardrock deposits offering better combined tonnage/grade characteristics (eg Renison, Dachang, Chacaltaya). Due to high sulphide content and fine grain size the Zeehan ores are difficult to treat by conventional beneficiation techniques. An integrated 'unstressed' circuit incorporating the best features of conventional processing and final concentrate upgrading by matte fuming - is expected to achieve an overall recovery of 75%.

The initial discoveries resulted from the investigation of historical reports and workings, whereas a magnetic signature led to the discovery of the largest body of mineralisation. Neither electrical geophysics nor geochemistry contributed directly to the discoveries.

The discoveries revealed two aspects which are not evident for the type occurrence at Renison and improve potential of the area;

1. Substantial sulphide-cassiterite mineralisation with poor magnetic signature.
2. Close spacial association between steeply plunging structure and stratigraphy as the preferred site of mineralisation.

Potential to at least double the resource is evident as J A Anderson's PhD research has demonstrated the likelihood for existing mineralisation to extend to significant depths. Some favourable structural/stratigraphic targets also remain untested.

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