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CRA EXPLORATION PTY. LIMITED

EL 28/88 ZEEHAN, TASMANIA

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BASE METAL MINERALIZATION POTENTIAL
IN THE
PRECAMBRIAN AGE ROCKS AROUND ZEEHAN

Timothy G Summons
October 1991

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1. INTRODUCTION

CRA Exploration Pty Ltd and Major Mining have entered in to a joint venture agreement to explore a group of tenements (Figure 1), generally situated to the south of the town of Zeehan in western Tasmania.

This report has been prepared in response to a request from T W Dickson to review, compile and interpret information relating to base metal mineralization in Precambrian age rocks within the joint venture area.

The multiplicity of mineralization present in the Zeehan district makes it desirable to present an overview of the regional setting, and of the history of prospecting/exploration and mining on the field, before attempting to synthesise the data.

2. GEOLOGY

2.1 Regional Stratigraphy

The Precambrian age basement (Oonah Formation) in western Tasmania is comprised of a lower sequence of quartz wacke and mudstone, overlain by an upper sequence of dolomite/magnesite and basaltic volcanics.

After deformation in the late Precambrian (690 Ma), there followed in late Precambrian/early Cambrian time a sequence of shallow water clastics and dolomite (Success Creek Group), in turn overlain conformably by mafic volcanics and limestone (Crimson Creek Formation).

Following erosion in early/mid Cambrian time, a sequence of mudstone, lithic wacke, chert and conglomerate (Dundas Group), was deposited, coeval with a succession of rhyolitic to andesitic volcanics (Mt Read Volcanics), which formed in an island arc setting further to the east.

Unconformably overlying these rocks are a siliciclastic sequence (Mt Zeehan Conglomerate) and a limestone sequence (Gordon Limestone), both of Ordovician age, in turn overlain conformably by siliciclastics, mudstone and limestone (Eldon Group) in Siluro-Devonian time.

The mid Devonian Tabberabberan deformation (with maximum expression in Cambrian to early Devonian age rocks), was followed in the mid/late Devonian (389 - 332 Ma) by the emplacement of a group of high level, S type granitoid masses.

2.2 Regional Mineralization

Several metallogenic events are recognised, as follows:

Proterozoic (late): volcanogenic massive sulphide - oxide deposits of pyrite-magnetite +/- Cu, Pb, Zn, Au (Savage River, Keith River).

Cambrian (? mid): volcanogenic massive sulphides, both disseminated Cu Ag Au (Mt Lyell), and massive stratiform Zn Pb Cu Ag Au (Rosebery, Hellyer etc).

Ordovician (late): stratabound and stratiform cabonate hosted exhalative Zn Pb (Oceana, Austral).

Devonian (late): granitoid related Sn W greisen/skarn/carbonate replacement/ vein (Renison, Bischoff, Queen Hill etc) with associated Ag Pb Zn vein mineralization (Zeehan, Dundas, Magnet).

2.3 Zeehan Area Stratigraphy

Specific aspects of the geology around Zeehan warrant further detailing;

CONAH FORMATION

The upper sub division is widespread, and includes dolomite, conglomerate, lithic wacke, siltstone & mudstone with basaltic lavas (high Ti alkali basalts).

Adjacent to Queen Hill it consists of dolomite, evaporites (sideritized), cherts, shales (grey & carbonaceous/pyritic), and alkali basalts.

In the Stonehenge - Nubeena area it consists of (quartz veined) dark coloured micaceous quartzites, interbedded with siltstone, slate, dolomitic limestone, cherts and mafic volcanics.

SUCCESS CREEK GROUP

A sequence of dolomite and sandy shales near Montana Hill is correlated with the Success Creek Group on the basis that it conformably underlies the Crimson Creek Formation.

CRIMSON CREEK FORMATION

Adjacent to Queen Hill it consists of volcaniclastic or tuffaceous sediments, limestone and tholeiitic basic volcanics.

In the Stonehenge - Nubeena area it includes siltstones, cherts (red/white), conglomerates (tuffaceous matrix), and apparently both basic and intermediate (high Mg andesite) volcanics.

DUNDAS GROUP
The fossiliferous Dundas Group comprises a sequence of greywacke, conglomerate and siltstones, all with the same provenance; these sediments occur to the south of the TLE mine and are present in Mcleans Creek south west of the Swansea mine.

2.4 Zeehan Area Structure

Major orogenic events occurred in the late Proterozoic (Penguin), and in the mid Devonian (Tabberabberan).
Structural features attributed to the Penguin Orogeny are the complex/multi (3) stage formation of co-axial flexural folds, and the development of a metamorphic belt (Arthur Lineament).
Of the five cleavages identified in the Oonah Formation, the first two formed with isoclinal folding, and the refolding of same respectively, while the last two are related to the mid Devonian deformation.

The Tabberabberan deformation had two phases, both of which affected the Zeehan district; the early phase produced north trending open folds, superimposed by the later north west trending upright folds, with resultant basin and dome structures. The later folding ("Zeehan - Gormanston trend") was associated with considerable faulting; this NW - SE trend is of regional status, and can be traced across the state (although one of the effects of post - Permian faulting may have been to reactivate older fractures).

Mapping by R Poltock for Renison in 1981 recognised predominantly west - east strikes in both the Oonah and Crimson Creek formations; isoclinal folding was seen in the Oonah Fmn, and faulted contacts were inferred with the younger rocks. A synclinal zone extending westward from the Swansea to the TLE and North Tasmanian mines, was seen to be constricted by a northerly cross fold, but correlation problems arising from inferred assymmetric folding were not resolved. An anticlinal zone (with dolomitic sediments in the core), was also recognised between the Comstock and Sunshine mines.
It is apparent that overturned and thrusted contacts exist between the Oonah Fmn and all younger rocks.

2.5 Zeehan Area Mineralization

Several different methods of classification could be adopted for the mineralization recorded in the Zeehan (Mineral) Field, and the chronologic approach is used below;

1.5.1. Proterozoic:
Pyrite, (in association with carbonaceous shales), is considered syngenetic.

1.5.2.Ordovician:
Pb Zn (Ag), both stratiform and epigenetic/stratabound styles in the Gordon Limestone were recognised by Amoco (Cyprus Mines) at the Oceana deposit as being of the sediment hosted exhalative (Irish) type.

Supporting this identification are the Pb isotope data which show the mineralization to be less radiogenic than the Devonian age vein mineralization, and to have similar isotopic signatures to the Cambrian age volcanogenic massive sulhides.

Similar exhalative Pb Zn mineralization is believed to occur in the Gordon Limestone elsewhere near Zeehan (Crown, Despatch, Austral).

1.5.3.Devonian:
Ag Pb Zn mineralization forms part of a zoned mineral field considered to be related to granitoid associated Sn (Cu Sb) mineralization. The early interpretation of this zoning was that the vein gangue mineralogy was centered on the Heemskirk Granite, with successive pyrite, pyrite/siderite, and siderite zones arranged concentrically about the endogranitic cassiterite mineralization (Waller 1904, Twelvetrees & Ward 1910, Edwards 1953, Both & Williams 1968, Both et al 1969).

Following the discovery of the Queen Hill/Montana/Severn sulphide-cassiterite/stannite replacement deposits [*], there is now considered to be good evidence for a blind (Devonian age) cupola to exist beneath Queen Hill, and that the Ag Pb Zn mineralization is both genetically related to, and centered on this intrusive feature (Solomon 1981, Collins & Williams 1986, Williams et al 1989, Anderson 1989). Solomon (1981) regarded the pyrite/siderite zoning to reflect the dissolution of (sideritic) Gordon Limestone.

The Queen Hill granitoid cupola related Sn deposit model is supported by several other zoned exogranitic Sn W deposits with outer haloes of Ag Pb Zn mineralization (Cleveland, Mt Bischoff, Moina .....and probably Magnet & Mt Farrell).

Most of the Zeehan field Ag Pb Zn vein deposits occur in the Oonah and Crimson Creek formations; the "veins" or lodes are typically irregular in shape, averaging 0.3m wide, and with strike and dip extensions of about 100m each.

[*]
The Queen Hill pyrite-Sn deposit is hosted in dolomite in the Oonah Formation, with a geological resource of 4 M tonnes @ 1.0% Sn;

The Montana (No 2) pyrite-Sn deposit is hosted in dolomite of the Success Creek Group, with an unknown but apparently small resource;

The Severn pyrite/pyrrhotite-Sn deposit is hosted in limestone of the Crimson Creek Formation, with a geological resource of 3 M tonnes @ 0.35% Sn, and 20 g Ag/tonne.

3. HISTORY OF EXPLORATION AND MINING

3.1. Early Exploration & Mining

The Zeehan mineral field was known in the early prospecting days of the 1870's for its tin content, but quickly changed to a silver-lead mining field with the discovery of argentiferous galena in 1882.

The field was progressively developed until 1898, following which production declined steadily until 1910 when most of the mines had closed due to the depletion of shallow ore; closure of the local smelter in 1913 was a precursor to the cessation of significant mining activity in 1919.

Exploitation of some 200 lodes (averaging 0.3m * 100m * 100m) resulted in the production of 200,000 tonnes of Pb, and 27 M ounces of Ag (Both et al 1969). Most of the production occurred in the period up to 1919, of which the majority (90%) came from lodes hosted by Proterozoic and Cambrian age rocks; around 55% of the Pb production and 60% of the Ag production was derived from 4 deposits (Montana No 1, Western, Queen & Oonah).

3.2. Systematic Exploration

Sundry prospecting activities occurred between 1919 and 1946 (eg tribute mining from the Nike and Swansea mines), when the current phase of systematic exploration (including a brief period of mining from the Oceana), began;

1946 - 1960 Zeehan Explorations P/L
Zeehan Explorations P/L (joint venture between North Broken Hill & Broken Hill South), did ground surveys to check the continuity of the Spray - Nubeena shear zone (including unsuccessful drilling at the Spray mine), and initiated the BMR managed magnetic, gravity and electrical (SP, EM) surveys.

These surveys were generally unsuccessful, viz - some of the gravity anomalies were due to concentrations of siderite, and the electrical surveys failed to give responses over known mineralization.

However, drilling around the Oceana mine proved encouraging, and after some rehabilitation work (including the sinking of a new shaft), the mine was reopened and went on to produce 129,000 tons of ore grading 11.6% Pb and 4.79 oz Ag /ton in the period 1954 - 1960.

1966 - 1970 Placer Prospecting P/L
Placer also focussed on the Spray - Nubeena shear zone, including soil sampling and a TURAM EM survey over the main Spray lode; Minops P/L farmed in to the property and drilled several holes in to the same lode, but achieved disappointing

results - 0.0025m of galena was interpreted as the Spray main lode between the 5 and 6 levels.

1970 - 1972 Tenneco P/L

Teneco dewatered, sampled and further drilled around the Spray mine; the cored hole cut a jamesonite lode (0.2m @ 16.8% Pb, 0.08% Zn, 8.8% Sb, 1.4% Cu and 267 oz Ag/ton), and further on the main lode from which only pyrite was recovered at a point 85 m below no 6 level. As Zeehan Explorations had earlier drilled a jamesonite quartz vein, a further 4 holes were dilled from no 5 level to test the extent of this lode, but failed to locate any significant mineralization.

In addition they conducted a TURAIR airborne EM survey of most of the Gordon Limestone area. Follow-up gravity, TURAM ground EM and SP surveys produced mixed results; thr ground EM survey detected several anomalies, including the Spray no 1 load, the Foam/Wave and Nubeena deposits, and probably graphitic shales. The SP survey failed to locate any significant anomalies close to Zeehan, and the EM anomalies recognized in the Grieve Valley south of Zeehan were found to be due to conductive overburden.

1974 - 1986 Mt Lyell Mining & Railway Coy (SPL 129)
Renison Ltd (EL 11/76)

1974 -75: The Barringer - Input airborne EM system was trialled by Geoterrex on several northerly trending lines between the Swansea and the Comstock mines. Strongly conductive anomalies with associated magnetic anomalism were located over the North Comstock, Comstock, Boss, Susannite and Britannia desposits.

1980 - 1981: The geological mapping showed the dolomites in the Oonah Formation to be more common than previously recognised, and the presence of a spilite-pyrite association (the pyritic beds containing minor galena), in the Oonah formation. The mapping also recognized the problem in distinguishing between the Cambrian age Crimson Creek Formation and the "fossiliferous" Dundas group rocks; original unconformable contacts between Oonah Formation and Cambrian sediments/volcanics are frequently thrust faulted and/or overturned.

1981 -1982: A major airborne EM (DIGHEM) and magnetic survey was conducted over the eastern end of the tenement. The DIGHEM system was considered to be more sensitive the TURAIR EM method, and it was hoped that DIGHEM would reveal EM anomalies over blind Queen Hill style mineralization; the 1975 TURAIR survey outlined various conductors around the flanks of the Queen Hill magnetic anomaly (200 γ), and a similar pattern was obtained by the DIGHEM survey on the northern side of the Stonehenge magnetic anomaly (400γ). {The Queen Hill deposit has anomalous responses to IP, SP, applied potential and airborne EM surveys}.

DIGHEM defined numerous (74) conductive anomalies, many of which were interpreted as lying along WNW trending zones regarded as indicating continuous (stratigraphic) black shale horizons. Several of these interpreted zones incorporate old workings , viz Susannite, Britannia, Comstock, South Comstock and Sunshine. None of the major WNW trending faults in the area gave a response, and the coincidence of some old workings (but not all) with conductive zones implies the pre Devonian-vein existence of such zones; (the correlation of DIGHEM with the Input EM is noteworthy - particularly for the Comstock - Britannia tract).

1982 -1983: Work in this period involved the establishment of the Stonehenge grid over the strong aeromagnetic anomaly, followed by bedrock geochemistry, ground magnetic, VLF EM and gradient array IP surveys. The VLF survey located most of the DIGHEM anomalies, and also defined several weaker zones not found by DIGHEM. The gradient array IP survey showed low resistivities over clays on the north side of the grid, as well as several chargeable zones (interpreted as due to graphite and/or pyrite in the sediments). The detailed ground magnetic survey confirmed the broad deep-seated anomaly located by the 1981 Department of Mines survey, and was interpreted by J. Bishop as due to a mafic intrusive. A single hole (TH12) is reported to have made two intersections "anomalous in base metals, As and Sb".

1983 -1984: Work during this period consisted of follow-up drilling to test the various anomalies produced by earlier work. Drill hole TH13 was collared 200m NNE of the Sunshine Mine, and was designed to test the southern extension of Spray No 3 lode; it traversed a fault channel which was weakly mineralized, viz 61m at 0.90% Pb, 0.59% Zn, 29 gAg/t.

Drill hole TH14 was collared 1 km NNE of the Tasmanian Mine in order to test a combined brecciated limonitic sandstone with a geochemical (Pb Zn Cu As W) anomoly and a strong VLF EM anomoly; the target returned 10.7m at 0.12% Pb, 0.04% Zn, 2gAg/t, and a further (deeper) intersection of 3.9m at 0.24% Pb, 0.01% Zn, 7 gAg/t was recorded in sandstone hosted quartz veins.

Drill hole TH 15 was collared 500m NNE of the Sunshine and drilled on the opposite azimuth to TH 13 to further assess the mineralization found in that hole; however, it also entered the fault zone and returned a best intersection of 24m at 0.27% Pb, 0.54% Zn, <1 gAg/t; the mineralization in both TH13 and TH15 is considered to be Devonian in age.

Drill hole Th16 was collared 200m east of the Spray main lode, with the object of testing same; the lode was not cut, apparently because a conjugate shear (Cross Chloride fault), appears to have accomodated dilational strain in this area of the Spray shear system,and thus impeded the movement of mineralizing fluids. Weakly stanniferous mineraliztion was encountered in several quartz vein stockwork zones
e.g. 1m @ 0.10% Sn, 0.03% As, 0.38% Cu, 0.01% Pb, 0.03% Zn;
1m @ 0.10% Sn, 0.40% As, 0.31% Cu, 0.16% Pb, 0.03% Zn;

1m @ 0.03% Sn, 0.50% Cu, 0.01% Pb, 0.01% Zn; none of which were confidently interpreted as the Spray main lode.

1984 - 1986: The EM 37 survey detected a large number of anomalies many of which were correlated with black shales and/or faults. Several single line anomalies (one later tested by TH17) were seen, including one over Grubbs workings; a follow-up UTEM survey produce anomalies generally in agreement with the EM 37 survey results, including a poorly defined response over Grubbs workings. The best anomaly located was 300m NNE of Grubbs, and is coincident with a VLF anomaly; it was interpreted as a fault, but not tested.

Drill hole TH17 was collared 400m NNW of Sunshine and designed to test the combined EM - magnetic anomaly; no significant mioneralization was met, and the anomalies are apparently due to graphitic shales with variably pyritic breccia zones.

A downhole EM survey (using a SIROTEM system) was done in hole TH17, but did not locate any off hole mineralization to explain the surface Em anomalies.

1978 - 1983 Amoco

Amoco focussed their attention on the Gordon Limestone, but most of the work was done around the Oceana and Austral Pb Zn deposits via gravity, magnetics, IP, EM and bedrock geochemical surveys. Subsequent core drilling outlined a subeconomic resource at Oceana (4 M tonnes @ 19.4% Pb, 4.0% Zn, 106 gAg/t), and associated studies of this deposit showed it to be of sedimentary exhalative origin (similar to the Irish deposits exemplified by Navan and Silvermines); Pb isotope data shows the mineralization to be at least Ordovician in age.

1983 - 1987 Amoco (Cyprus Mines) - EZ Coy JV

The joint venture partners focussed their attention on other areas of Gordon Limestone to the south of Oceana, namely Pyramid, Myrtle, Grieves, Rose Valley and Baura; they conducted various EM surveys (Genie, UTEM, EM37, SIROTEM), bedrock geochemical sampling, gravity and dipole - dipole IP surveys.

Auger sample anomalies were confirmed by trench sampling but many were later shown to be spurious and due variously to transported clays, or to secondary dispersive effects about strongly depleted primary mineralization.

Core drilling of coincident geochemical-UTEM anomalies was disappointing, the UTEM responses being due to either fault zones, or to marked lithological contrasts (e.g. limestone versus black shale).

The results of a dipole-dipole IP survey of a gravity anomaly in the north Austral valley and the drill results of a EM37 anomaly near the Montagu deposit are unknown.

The EZ Coy concluded in 1987 that the Myrtle - Rose Valley area had good potential for Pb Zn mineralization on the basis of several untested geochemical anomalies, incompleted bedrock sampling, the non-conductive nature of the target mineralization, and the low density of drill holes on the various grids.

4 SYNTHESIS

4.1 Literature Review

The result of reviewing both early mining data and more recent/systematic exploration activities, has been to show that there has been no organized evaluation of base metal mineralization in the Oonah Formation which is not vein hosted. The old data for the Zeehan field suffers from a deficiency in that the Zn mineralization is poorly documented; coupled with this is the ambiguity surrounding the "pyritic formations", which at first glance may seem to be syngenetic in origin within the Oonah formation.

The reasons for these shortcomings are readily deduced;

- ore with low Ag tenor was unpayable which meant that most focus was on the silver rich galena (rich) ores, to the exclusion of sphalerite dominant mineralization.

- the structural complexity which characterizes the Oonah Formation (with likely mobilization of sulphides along shears/pressure shadows etc.), in conjunction with the predisposition of the early mining fraternity to want to see cross-cutting sulphide lodes, means that "pyritic formations" as recorded are frequently not amenable to further interpretation.

- the frequent occurrence of carbonate horizons in Oonah formation, Crimson Creek Formation etc. simply increases the potential for carbonate replacement style of mineralization. Clearly the granitoid related mineralizing systems operative in mid/late Devonian time were extensive and pervasive, and it is reasonable to interpret many of the pyritic formations as being of Devonian (replacement) origin. The problem thus becomes one of differentiation between a Devonian age carbonate replacement deposit, and a Proterozoic age sulphide deposit which has a Devonian overprint (i.e. either replacement or modification).

Consequently, the combination of structural complexity and Devonian age hydrothermal replacement, means that although a given pyritic formation may appear to be stratabound and/or is stanniferous, it should not automatically be regarded as being uniquely Devonian in age; such units warrant further attention.

The pyritic occurrences are generally associated with;
- dolomite or dolomitic limestone (+/- talc);
- mafic volcanics and tuffs - particularly in the Oonah/Western/Montana mine area;
- carbonaceous (graphitic) shales.

The most valuable early geoscientific work was that done by the geologists and mine managers who were able to record factual structural, lithological, mineralization and alteration/weathering information (e.g. Waller 1904).

4.2 *Structural Review*

4.2.1. Devonian

The disposition of Devonian age fissure fill veins in the Zeehan field is apparently erratic, with a large concentration of deposits in the Argent Valley, the Western-Montana area and to a lesser extent in the Nike-Spray area.

An attempt has been made to "look through" the Devonian distribution of veins to ascertain the existence, or otherwise, of any underlying structural patterns.

The approach adopted required initially that the Devonian age structures be interpreted, as well as assuming that the vein hosted Ag Pb Zn mineralization *was sourced from* pre-Devonian age rocks.

The method used was based on a 0.5 x 0.5 km grid overlaid on the map produced by Waller in 1904 (Figure 2), with each cell covering 0.25 sqr km of area; the cell size was selected so that the larger of the vein deposits would not be inadvertantly truncated. Care was taken to *only* measure the actual length of mineralized fractures (veins), as G.Waller and many of his contemporaries were prone to extrapolating in order to define the enigmatic " Mother Lode ".

Within each cell the product of the cumulative length of veins and the frequency of veins was plotted and then contoured to produce a "mineralization intensity" or "fracture permeability" map (refer Figure 3). This map depicts the Argent valley (Argent - Florence workings etc) as being the most *intensely mineralized*,followed equally by the Queen, Oonah, Western and Nike/Spray workings.

Interpretation of the fracture permeability data was done using a combination of the superbly detailed mine scale structures (Waller 1904, Twelvetrees & Ward 1910 etc), with the regional structural data provided by later workers (eg King & Blisset 1969).

The sense of movement about faults operative during Devonian mineralization can be confidently interpreted as being dextral for the Montana and Spray faults , and sinistral for the Argent and Queen faults; less well defined detail supports dextral motion on the Despatch and Tasmanian faults, and left - handed motion on the Comstock *fault(s)*.

The following faults/fracture zones/shear zones (as shown on Figure 4), have been interpreted/inferred;

- WNW trending, dextral movement (Montana, Balstrup, and Tenth Legion faults);
- NW trending, dextral movement (Despatch, King, Spray and Tasmanian faults);
- NNE trending, sinistral movement (Queen, Argent, Florence, North Comstock and Comstock faults).

The arrangement of these fractures suggest a conjugate disposition in a major right-lateral shear system (including analogues to Riedel fractures), as follows;

Major/Primary shears: WNW trending faults (eg Montana, Balstrup, Tenth Legion)

Sympathetic (R1) shears: NW trending faults (eg Despatch, King, Spray, Tasmanian)

Antithetic (R2) shears: NNE trending faults (eg Queen, Argent, Florence, Comstock)

Furthermore, the left lateral (antithetic Riedel) shears define a markedly broad zone in the Argent-Florence tract which is interpreted to be a dilational jog in the overall right-lateral shear system. Movements on the left-lateral Queen faults have induced strain in the mafic volcanics indicative of brittle-ductile interfaces.

The fault-bounded nature of both the mafic volcanics between Queen Hill/Montana Hill, and the (tuffaceous) Crimson Creek Formation in the Argent valley, are suggestive of earlier movevement along the regional right-lateral shear system.
Other dilational jog zones may have existed to the north in the vicinity of the Big Ben and Quigleys mines , and to the south, immediately north of the Oceana mine.

4.2.2 Cambrian/Ordovician

The Oceana Pb Zn mineralization has been demonstrated to be of Ordovician age on the basis of both Pb isotope data, and the recognition of the sygenetic (stratiform & stratabound) exhalative style of the mineralization.

Mineralizing fluids were channeled up at least two faults (Oceana and Mine), with associated dolomitization of the host limestone; rotation of (the present orientation) these faults in to a syn-mineralization attitude shows the Oceana and Mine faults to have trended ENE/NE and NE/NNE respectively.
These orientations are interpreted to indicate the existence of a series of (? half) grabens developed in response to left lateral shearing along ENE/NE transcurrent faults; the potential would have existed in this stress regime for the formation of both stratabound and stratiform Pb Zn mineralization.

The similarity between the Pb isotope data for the Oceana deposit and the (Cambrian age) volcanogenic massive sulphide deposits in the Mt Read Volanics, implies the structural setting envisaged above may have been operative during Cambrian time.

Examination of the fracture permeability (mineralization intensity) contours for the Devonian age veins (Figure 3), shows that if the Devonian fractures are considered as specific sections through pre-existing base metal mineralisation in the basement, then ENE/NE oriented panels or corridors can be inferred, which encompass groups of old mines associated with generally similar fracture permeability.

Interestingly, the alignment of the Ag/Pb ratio contours (also shown on Figure 3), within these corridors complements the ENE/NE trending sinistral transcurrent fault model.

These structural panels are shown on Figure 5, and have been labelled A, B, C, ...to O; possibly more significant corridors include:

B - incorporating the Oonah, Junction, Western & Montana no 1
C - " " Queen & Montana no 2
D - " " Comstock, Boss, Susannite, Nike Florence & Silver King Extended
E - " " Brittania, Spray North & Argent group
G - " " Stonehenge, North Tasmanian, Spray & Silver King
K - " " Swansea, Grubbs, Nubeena, Maxim, North Austral, South King, Bell & Sunrise.

4.2.3 Proterozoic

As intimated in section 3.2.1, earlier (than Devonian) movement along the NW - SE trending direction may have taken place; assuming that the major/regional stresses operative during Cambro-Ordovician time were as described in section 3.2.2, then the earlier (ie pre-Oceana), NW - SE directed movement would have occurred in either early Cambrian or latest Proterozoic time.

Alternatively, by adopting the "big picture" approach, one can envisage the existence of a NW - SE mega shear (crustal suture) which has operated intermittently through time (ie from the Precambrian through to the Tertiary).

Right lateral movement on such a system during Cambro-Ordovician time would incorporate NE aligned antithetic (sinistral) mega shears similar to those inferred for that period.
However, any model of Precambrian stuctural setting(s), and thus mineralization model(s), should be able to explain the apparently regular arrangement of Fe Cu Pb Zn Ag Au Sn W mineralization in to broad ENE aligned zones in western Tasmania; examples of such zones include :

- Interview River/Savage River/Cleveland/Magnet/Mt Bischoff/Kara
- Mt Lindsay/Que River/Hellyer
- Federation/Oceana/Queen-Hill/Zeehan/Renison/Rosebery/Hercules/Mt Farrell/Granite Tor.

4.3 Silver:Lead (Ag/Pb) Ratios

The early miners on the Zeehan field used the Ag/Pb ratio to rank the various deposits; this factor is the ratio of Ag grade to Pb grade, as measured by the troy ounces of Ag per long ton of ore, divided by the units (%) of Pb in the ore. A typical, medium silver grade galena ore might assay 75 oz Ag/ton and 50% Pb, giving a Ag/Pb ratio of 1.5.

Ag/Pb ratios were recorded for most of the mines, many of which varied within each deposit; contemporary opinions for such variations included depth within the lode (increasing depth = increasing sphalerite etc), sphalerite content, orientation of the reef, or type of host rock.

The silver is typically present as tetrahedrite or in galena in primary lode material, with argentite and pyragyrite contributing to the bonanza grades found in the supergene and oxide zones. However, tetrahedrite is also recorded in sphalerite, and limited electron microprobe data on galena samples suggests a grouping of Ag/Pb values around 0.45 and 0.90.

Excluding remnant silver sulphosalts in gossan cappings, the Ag/Pb ratios range from about 0.3 to 9.5, with most in the interval 0.7 to 2.0. Typical values for each of the old mines are shown in Figure 3, from which it can be seen that the maximum values occur around the Western/Oonah/Queen, the Spray and the Comstock areas.

King & Blisset (1969) categorised Ag/Pb ratios on the basis of host rock age, in addition to subdividing the Oonah Formation according to lithologies; that approach has been essentially maintained in the present exercise, but with additional host rock categories for the Crimson Creek Formation and the Eldon Group.

Although Devonian age Pb Zn vein style mineralization probably occurs in the Gordon Limestone, there is good evidence that most of the mineralization is of exhalative origin. It is noteworthy that the graph of Ag vs Pb for drill core samples from the (Gordon Limestone hosted) Mariposa and Sunny Corner Pb Zn prospects, shows a concentration of Ag/Pb ratios between 0.4 - 0.6, (within a total range of 0.1 - 1.5). Assuming the tetrahedrite is devoid of Pb, the data imply that galena contributes Pb in the (Ag/Pb) range 0.1 - 0.4, beyond which tetrahedrite contributes Pb in the range 0.4 - 1.5.

All Ag/Pb data (both recorded and calculated), was then treated statistically in 5 subsets;

Oonah Formation (with mafic volcanics = Oonah-1)
" " (without " " = Oonah-2)
Crimson Creek Formation
Gordon Limestone
Eldon Group.

Plots of the Ag/Pb values for the different data sets showed them to be variably polymodal, and to be comprised (ie amenable to modelling by use of), individual lognormal distributions, as depicted on Figure 6.

The total effect of these distribution plots can be further appreciated from the following table;

Distribution of Ag/Pb Ratios

Data Subset	n	Distribution Shape	Distribution Character	Median Value	% of sub pop A	B	C
Oonah - 1	17	bimodal	lognormal	1.5	10	90	-
Oonah - 2	49	trimodal	"	1.2	5	65	30
Crim. Ck	15	? bimodal	"	0.6	<5	>40	55
Gordon Ls	66	? trimodal	"	0.3	~3	10	87
Eldon Gp	8	? "	"	0.9	?10	75	?15

This data is considered to show a trend from Oonah - 1 to Gordon Limestone, based on the following :

- the decline in median Ag/Pb ratios;
- the increasing size of sub population C (concomitant with decreasing size of sub population B).

Except for the fact that the Ag/Pb data for the Gordon Limestone characterises Pb Zn mineralization of Ordovician age, the trend in Ag/Pb values would appear related to cumulative thickness of "overburden" covering the Oonah Formation (Oonah-1) rocks ....ie to be a measure of increasing distance of hydrothermal fluid migration, with accompanying variation in fluid composition (& mineralogy etc) in accord with changing physico-chemical conditions.

However, the partitioned value of 1.3 for sub population B in the Gordon Limestone subset (Figure 7), and the (predominantly) unimodal aspect of the Ag/Pb values in mafic-bearing Oonah Formation, suggest a common genesis for all Ag Pb Zn mineralization in the Zeehan district; that source of base metals is considered to be within the Oonah Formation.

Explanation of the apparently discrepant data for the Eldon Group may be that it is in faulted juxtaposition with the "Oonah source beds", or that the data set is of limited statistical validity.

5 CONCLUSIONS

5.1 All previous exploration and mining effort on the Zeehan field has been directed at either Devonian age mineralization (vein hosted Ag Pb Zn, & carbonate replacement Sn), or Ordovician age mineralization (carbonate hosted exhalative Pb Zn); there is no record of any systematic exploration for base metals in the Precambrian age basement rocks.

5.2 Discrimination between Devonian age Sn Cu Sb Zn Pb Ag vein and carbonate-replacement style mineralization (with associated complex replacement parageneses and multi-stage veining), and syngenetic Pb Zn (Ag) mineralization of Proterozoic age, is complicated by the following :

- hydrothermal overprinting by Devonian fluids, and by
- polyphase deformational character of the Proterozoic rocks with potential for tectonically remobilized sulphide bodies.

5.3 Evidence supporting base metal mineralization in the Proterozoic age Oonah Formation is varied, but includes:

- the presence of a pyrite-galena-sphalerite association (probably spatially connected with the occurrence of mafic volcanics and carbonaceous shales); although many of the "pyritic formations" are likely to be of Devonian origin, occurrences of Pb Zn bearing pyrite at the Sunshine, Great Western, near Silver Beach and near Grubbs mines appear to pre date the Devonian age mineralization.

- the presence of two types of galena with notably different Ag/Pb ratios in the Susannite deposit, implies the coarse grained galena (Ag/Pb ~1.0) postdates the fine grained galena (Ag/Pb ~0.5), and the latter may be syngenetic in the Oonah Formation.

- the distributions of Ag/Pb ratios of the Devonian age Ag Pb Zn vein mineralization according to host rock, depict a trend interpreted to indicate a source of Ag Pb Zn in the Oonah Formation basement rocks.

5.4 Reconstruction of the regional stress regimes operative during mineralizing events in both Devonian and Ordovician time, has allowed the recognition of ENE/NE trending structural/mineralization corridors of likely (and possibly older than) Cambrian age.

Elucidation of the structural setting of the Zeehan area in late Proterozoic time is equivocal - available evidence can be interpreted to show several different mega lineament orientations.

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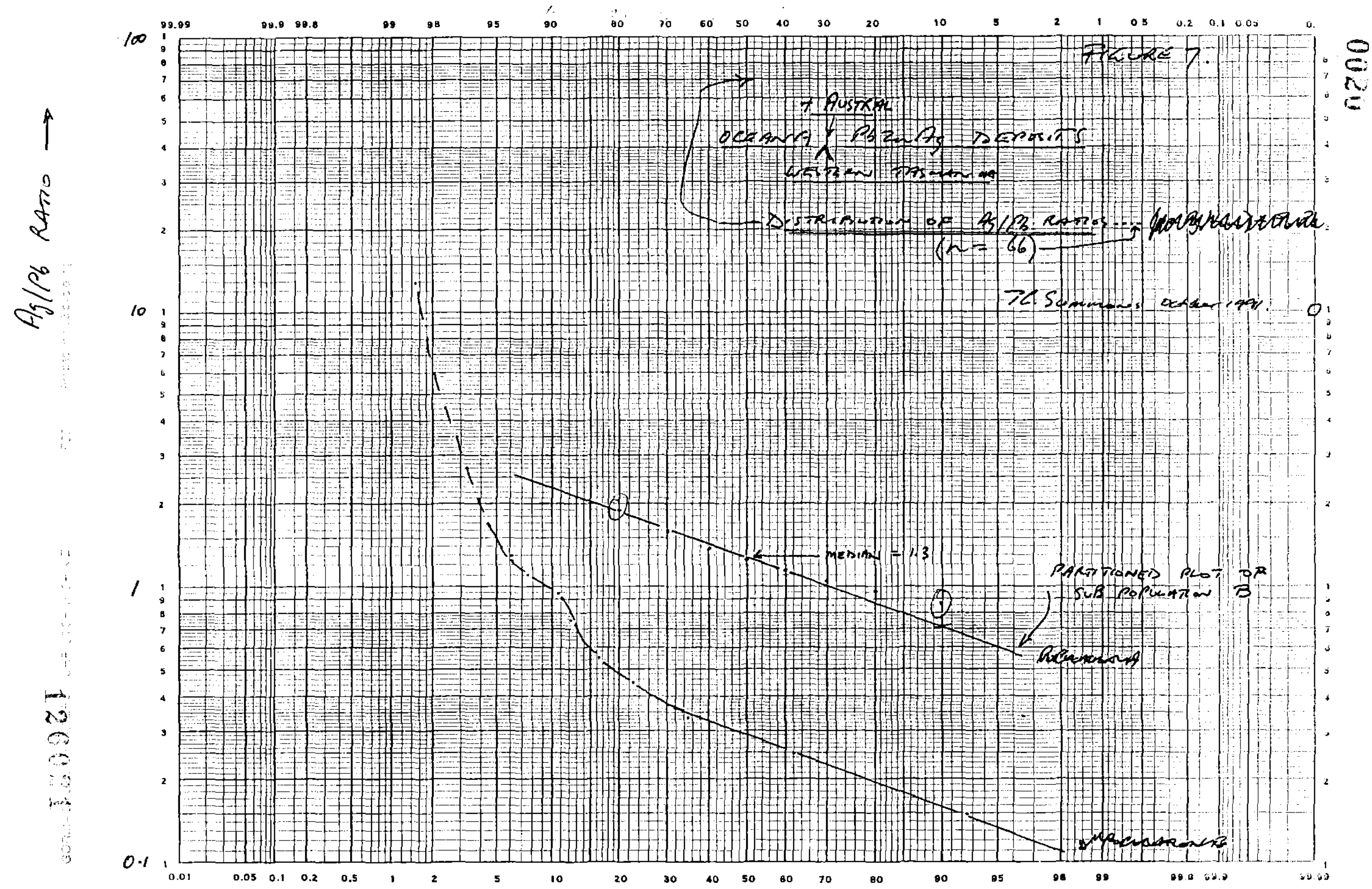


FIGURE 7.
+ AUSTRAL
OCEANIA Pb Zn Ag DEPOSITS
WESTERN TASMANIA
DISTRIBUTION OF Ag/Pb RATIOS
(n = 66)
MEDIAN = 1.3
PARTITIONED PLOT FOR SUB POPULATION B
Ag/Pb RATIO
CUMULATIVE FREQUENCY

SAME AS 6.

FIGURE 6.

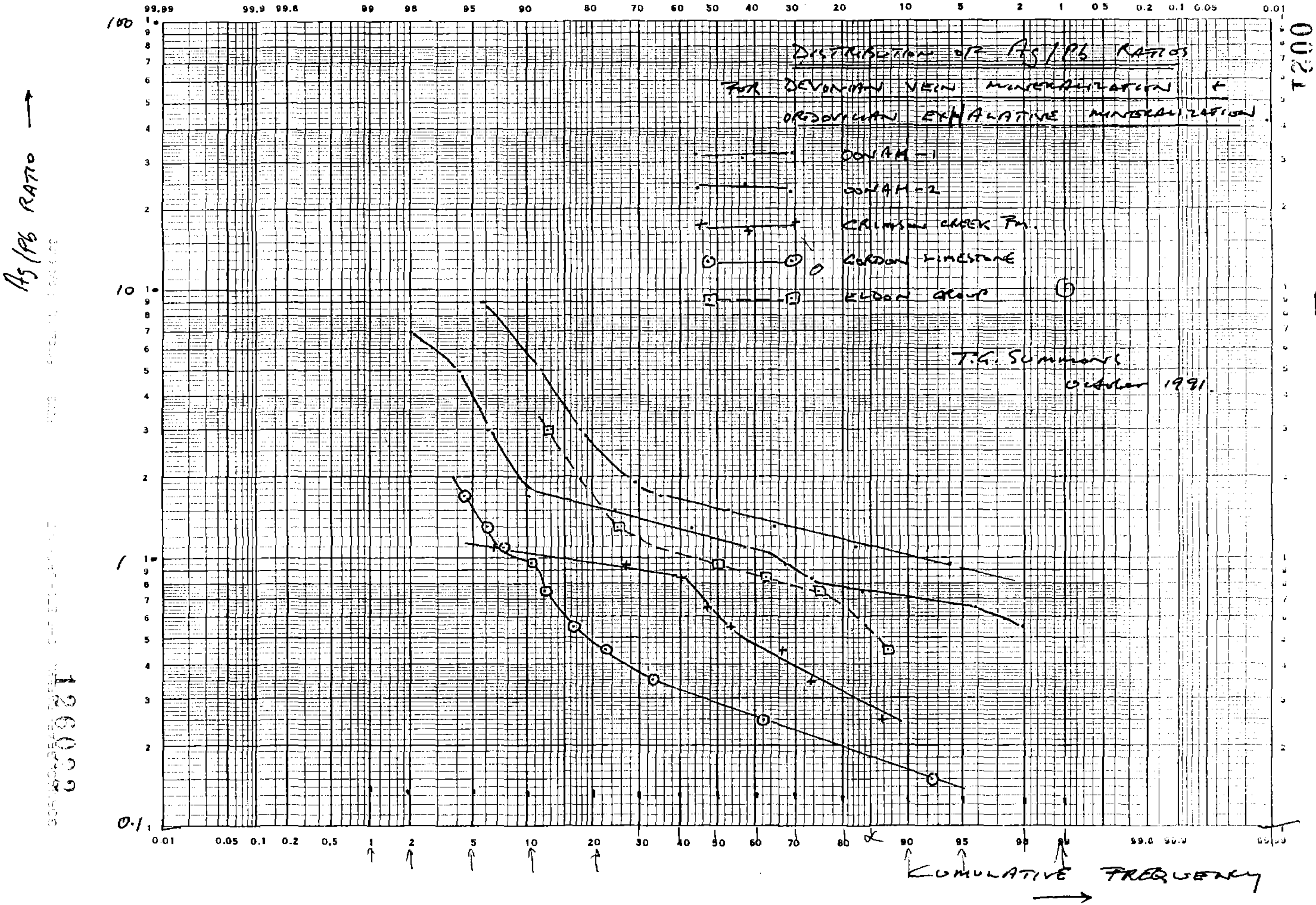
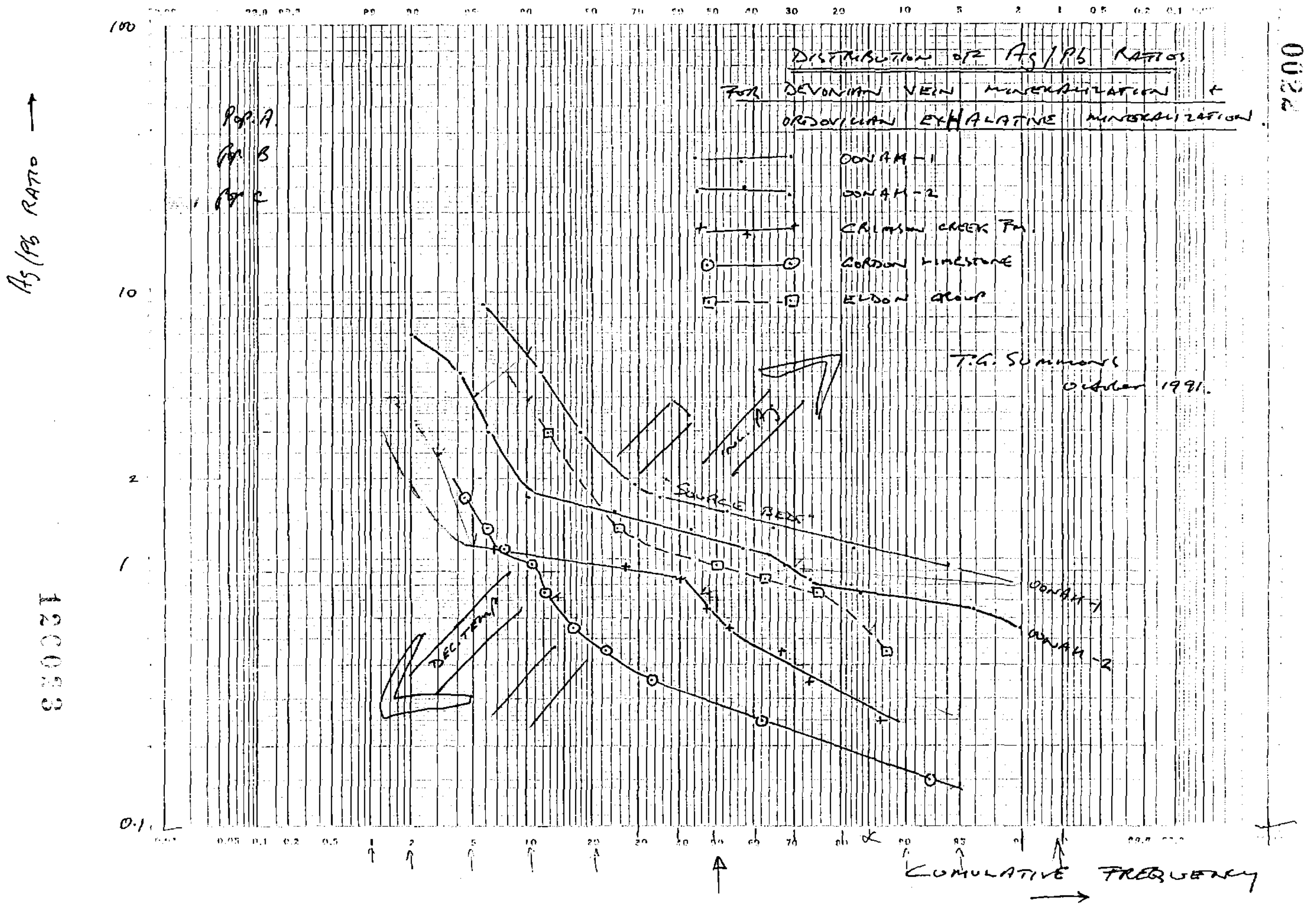

DISTRIBUTION OF As/Pb RATIOS
FOR DEVONIAN VEIN MINERALIZATION +
ORDOVICIAN EXHALATIVE MINERALIZATION.
OONAH-1
OONAH-2
CRIMSON CREEK FM.
GORDON LIMESTONE
ELDON GROUP
T.G. SUMMONS
October 1991.
As/Pb RATIO
CUMULATIVE FREQUENY

FIGURE 6.



0024

12063

126024

2. The large polymetallic deposits only occur north of the Henty Fault zone whilst small sub-economic deposits at Red Hills, the Comstock Valley and Voyager 19 lie within the volcanics to the south of the Henty Fault zone.

3. The polymetallic massive sulphide deposits occur locally within a narrow horizon of shales (e.g. Rosebery, Hercules) or epiclastics (e.g. Que River, Hellyer) which form part of a sequence of submarine volcanics, epiclastic tuffs and minor sediments.

4. Thick sequences of rhyodacitic [illegible] underlie some of the deposits (e.g. Hercules, Rosebery), which suggests a change from [illegible] to submarine conditions prior to mineralisation.

5. The silicate chemistry of the host [illegible] is not related to size or grade of the [illegible]. High-grade deposits are associated with host [illegible] of rhyodacite composition (Rosebery), [illegible] andesite composition (Que River) or andesite [illegible] composition (Hellyer).

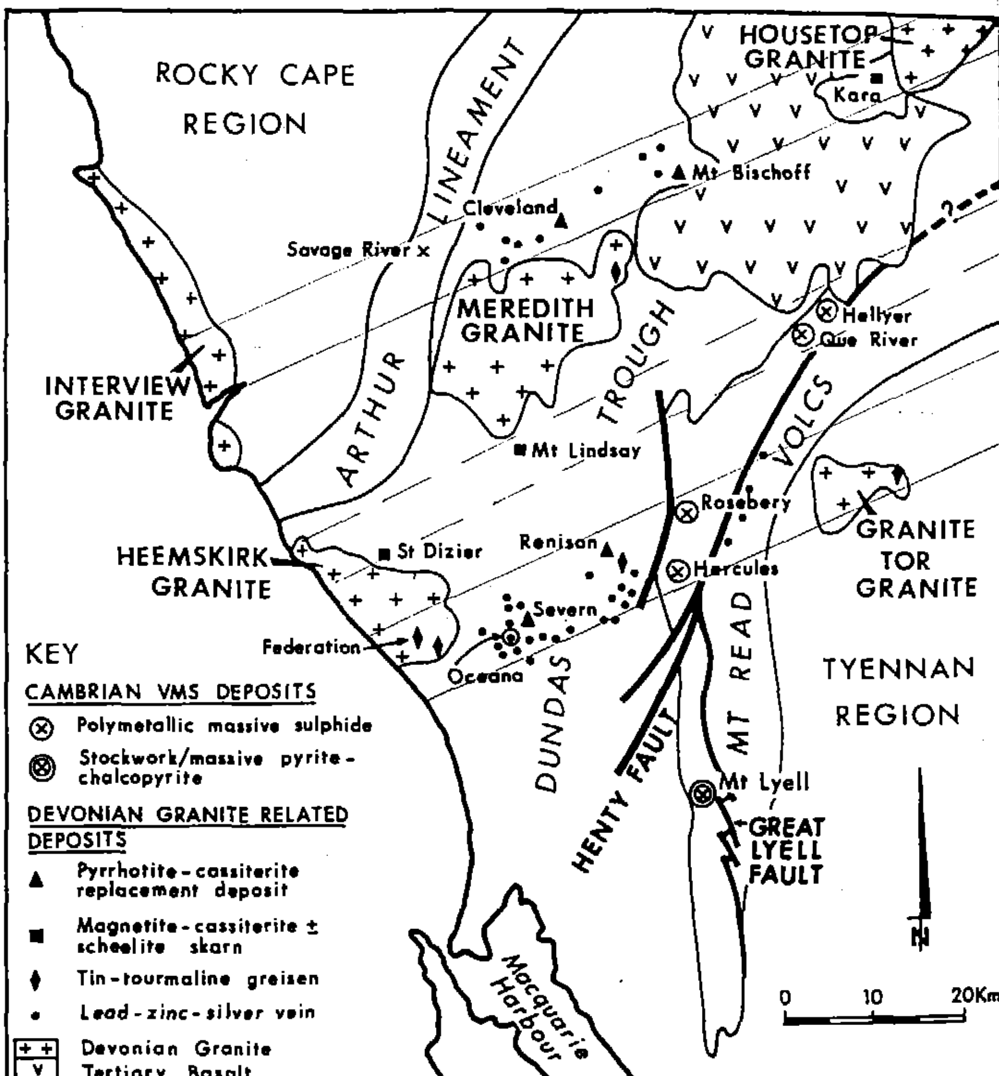
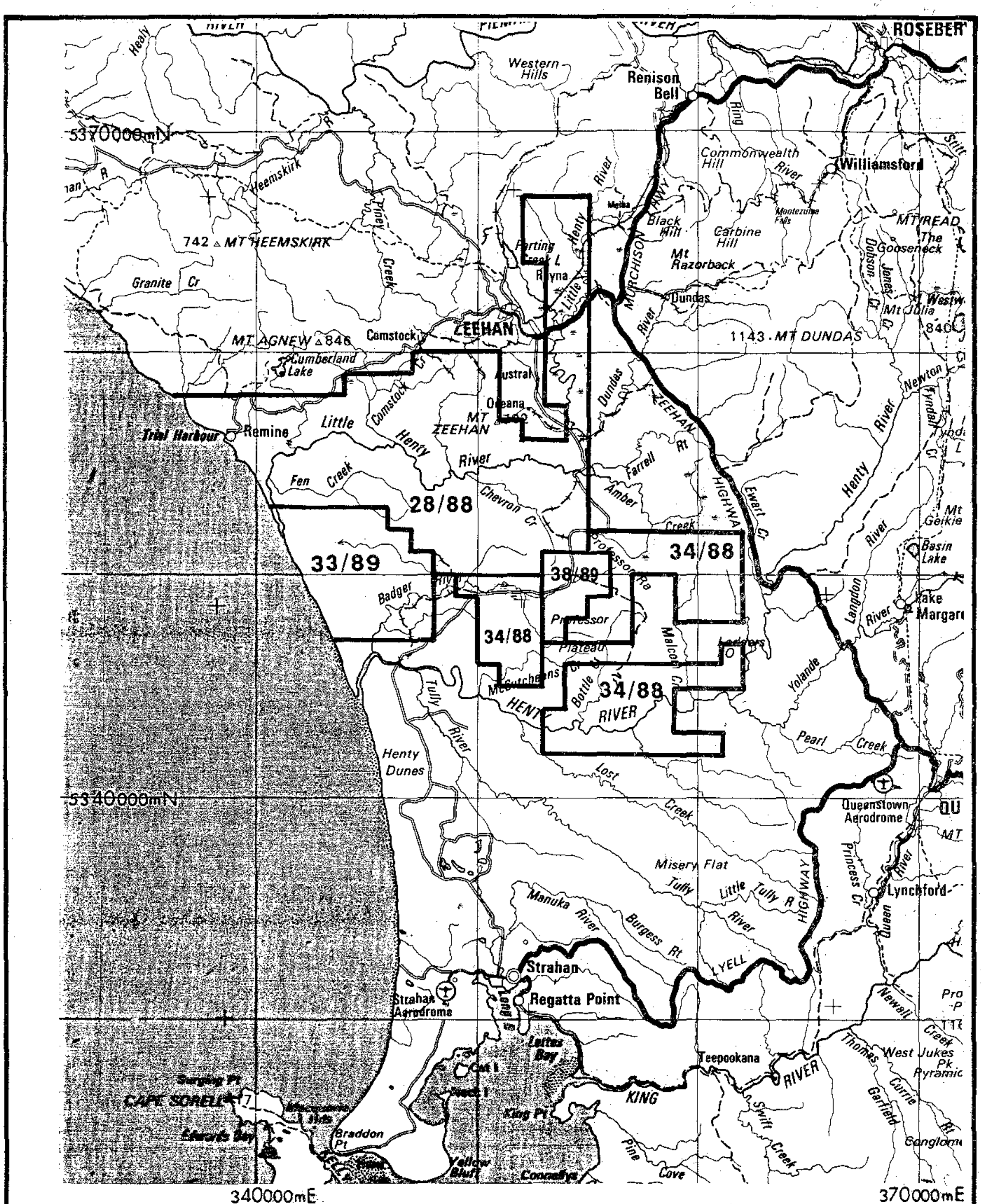


Fig. 11.2 Location of major mines and mineral occurrences in western Tasmania.

5 cm

0024



126025

5 cm

91-3313.

0 5 10 15km

CRA EXPLORATION PTY. LIMITED

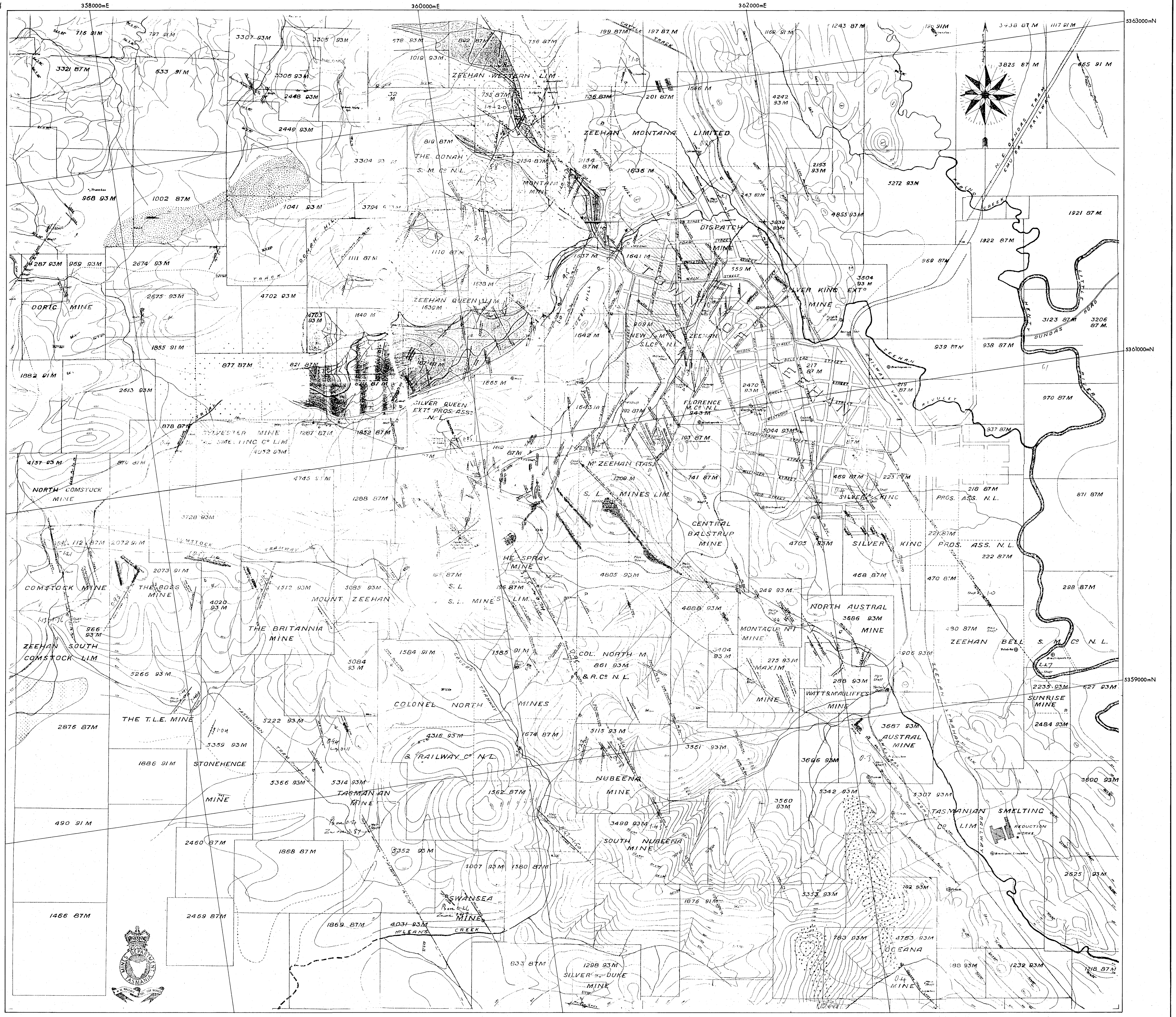
ZEEHAN JOINT VENTURES

LOCALITY PLAN

Figure 1

Geol: T. Summons	Scale: 1:250 000
Drawn: A.Jelen NOV.1991	Report No: 17636
Ref: SK55 - 5	Plan No: Tv 431

10153



- SILURIAN STRATA SLATES SANDSTONE &c.
- MELAPHYRE
- DYKES MASSES & BEDS OF MELAPHYRE IN SLATE & SANDSTONE
- MELAPHYRE-TUFFS WITH INTERBEDDED SLATE
- GABBRO & SERPENTINE
- SILURIAN CONGLOMERATE
- GLACIAL MORAINE
- IRONSTONE

STRIKE & DIP OF STRATA: SANDSTONE, SLATE

FOSSILIFEROUS STRATA ⊕

0 200 400 600 800 1000m

NOTE: (by G.A.Waller, 1904) enlarged to 1:10 000. AMG's are approximate.

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91-3313.

CRA EXPLORATION PTY. LIMITED

GEOLOGICAL SKETCH PLAN OF

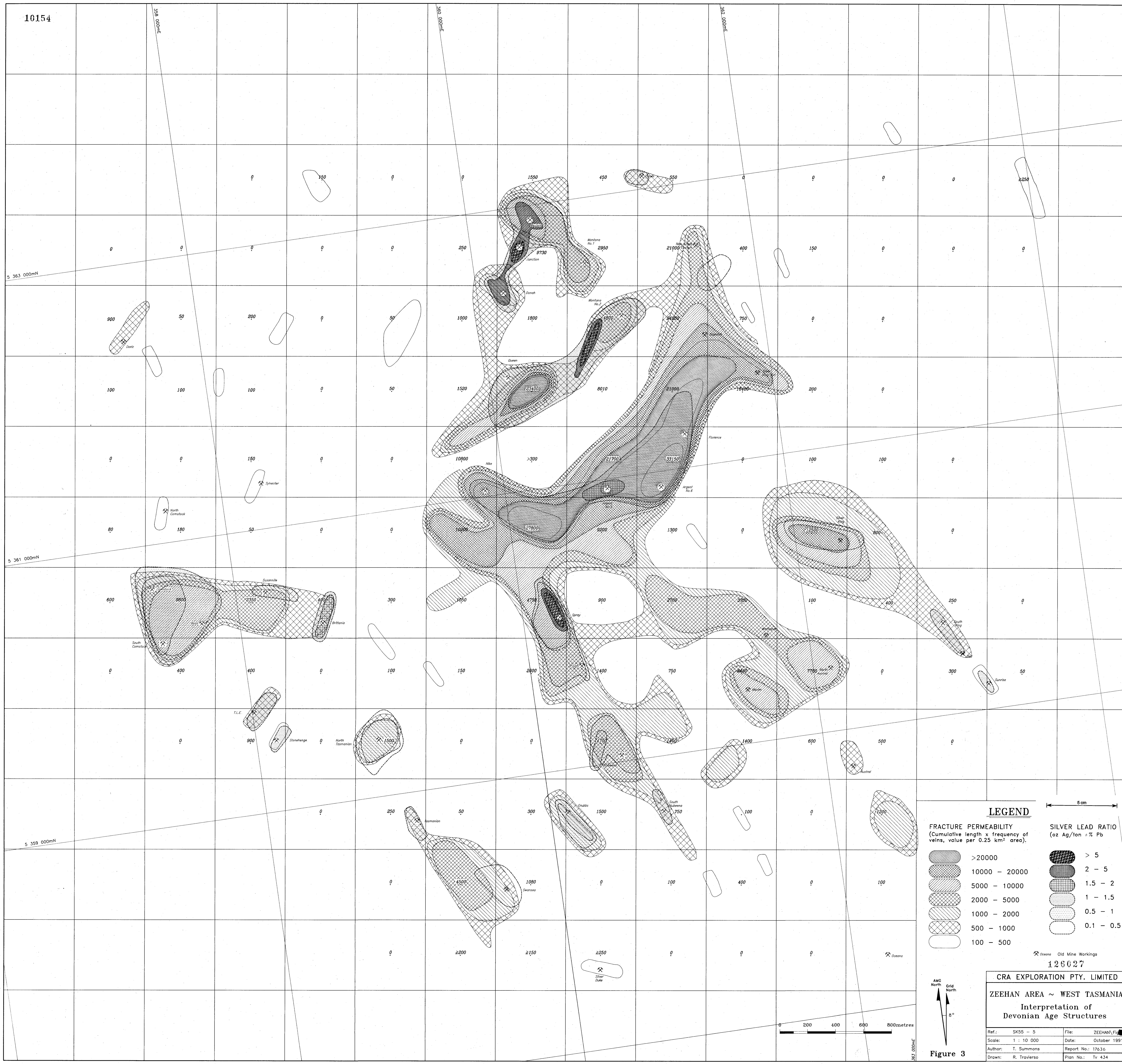
ZEEHAN MINING FIELD

5 cm

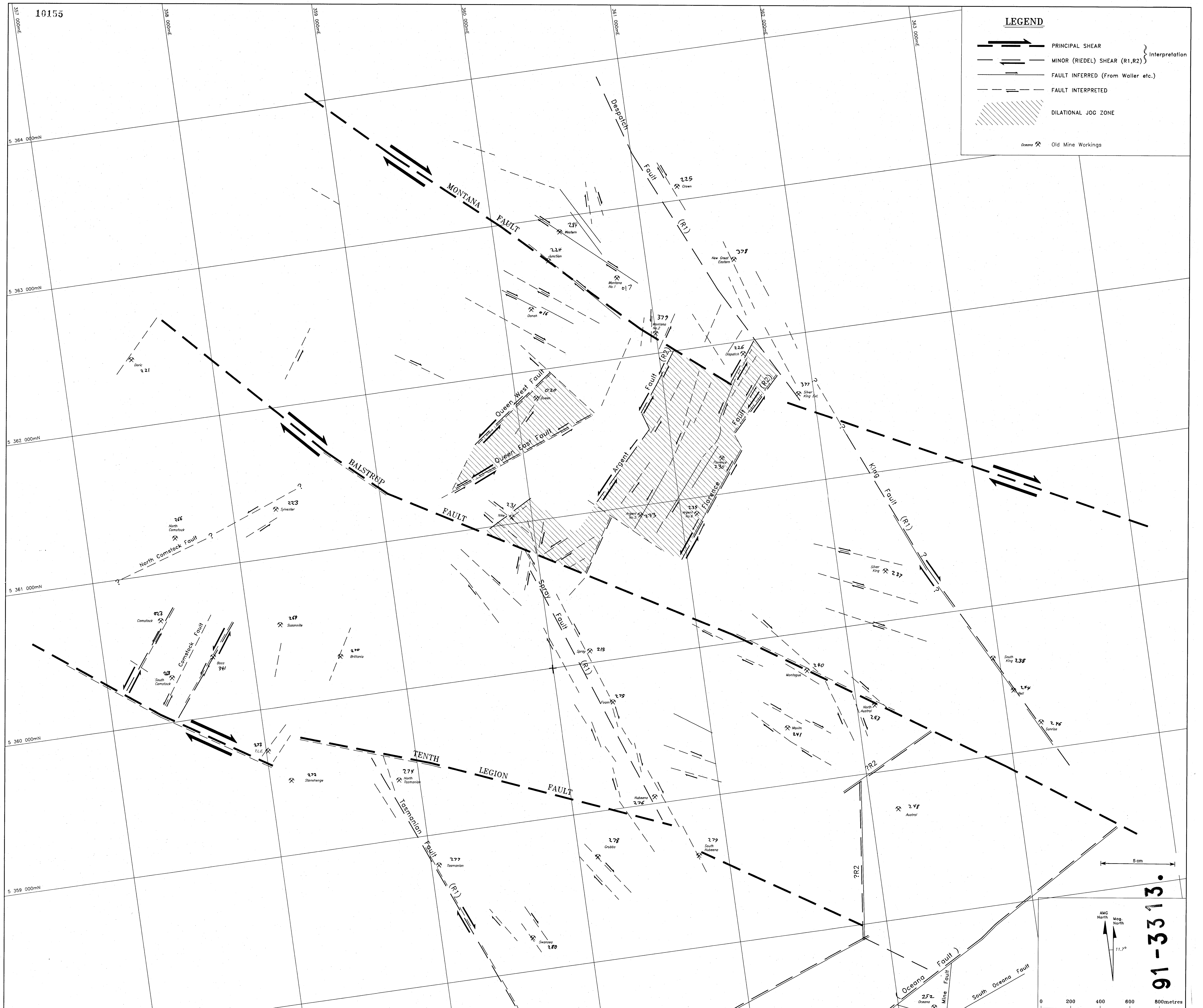
Figure 2

Ref.: SK55-5	Scale: 1:10 000
Author: Tas. Mines Dept.	Report No.: 17636
Drawn: NOV. 1991	Plan No.: Tv 432

10154


358 000mE
360 000mE
362 000mE
363 000mE
5 363 000mN
5 361 000mN
5 359 000mN
Montana No.1
Montana No.2
Junction
Oonah
Queen
Nike
Florence
Argent No.6
Silver King
South King
Sunrise
Doric
Sylvester
North Comstock
South Comstock
Britannia
Susannite
T.L.C.
Stonehenge
North Tasmanian
Spray
Grubbs
South Mt Zeehan
Austral
Tasmanian
Swansea
Silver Duke
Oceana
0
200
400
600
800metres
LEGEND
FRACTURE PERMEABILITY
(Cumulative length x frequency of veins, value per 0.25 km² area).
>20000
10000 – 20000
5000 – 10000
2000 – 5000
1000 – 2000
500 – 1000
100 – 500
SILVER LEAD RATIO
(oz Ag/ton ÷ % Pb
> 5
2 – 5
1.5 – 2
1 – 1.5
0.5 – 1
0.1 – 0.5
5 cm
Oceana Old Mine Workings
126027
AMG North
Grid North
8°
Figure 3
CRA EXPLORATION PTY. LIMITED
ZEEHAN AREA ~ WEST TASMANIA
Interpretation of
Devonian Age Structures
Ref.: SK55 – 5
File: ZEEHAN\Fig[redacted]
Scale: 1 : 10 000
Date: October 1991
Author: T. Summons
Report No.: 17636
Drawn: R. Travierso
Plan No.: Tv 434

10155



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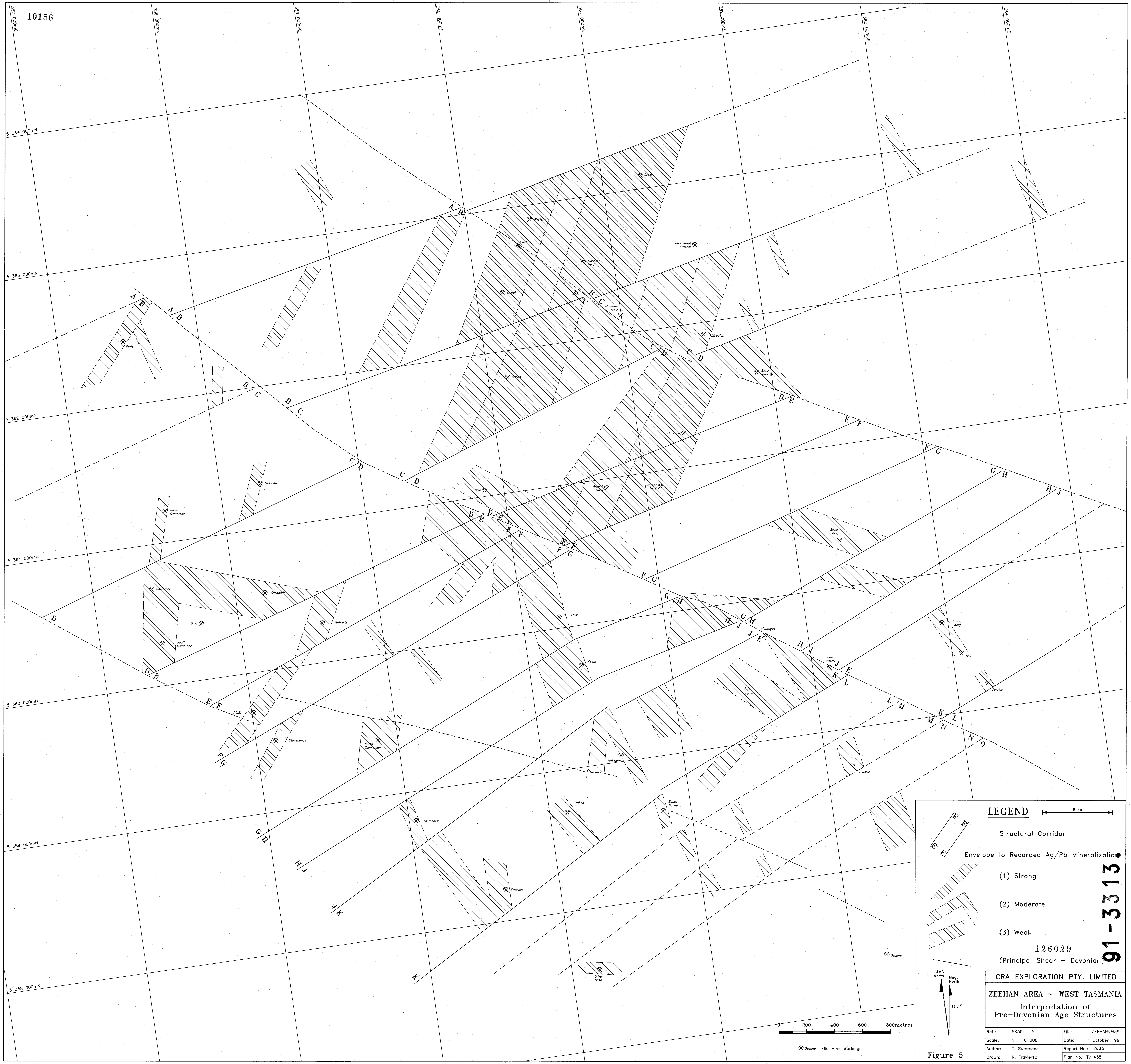
ZEEHAN AREA ~ WEST TASMANIA

Interpretation of Devonian Age Structures

Figure 4

Ref.:	SK55 – 5	File:	ZEEHAN\Fig4
Scale:	1 : 10 000	Date:	October 1991
Author:	T. Summons	Report No.:	17636
Drawn:	R. Travierso	Plan No.:	Tv 434


10156
357 000mE
358 000mE
359 000mE
360 000mE
361 000mE
362 000mE
363 000mE
364 000mE
5 364 000mN
5 363 000mN
5 362 000mN
5 361 000mN
5 360 000mN
5 359 000mN
5 358 000mN
Western
New Great Eastern
Montana No.1
Montana No.2
Dispatch
Queen
Florence
Sylvester
North Comstock
Comstock
Boss
South Comstock
Brittania
Spray
Foam
Montague
North Austral
Silver King
South King
Bell
Sunrise
Maxim
Stonehenge
North Tasmanian
Nubeena
Austral
Grubbs
South Nubeena
Tasmanian
Swansea
Oceana
Silver Duke
LEGEND
5 cm
Structural Corridor
Envelope to Recorded Ag/Pb Mineralization
(1) Strong
(2) Moderate
(3) Weak
126029
(Principal Shear - Devonian)
91-3313
AMG North
Mag. North
11.7°
CRA EXPLORATION PTY. LIMITED
ZEEHAN AREA ~ WEST TASMANIA
Interpretation of
Pre-Devonian Age Structures
0 200 400 600 800metres
Oceana Old Mine Workings
Ref.: SK55 - 5
File: ZEEHAN\Fig5
Scale: 1 : 10 000
Date: October 1991
Author: T. Summons
Report No.: 17636
Drawn: R. Traviorso
Plan No.: Tv 435
Figure 5

10157

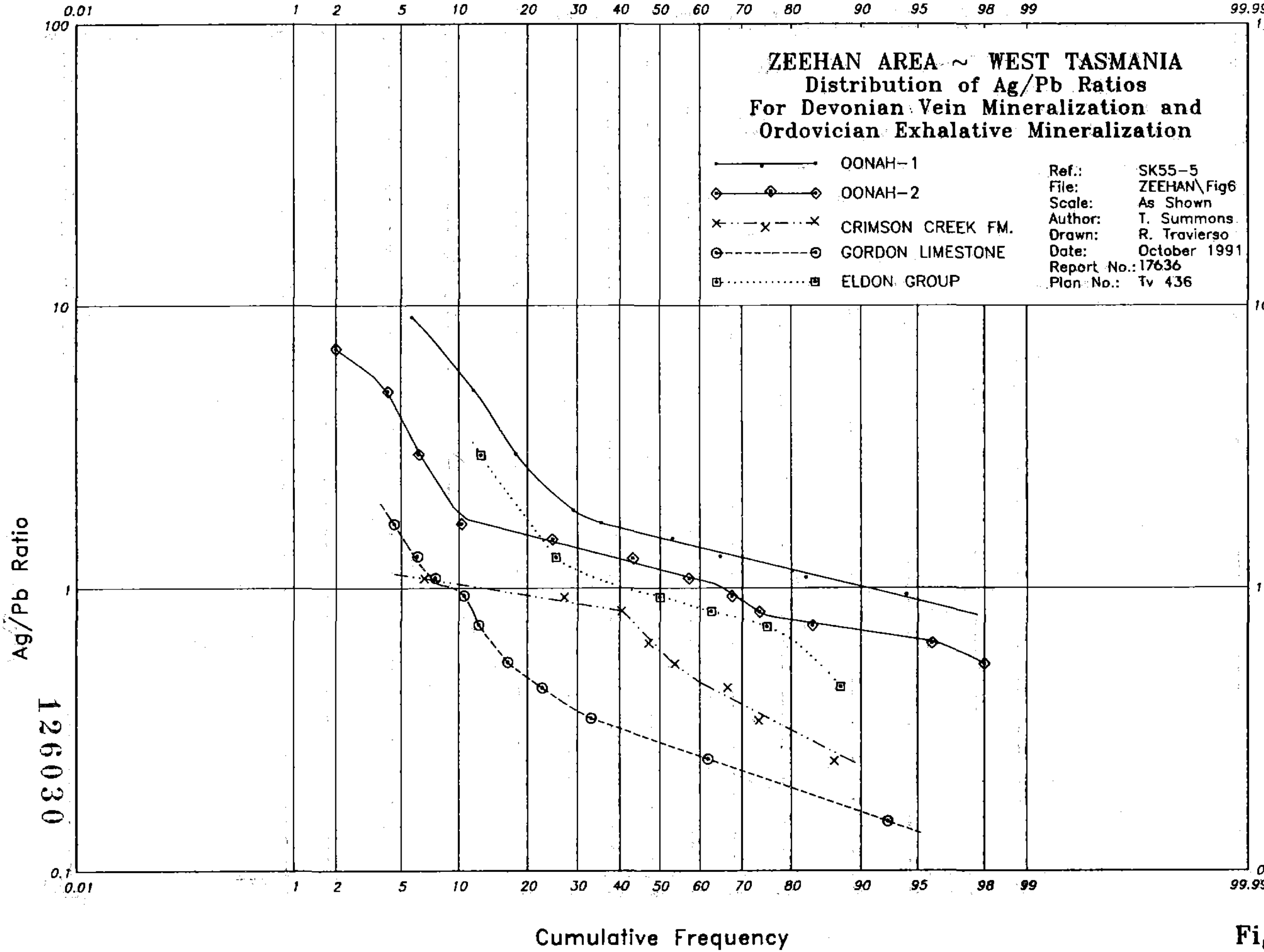


Fig. 6

91-33 3.

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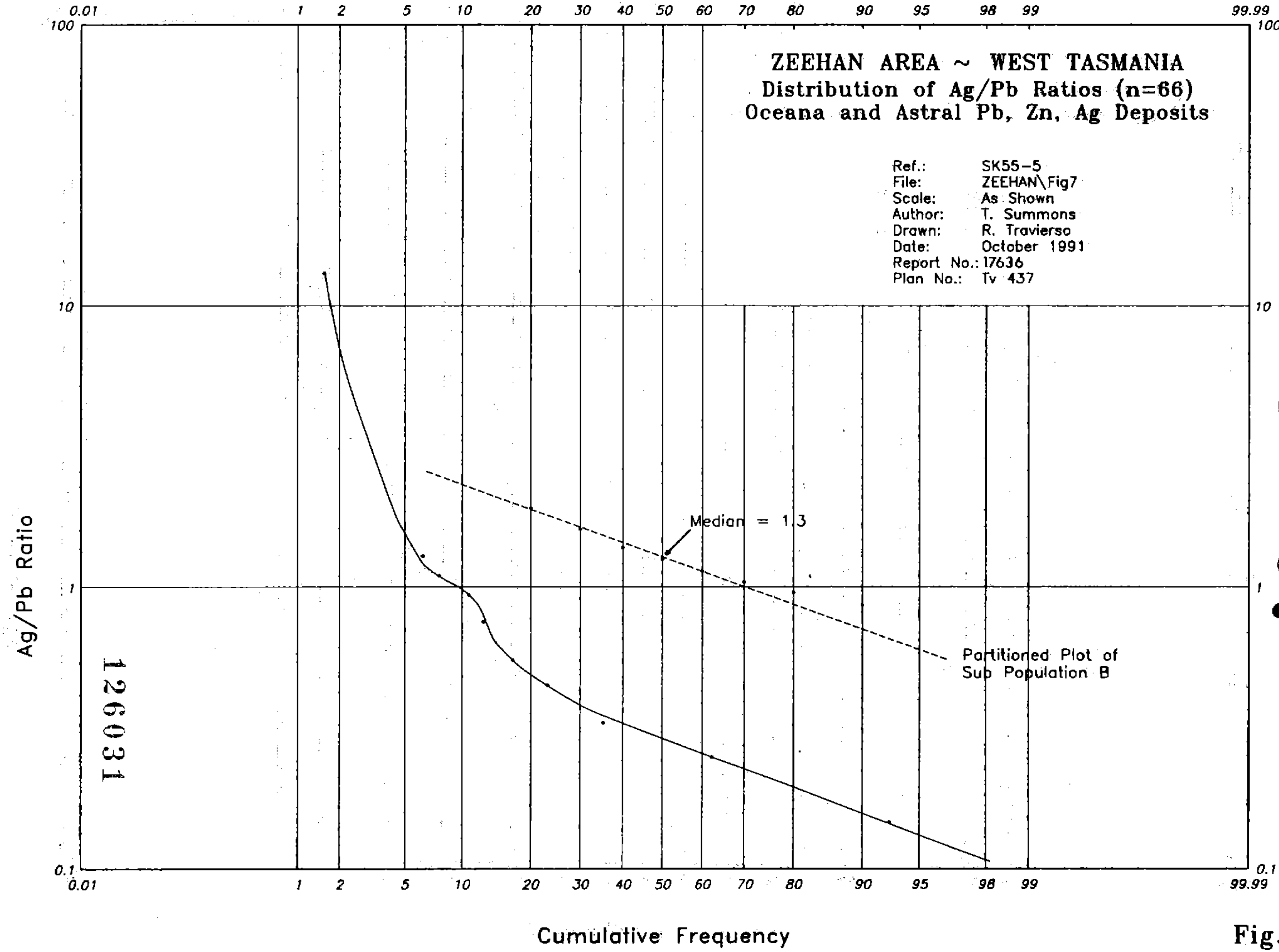

Fig. 7

126031
91-33.3.
10158