000

72 001

D of M | A.D. | G. | E.O. | D.S.M.E
Registrar
Received 1 - SEP 1983 | E & IL
Answered
DEPT. OF MINES
REF. No. 8084/83
83-2028
Vol 1/4

GEOLOGICAL ASSESSMENT OF THE FOLEY ZONE MINERALIZATION AT CLEVELAND MINE TASMANIA.

ERRATA

PLEASE READ ALL REFERENCES TO "FLOURITE" AS "FLUORITE".

EVD AUG. 1983

BY: E V DRONSEIKA
PROJECT GEOLOGIST
CLEVELAND TIN LTD

MAY 1983

TABLE OF CONTENTS

1. GENERAL GEOLOGY

1.1 Geologic Setting
1.1.1. Regional
1.1.2. Local
1.2 History of Discovery and Exploration
1.3 Data Collection Methods

2. DETAILED GEOLOGY

2.1 Quartz Porphyry Intrusive
2.1.1. Location, Dimensions and Shape
2.1.2. Structural Control
2.1.3. Lithological Control
2.1.4. Original Mineralogy
2.1.5. Alteration

2.2 Vein Stockwork
2.2.1. Location and Dimensions
2.2.2. Veining Sequence
2.2.3. Location of Vein Phases
2.2.4. Vein Mineralogy
2.2.5. Zoning Within Individual Vein Phases
2.2.6. Metal Zoning
2.2.7. Multiple Veining
2.2.8. Evolution of Veins
2.2.9. Vein Density
2.2.10. Vein Orientation
2.2.10.1 Drill Core
2.2.10.2 Underground Exposure
2.2.10.3 Implications for Drilling
2.2.11. Vein Size
2.2.12. Vein Grades

2.3 Wall Rock Alteration

2.4 Hydrothermal Brecciation

2.5 Tin Lode Mineralization and Foley Zone

2.5.1. Relationship

2.5.2. Wolframite Bearing Henry's Lens

2.5.3. Genetic Implications

2.6 Comparisons With Similar Deposits

2.7 Academic Work

3. EXPLOITATION IMPLICATIONS

3.1 Assay Results

3.1.1. Major Metals

3.1.2. Trace Elements

3.1.3. Assay Repeatability

3.2 Geostatistics

3.2.1. Compositing

3.2.2. Distributions

3.2.3. Variograms

3.2.4. Kriging

3.3. Geological Resource

3.4. Ground Conditions

3.5. Groundwater and Gas Problems

3.6. Photometric Sorting

4. FUTURE EXPLORATION

4.1. General Exploration Approach

4.2. Exploration Potential At Cleveland (Foley North?)

4.3. Recommended Further Drilling

ACKNOWLEDGEMENTS

REFERENCES

APPENDICES

A. Petrology
B. Major and Minor Metal Assays
C. Geostatistics
D. Metallurgical Results
E. Groundwater Monitoring Results

LIST OF DIAGRAMS

1. 9 Level Assay Plan - Zinc
2. " " " " - Copper
3. " " " " - Chromium
4. " " " " - Cobalt
5. " " " " - Total Tin
6. " " " " - Lead
7. " " " " - Bismuth
8. Longit. Proj. Halls - Zinc distrib.
9. " " " - Lead "
10. " " " - Bismuth "
11. Plan of 32 level R.L. 850m
12. Schematic Longit. Proj. of Quartz - Porphyry
13. Quartz Porphyry Exposure 25 level.
14. Paragenetic Mineral Sequence.
15. Section 4960E. Vein/alteration distribution - Phase V3 (Quartz)
16. " " " " " - Phase V4 and V5 (Quartz-sericite)
17. " " " " " - Phase V6 (Quartz-molybdenite)
18. " " " " " - Phase V7 (Quartz-wolframite)
19. " " " " " - Phase V8 (Quartz-siderite)
20. " " " " " - Phase V9 (Topaz-pyrite)
21. Assay Profile DDH C1713
22. Vein Number - Dip Distribution DDH C1615
23. Vein orientations - Stereographic Projection
24. Vein Mapping Plan - 21 Level Battery Access Drive
25. Vein Number - Size Distribution DDH C1615
26. % Thickness - Size Distribution DDH C1615
27. Vein Number (<1cm) - Size Distribution DDH C1615
28. % Thickness - Size Distribution DDH C1608
29. Vein Size Distribution DDH C1713

30. Vein Density vs Assays DDH C1754
31. Longit. Proj. of Halls B Lens Mineralogy
32. Longit. Proj. of Henry's Lens
33. Vein Stockwork Khazakstan Deposit U.S.S.R. (after Scherba)
34. Assay Profile DDH C1637
35. Assay Profile DDH C1642
36. Long. Proj. Halls B Lens. Exploration Target.

006

LIST OF PHOTOGRAPHS

1. - Discordant topazized quartz porphyry intrusive contact (left) with shale (right) 25 level decline.
2. - Topazized quartz porphyry apophysis (outlined in red) within shale and sandstone in 25 level decline. Distance between yellow marks 1m.
3. - Aerial photograph of mine workings showing east-west trending Foley lineament.
4. - Remnant zoned feldspar in sericitized quartz porphyry. Dark spots are tourmaline. DDH C1615 - 189.3m.
5. - Topazized, pyrite-cassiterite bearing quartz porphyry. DDH C1713 - 209.6m scale in cms.
6. - Topazized quartz porphyry with pyrite "ghost" after original feldspar. DDH C1615 - 247.9m.
7. - Topaz-pyrite altered porphyry (top) with grey sericite alteration (below). Relict feldspars (brown) are replaced by siderite. DDH C 1615 - 208.8m.
8. - Sericite-illite altered (greisenized) sandstone cut by later quartz veins. DDH C1713 - 195.6m.
9. - Grey sericite alteration and yellow illite alteration contact in quartz porphyry. Fine dark spots are wolframite and sphalerite. DDH C1713 - 227.5m.
10. - Yellow illite alteration (left) with kaolinite alteration (centre) and sericite alteration (right) in quartz porphyry. DDH C1633 - 542.8m.
11. - Kaolinite altered quartz-porphyry. DDH C1713 - 201.8m.
12. - Multi-pulse illite altered sericite veins (V3, V4) cut by later sericite - quartz veins (V5). DDH C1634 - 106.6m.
13. - Cross cutting veins sub-horizontal multi-pulse mineralized vein (V7) cutting earlier near-vertical compounded quartz veins (Ve & V6). DDH C1754 - 170.4m.
14. - Composite quartz veins with phases V6, V7 & V9 (vertical-right side) cutting earlier quartz sericite veins V4. DDH C1634 - 159.8m.

007

15. - Localized siderite replacement of multi-pulse quartz-sericite veins (V4). Mineralized quartz vein (V7) at bottom. DDH C1634 - 138.8m.
16. - Wolframite bearing quartz vein (V7). Note molybdenite selvage on vein contact. Illite-flourite in centre of vein. 21 battery access drive east side-wall.
17. - Wolframite blade with inclusions of bismuthinite and native bismuth, minor molybdenite against wolframite. Quartz with yellow interstitial illite. Blade is approx. 14mm long. DDH C1634 - 145.4m.
19. - Arsenopyrite-pyrite-tourmaline vein (V8) with silicified contacts against weakly biotite altered sandstone. DDH C1637 - 60.5m. scale in cms.
20. - Pyrite-quartz-chalcopyrite-sphalerite vein (V8) in topaz altered mineralized quartz porphyry. DDH C1634 - 108.9m.
21. - Brown siderite replacement after earlier multiple sericite and quartz veins. DDH 1637 - 94.10m.
22. - Quartz-topaz-pyrite vein (V9). 21 Battery Access Drive east sidewall.
23. - Numerous very thin late quartz-topaz-pyrite veinlets (V9). Veinlets form directly up-dip from porphyry 60m below. 21 Battery Access Drive west sidewall.
24. - Dense compound veining (bottom half of tray). DDH C1637 -81m.
25. - Multiple invasions of several vein phases (V3, V6, V7, V8, V9) producing one apparent vein. DDH C1803 - 102.7m.
26. - Well mineralized zone. Dark spots in quartz veins are wolframite. DDH C1754 - 148m.
27. - Stage V6 and V7 mineralized veins (vertical) forming composite (side by side) single vein at top. Early stage V3 vein horizontally. 21 Battery Access Drive west sidewall.
28. - Highly irregular gashing and "stoping" flat quartz veins. 21 Battery Access Drive loading bay.
29. - Early stage V3 vein tension gash type junction. Higher

008

vein on right side indicates possible porphyry centre to the right. 21 Battery Access Drive east sidewall.

30. - Siderite-sericite bleached sandstone with dark grey tourmaline alteration. Mineralized vein (V7) with topaz-pyrite centre (V9) on left. DDH C1754 - 146.5m.

31. - Intense tourmaline altered quartz porphyry (top left) against bleached (siderite, sericite, clay altered) sandstone. DDH C1633 -496.9m.

32. - Interconnecting flat near barren quartz veins (V3). Note dark tourmaline alteration adjacent vein in bleached sandstones. 21 Battery Access Drive west sidewall.

33. - Siderite, sericite, clay altered (bleached) sandstone surrounded by brown biotite altered sandstone. 21 Battery Access Drive east sidewall. 1m between white paint marks.

34. - Wolframite clots (circled) in green biotite-flourite-sellaite altered Henry's lode. DDH C1754 - 61.1m.

35. - Sericite-tourmaline matrix breccia with quartz, country-rock fragments. Sericitized porphyry on extreme left. Sandstone on right. DDH C1741 - 99.1m.

36. - Very late stage pyrite-marcasite vughy breccia. DDH C1811 - 90.1m.

37. - Native bismuth (white) and bismuthinite (grey) in quartz-sellaite altered tin lode (Henry's). DDH C1842 - 42.9m.

38. - Heavily topazized Henry's lode (left) against topaz-flourite vein V9 (right). 21 Battery Access Drive west sidewall.

39. - 15mm to 65mm particle size "accept" from photometric sorter.

40. - 15mm to 65mm particle size "reject" from photometric sorter.

INTRODUCTION

The success of any future commercial exploitation of a mineral deposit is dependant on good foundational information be it economic, metallurgical or geological. The work within the report provides a basic geological understanding of the deposit.

This report documents work carried out in the exploration of Foley Zone at Cleveland up to April 1983. Most of the information is derived from diamond drilling carried out from early 1980 up to the present date. It was unfortunate that full-time work had not commenced earlier so that important exposures such as the porphyry intersection in the main decline could have been observed more carefully while they were still fresh. Time, new observations, further drilling and new exposures underground will obviously change many of the author's conclusions.

Foley Zone is named after J.L. Foley who first pegged a lease at Cleveland in 1900 (Cox 1968). He first thought the gossan outcrops to be cappings on silver-lead lodes.

010

SUMMARY

Foley Zone is composed of an altered cassiterite bearing quartz-feldspar porphyry intrusive plug or dyke surrounded by a tungsten-molybdenum-bismuth mineralized quartz-flourite vein stockwork.

At a 0.2% WO_3 cut-off the indicated geological resource above 850 R.L. is 3.8 million tonnes at 0.28% WO_3, 0.05% Sn, 0.02% MoS_2.

A second mineralized system similar to Foley Zone is inferred to exist north of Foley Zone at a much deeper elevation.

DISCUSSION

1. GENERAL GEOLOGY

1.1 Geological Setting

1.1.1. Regional

The Cleveland deposit, situated at Luina in north-western Tasmania is located approximately 12 km west of Waratah and 65 km south-west of Burnie. The tin ore-bodies currently mined are of the 'sulphide-cassiterite' type of which Renison Mine and Mt. Bischoff Mine are other examples.

The deposit occurs within an early Palaeozoic north-south trending eugeosynclinal trough (Dundas) located between two regions of Precambrian basement rock (Collins 1981). It lies within an unfossiliferous sequence dominated by interbedded argillite, siltstone, greywacke turbidite with conglomerate, chert, limestone and basaltic volcanic rock probably equivalent to the Crimson Creek Formation of Early Cambrian age that outcrops in the Renison Bell area (Blissett 1962). To the west are fault-bounded partially serpentinized ultramafic and mafic rocks of the Heazlewood River Complex. As a result of the Devonian Tabberabberan orogeny several granite plutons (Meredith, Heemskirk, Pieman, Interview River) were intruded into the sequence during Late Devonian to Early Carboniferous times. The tin replacement bodies and tungsten stockwork mineralization at Cleveland together with much of the tin replacement, skarn, greisen and silver-lead-zinc vein mineralization in Western Tasmania are believed to be genetically associated with the intrusion of these granitic plutons. The nearest known surface exposure of granite is 4 kms south of the mine workings. Quartz porphyry dykes probably contemperaneous with the intrusion of the Meredith granite occur throughout the area. The Foley porphyry and the dykes at Mt. Bischoff are examples of these. A few dolerite dykes intruded the Cambrian sequence of the area during the Jurassic. A large partially eroded Tertiary basalt sheet covers an area to the east of Luina.

1.1.2. Local

Four main stratigraphic units are recognized within the sequence of the mine area.

1. Ultrabasic Sequence - Very little detailed geology is known due to poor surface exposures and very limited diamond drilling intersections. Dark grey-green serpentinites and lighter talc rocks occur interbanded with altered gabbros, dolerites and other basic rocks. The sequence is thought to have been emplaced 'en masse' and faulting is evident along its contact with the Crescent Spur Sandstone unit. It is a part of the Heazlewood River Complex (Rubenach 1973).

2. Crescent Spur Sandstone - This unit is typically a turbidite sequence from 30m to over 350m thickness (Collins 1980) and composed of grey fine to medium grained micaceous greywacke with interbedded red and brown argillite and minor grey banded chert. Minor serpentinites and altered basic rocks also occur interbedded or tectonically intruded within sandstone and argillite-shale in an area adjacent to the Ultrabasic Sequence.

3. Halls Formation - Approximately 100m thick near surface to 200m thick at depth, this unit is dominated by light grey to dark brown shale and interbedded sandstone-greywacke with lesser chert and an internal unit of mafic pyroclastics and volcanics (Henry's volcanics). At least 10 discrete lenses of tin mineralization are recognized within the formation. Some tin lenses have been observed to continue into limestone in the north of the mine.

4. Deep Creek Volcanics - These are composed of predominantly massive basaltic lava of spilitic composition with intercalated and interbedded pyroclastics, volcanoclastic greywacke, argillite and red-grey chert, and have an overall thickness of around 200m.

Within the immediate mine area, the sequence strikes NNE and dips very steeply (80°) to the east. Several low angle reverse faults dissect the sequence.

1.2 History of Discovery and Exploration

In June 1970, 0.77% WO_3 was detected in sample 2790 from hole C2 drilled into near surface Battery lens. The assay was queried but later dismissed as being only of academic interest.

A mineralogical report numbered 1398 from McPhar Geophysics and dated November 1973 described "greisenized mineralized skarn' from sample 91497 whose location within the mine remains unidentified.

Although not documented a project initiated by K.G. Palmer between 1974 and 1978 aimed to establish a metal zoning pattern within and encompassing the main tin lode horizons. The metal content of veins was thought to mimic and reflect some of the basic metal variations in the tin lode they surrounded. The metals assayed for were Cu, Pb, Zn, Bi, Co, Cu and Sn. Certain elements showed a zoning tendency around an area in the central region of the mine (see diag. 1 to 10).

A central high temperature zone was inferred characterized by the presence of wolframite, bismuthinite and molybdenite, surrounded by an outer low temperature zone defined by the appearance of galena and sphalerite. During 1978 mining development on 17 B-South Drive and 20-22 Level Decline exposed molybdenite and wolframite bearing quartz veins above the inferred zone. In November 1978 two holes were initiated (K.G. Palmer 1978) to test this high temperature zone but drilling was delayed due to the lack of suitable sites. In February 1980, the 'discovery hole' C1485 the first of the proposed holes, intersected increasingly mineralized quartz vein stockwork and altered quartz porphyry at about R.L. 1000 elevation (sea-level) on Halls Gd section.

Following hole C.1485 two holes (C.1501 and C.1570) were drilled some 120m north and south of C.1485 on Halls J and GK section to test for strike continuation of mineralization intersected in hole C.1485. Only very weak mineralization was detected. In November, 1980, the 24-26 Level Decline intersected weak stockwork and heavily altered quartz porphyry at about 1000RL on Hall's Gc section. Two holes (C.1608 and C.1611) were collared on Gd section near to the newly exposed quartz porphyry in the decline in an attempt to establish the attitude of the dyke. Large quartz stockwork zones were encountered but no porphyry. A vertical hole on 25 Level (C.1615) intersected moderate stockwork and porphyry 80m below the collar. Two holes (C1627 and C1634) were drilled on the northern side of the porphyry on Ga section. Patchy stockwork and traces of quartz porphyry in the form of thin veins were observed. One hole (C1633) further north on J section fortunately deviated enormously and intersected altered porphyry at the very deep level of RL550 (450m below sea level). The hole had swung around perpendicular to the strike of Foley Zone.

Given the limited amount of porphyry intersections a body steeply dipping (80° to the north) and cross-cutting the stratigraphy (with a strike of 280°) was suggested (see diag. 11).

In July, 1981, a new grid based on the orientation of Battery Reference Plane (strike 290°) was established. Hole C1637 was attempted across the width of the intrusive intersecting minor quartz porphyry, dense stockwork and alteration where they had been projected to lie. It became apparent that the inferred strike and dip direction of the porphyry was valid. Shortly after, hole C1642 was drilled some distance up-dip from C1637. Low grade mineralization was intersected at its projected position thus confirming the inferred dip. The new Foley Grid was maintained and no further drilling on Hall's sections was attempted. Given the satisfactory results of the previous drilling in July, 1981, a proposal (E.V. Dronseika, 1981) based on an urgency to define the zone was submitted in accordance with the

Foley Zone Master Plan (C.I. Roberts 1981). A platform just above 26 Level was recommended with 370m of horizontal development and sky-raises at 8 drill sections spaced at 40m intervals.

There would be a fan of 4 holes per section with each section generating a total of 900m of drilling. A total of 7200m of drilling was planned. The recommendation was adopted and access development for drilling sites attempted in earnest although the actual progress of the main access decline was slow. In December, 1981, this proposal was modified due to a drop in urgency and drilling commenced in January, 1982. The number of holes was reduced to 13 and totalling only 3150m. Drill holes towards the extremities of the projected mineralized zone (included in the previous recommendation) were not planned but would be initiated later should earlier holes show encouragement. Most of these holes were completed according to plan and form the basis of the overall definition of Foley Zone.

The possibility of short term exploitation of higher grade tungsten mineralization to counter reduced metal sales through tin quotas was suggested. In July, 1982, a re-assessment of drilling priority was undertaken to assess high grade targets within easy reach of current mining development. A dense pattern of drill holes aimed at investigating possible high grade mineralization footwall (southern side) to the porphyry above 28 Level was planned. This program involved drilling 14 holes totalling 2030m. Since January, 1981, 3336m of drilling has been completed in a systematic campaign to evaluate Foley Zone.

Drilling throughout has been generally trouble-free although some early holes hit large volumes of carbon dioxide gas and water (see later discussions) requiring cemented collar pipes and quick fitting valves.

1.3 Data Collection Methods

Approximately 5500 metres of core was logged in detail noting country rock, general wall-rock alteration, general structures, lode mineralogy, vein thickness, vein mineralogy and vein-core angle intersection. In a few cases (e.g. hole C.1615 - 1186 veins) every vein in excess of 1mm. thickness was logged. Limited exposures of veined underground workings were also mapped. It should be stressed that much of the purely geological information was obtained from observations of core alone and as such, conclusions drawn from these observations, particularly vein relationships, may not be as strong as those obtained from large continuous exposures underground.

2. DETAILED GEOLOGY

2.1 Quartz Porphyry Intrusive

2.1.1. Location, Dimensions, Shape

The porphyry occurs deep in the central footwall portion of the mine sequence around Halls Gd Section. It is virtually confined to the Crescent Spur Mica Sandstone unit which is immediately footwall to Hall's Formation (see diag II). Henry's lode position appears to terminate the porphyry in the east. Limited drilling to the west indicates the porphyry to either terminate within the mica sandstone or plunge very steeply towards the Ultrabasic Sequence contact further to the west. The top of the porphyry is inferred to be at approximately 1000 R.L. (Sea-level) and the deepest drill hole intersection to date is at 400 R.L.

The original exposure on 25 level Decline revealed a body 15m long, 3m to 6m wide with an irregular strike and highly discordant contacts with the country rock (plate 1.). An almost flat lying apophysis branches off the main body and develops along the sidewall for about 9m (plate 2).

The drilling to date has indicated a narrow dyke at higher levels widening to a broader plug at depth. Where well developed the dimensions would be approximately 80m in strike length and up to 33m at their greatest horizontal width. The body is interpreted to change from a massive centre to numerous thin veins towards the margins. It also appears to bifurcate in its extreme upper and western margin although large internal country rock rafts and xenoliths may be an alternative interpretation. As apophyses and off-shoots have been observed in mining development a flexible view concerning the specific shape interpreted from diamond drilling alone is warranted.

A single isolated deep intersection (hole C1633) at approximately 500m below the top of the intrusive implied a possible horizontal

width of at least 25m although one contact (on the footwall-southern side) had not been conclusively established due to extreme silica-topaz alteration. A width of approximately 30m. is suggested at that depth. The overall shape may be therefore assumed to be close to that of an elongate plug with bifurcating and feathered margins.

2.1.2. Structural Control

Inspection of the quartz porphyry exposure on 25 level decline has shown the porphyry to be locally very irregular in shape. Sub-parallel late stage veins (V9) may trend along the general strike trend of the porphyry intrusive but any large scale structure, fracture, shear or master joint controlling the direction appears absent. On 21 level Battery Access Drive directly up dip (60m) of the porphyry, few very fine late stage veins (V9) form parallel to the projected dip and strike of the porphyry. Again no obvious master controlling structure is visible. On 17 B-South Drive further above (150m) the porphyry, late stage veins parallel to the projected strike and dip are no longer present. Very few late stage veins do occur in obvious oblique moderate to steeply dipping joint structures but none that may mimic the strike and dip of the prophyry.

However, on the surface a large photo-lineament appears to coincide with the projected up dip position of the porphyry (Plate 3). The strike of the lineament matches that of the projected porphyry strike very closely. The lineament continues in an easterly direction for several kilometres and parallel lineaments occur to the south and possibly to the north.

Since limestone occurs north and south of the tin mineralization in the mine the initial localizing control of replacement mineralization (tin lode) may not have been totally lithological but in part structural. The deep underlying undiscovered granite

cupola implied to exist below the mine and the focus therefore for mineralizing solutions may be localized about these apparently buried cross-structures. These lineaments may be more significant than previously realized and should be appreciated in their effect to localize mineralizing fluids in conjunction with appropriate lithologies. The appropriate lithologies for tin replacement (lode) lenses being carbonate (limestone) and for quartz vein stockwork being sandstone.

2.1.3. Lithological Control

The quartz porphyry intrusive is thought to act as a conduit or funnel for hydrothermal fluids generating mineralized stockworks.

The porphyry cuts across the stratigraphy and is confined to the central and eastern portion of the Crescent Spur sandstone (diag. 12). Exposures on 25 level decline (diag. 13) show the porphyry to rapidly taper and diminish over metres on entering Henry's lode. This has been confirmed by drilling on sections below 25 level.

To the west on 24-25 level drilling platform, minor altered ultrabasic rocks and siltstones interbedded with the sandstones appear for the first time in the development face. Drilling in this area has also shown the porphyry to taper out. Between these two extremities the porphyry develops a maximum horizontal width of just over 30m in rock which is dominantly sandstone. In longitudinal projection the highest elevations of porphyry occur at the east and west margins where non-sandstone rocks appear, with a central saddle or trough in predominant sandstones above the thickest development of porphyry. One is left with the impression that the porphyry may have been compelled to migrate higher at its longitudinal margins where it was unable to develop any width. The bulk physical properties of the sandstone at the time of the porphyry intrusion (low tensile strength??) are

therefore thought responsible for localizing the intrusive. One would also expect the porphyry and surrounding stockwork to plunge downward with the sandstone.

Massive sandstones or units with equivalent bulk physical characteristics may therefore constitute appropriate hosts for intrusive stockwork systems elsewhere in the region. At Storey's Creek, Tasmania; cassiterite and wolframite bearing quartz veins are confined to a massive competent sub-greywacke unit within the Mathinna Group (Kingsbury, 1965), which may be a unique lithology in the area.

2.1.4. Original Mineralogy

The original mineralogy of the porphyry is not clear due to the heavy topaz, quartz, sericite, carbonate, tourmaline and clay alteration. Relict textures and limited petrographic work have indicated the rock to have contained euhedral quartz (up to 1 cm in diameter) and probably K-feldspar phenocrysts (up to 2 cms lengths) in a fine grained quartz-feldspar groundmass (Plate 4). In some specimens a phyllosilicate which may have been biotite originally, occurs in accessory quantity as partially destroyed grains in the groundmass.

Very fine zircons centred within these grains have also been noted. In hand specimen quartz phenocrysts are generally visible and the rock looks similar to porphyry outcropping at Mt. Bischoff. The heavily topazized zones contain visible cassiterite together with pyrite (Plate 5).

2.1.5. Alteration and Relationship with Veining

Virtually all matrix alteration of the quartz porphyry can be related to specific vein phases.

The central zone of the porphyry intrusive is intensely altered by topaz, pyrite, chalcopyrite and cassiterite, and veins are uncommon (Plates 5, 6, 7). Directly above this central zone but in the country-rock dense topaz, pyrite, chalcopyrite and cassiterite bearing veins are observed and successive drill holes are able to trace this zone as it continues up-dip above the porphyry.

It is therefore suggested that fluids passing through the porphyry have reacted with the matrix to form a characteristic alteration mineral assemblage. Where these fluids have been forced to continue to migrate they appear in the overlying rocks as individual veins with a similar mineral assemblage still confined however to a central near vertical zone. A dense quartz-sericite veined zone lies directly up-dip of sericitized quartz porphyry. Only in some rare instances does sericitized (greisenized) country-rock form (Plate 8).

Overprinting of alteration types within the porphyry (Plate 7) is consistent with overprinting of characteristic veins. One should therefore assume that pervasive alteration in the porphyry and veins with similar characteristic mineralogy are related to the same hydrothermal event.

Illite alteration is localized within the sericite alteration zone on the margins of the porphyry. Lemon coloured illite alteration grades into grey sericite alteration and the two types of alteration are thought to be directly related (Plate 9, 10). It is suggested that successive pulses of hydrothermal fluid generating sericitic alteration may become progressivley enriched in water or inter-act with circulating ground water. Illite therefore probably forms after simple hydration of early sericite.

Argillic alteration also occurs within the sericitic zone of the porphyry (Plate 10, 11). The matrix here is often bleached white, leached, porous and soft contrasting with the typically competent

rock found in normal core. It is suggested that these zones form around localized fractures and shears and are the result of probable late stage circulating groundwaters entering as the entire system cools down and withdraws in a manner similar to that modelled for porphyry copper systems.

2.2 Vein Stockwork

2.2.1. Location and Dimensions

The quartz vein stockwork surrounding the porphyry weakens into the Ultramafic Sequence to the west and into Halls Formation to the east. Isolated veins attributed to Foley Zone have been located as far up-dip as 8 Level Khaki Lens and this would probably represent the top of the system approximately 310m above sea level (RL1310). Stockwork veins exist next to intense porphyry alteration in the very deep intersection of drill hole C1633 at R.L. 400 on Hall's Ga section. Isolated mineralized quartz veins have been located as far north as Hall's Ka section in hole C1786 and as far south as Hall's Gk section in hole C1501.

The approximate dimensions of the stockwork surrounding the porphyry discovered to date would be 900m to 1000m in vertical height, 300m in horizontal width and 300m in strike length.

2.2.2. Veining Sequence

From cross-cutting relationships (Plate 12, 13, 14), vein overprinting and vein displacements observed in core and thin section, a list of tentative vein types in paragentic sequence is given (Table 1) starting with the oldest vein. A mineralogical paragenetic sequence is also shown (Diag. 14). Areas where high vein densities occurred (e.g. hole C1637) were specially studied for vein cross-cutting relationships.

Veins with almost identical mineralogy have been observed to cut each other. Therefore several pulses of the same vein phase are recognized (Plate 12). No specific time interval is implied when one vein cuts another. For example the style and displacement of a phase V11 vein cutting a phase V2 vein is similar to that of a late V7B vein cutting an earlier V7A vein.

It should be pointed out that this knowledge has come from exhaustive detailed logging of thousands of individual veins. Detailed sequences of veining in other complex stockwork deposits appear to have come only from Russian and Chinese geologists and this information is not always readily available.

2.2.3. Location of Vein/Alteration Phases

Of all the vein phases (V1 to V11) described, seven phases (V3, V4, V5, V6, V7, V8, V9) are volumetrically and economically significant and their approximate bulk distribution is shown on section 4960E. (Diag. 15 to 20). In most cases the vein density of a specific phase would be approximately in excess of 10%, although phases V6 and V8 whose vein densities are less than 10% are also included. It should be stressed that isolated and low levels of veins of different phases can be found over the entire system and that only broad areas are described below. It should also be stressed that veins may be mineralized heterogeneously and that some errors in identifying a specific vein phase in core is likely.

Phase V3: This essentially quartz dominant phase is localized along the southern side of the quartz porphyry and to a lesser extent along the northern flank. It is probably developed over the top of the quartz porphyry body as later tungsten bearing quartz veins appear to have invaded earlier barren veins.

Phase V4 and V5: This sericite rich vein and alteration phase occurs across the entire porphyry, a very short distance into the adjacent country rock and a short distance directly above the porphyry. Where later phases (e.g. topaz rich) are predominant elsewhere in the porphyry relict isolated zones of this phase are still visible in the groundmass.

Phase V6: Quartz-flourite veins with strong molybdenite mineralization form a halo in the country rock surrounding the porphyry. The veins although small may contain up to 40% molybdenite (visual estimate) so only low vein densities are required to generate the assay peaks observed.

Phase V7: Quartz-wolframite veins (with or without sericite) occur across and within the porphyry but appear to be best developed or centred on the southern side of the intrusive. On section 4960E this strong development appears to reach across the top of the porphyry from the southern side although this trend is not shown on section 5000E where it is clearly developed strongly on the southern flank.

Phase V8: This vein phase does not occur to any large extent within the stockwork. It is inferred to cause some siderite and tourmaline alteration of earlier sericite within the porphyry and as such is confined essentially to the porphyry.

Phase V9: Quartz-topaz-pyrite alteration and veining is confined to the centre of the porphyry and to a narrow zone immediately above the centre. Most of the cassiterite within the system is present in this zone.

026

TABLE 1. LIST OF VEINS IN PARAGENETIC SEQUENCE

KEY: Major Mineral - TOPAZ : 20% + (approximately)
Minor Mineral - Topaz : 5 % to 20% (approximately)
Accesory Mineral - topaz : Trace to 5% (approximately)

Vein Phase No.	Mineralogy
V1	SIDERITE - QUARTZ
V2	QUARTZ - Fluorite - sericite
V3	QUARTZ - Flourite - wolframite - illite - molybdenite
V4 (3 pulses)	QUARTZ - SERICITE - (K-Feldspar) - sphalerite - topaz - illite.
V5	QUARTZ - SERICITE - Flourite - wolframite - cassiterite - tourmaline.
V6	QUARTZ - Molybdenite - Flourite - Bismuthinite - Native Bismuth - Wolframite - sericite - cassiterite-topaz
V7A (2 pulses)	QUARTZ - Wolframite - Flourite - Molybdenite - Bismuthinite - Native Bismuth - topaz - illite - cassiterite - tourmaline - siderite.
V7B (2 pulses)	QUARTZ - Sericite - Wolframite - Flourite - Molybdenite - Bismuthinite - Native Bismuth - siderite - tourmaline - cassiterite - topaz.
V8	QUARTZ - SIDERITE - ARSENOPYRITE - TOURMALINE - FLOURITE - Sericite - Topaz - Illite - cassiterite.
V9 (2 pulses)	TOPAZ - QUARTZ - PYRITE (after rare pyrrhotite) - Chalcopyrite - Siderite - Flourite - Cassiterite - tourmaline - arsenopyrite - illite - beryl.
V10	ARSENOPYRITE - PYRITE - CHALCOPYRITE - SPHALERITE - tourmaline - siderite - quartz - flourite - cassiterite.
V11	FLOURITE - SIDERITE - illite.

2.2.4. Vein Mineralogy

Phase V1: Fine carbonate veinlets with or without thin irregular quartz veins. These occur as thin fine grained altered mesh fractures with locally developed barren quartz veins. Thicknesses are of the order of 1mm and they are observed only locally in the stockwork almost immediately adjacent to and above the porphyry. They comprise probably less than 1% of all veins around the porphyry.

Phase V2: Quartz veins. Generally barren, irregular and around 2mm thick. Like the first phase they occur very near the porphyry and also probably represent less than 1% of all veins. The vein is essentially quartz as fine anhedral crystals.

Phase V3: Quartz with very minor wolframite veins. Major quartz occurs as fine anhedral crystals throughout with very minor anhedral flourite crystals interstitial to quartz. Very few fine aggregates of sericite also appear interstitial to quartz and can be partially replaced by siderite. Very minor wolframite forms isolated aggregates or solitary anhedral crystals included in quartz.

In larger veins some distance from the porphyry, the central part of the vein may contain large amounts of flourite interstitial to quartz. Lesser amounts of soft milky white, cream or light grey illite forms as infillings to vughy areas established by euhedral quartz growth. wolframite and molybdenite form subhedral to euhedral crystals in localized aggregates interstial to quartz.

This phase may be responsible for large amounts of silicification adjacent to and within the porphyry. In numerous cases tungsten bearing quartz veins of the later phases (V6, V7) show some evidence of invading the centre of this earlier quartz vein phase. The phase may therefore have been prone to replacement because it has a vughy character or because replaceable minerals e.g. sericite, flourite and illite, formed in the centre of the vein.

028

Phase V4: Quartz-sericite veins. Quartz occurs as anhedral crystals with interstitial dense aggregates of fine sericite. In a few areas close to the porphyry K-feldspar develops as anhedral to subhedral crystals often containing inclusions of skeletal sericite and kaolinite. Most feldspar is cloudy and shows some development of kaolinite. The feldspar rich veins often grade or change rapidly into sericitic rich veins over millimetre widths and appear to form after sericite. Isolated brown sphalerite occurs (Plate 9) as fine grains occasionally enclosing muscovite.

Three similar pulses of sericite veins have been observed cross-cutting each other with later pulses often being progressively enriched in sericite to the extent that sericite almost dominates quartz. Internal layering within apparently single veins may also be interpreted as the result of multi-pulse injection along the same structure (Plate 12, 15).

This sericite vein phase is thought responsible for sericitization (greisenization) of the porphyry. Feldspathization of the porphyry has not been observed yet, probably because of the very low distribution of feldspar in veins through the system. However, minor feldspathization of the porphyry is expected within the sericite alteration zone.

Phase V5: Quartz-sericite with trace wolframite veins. This phase is almost identical to phase 4 except it contains minor to trace amounts of wolframite rich veins. Quartz is the major mineral present as fine anhedral crystals. Sericite forms aggregates interstitial to quartz. Minor to trace flourite occurs as fine anhedral crystals interstitial to quartz. Wolframite appears as isolated elongate crystals and in localized aggregates. Rare cassiterite may be present as very fine scattered anhedral crystals.

Phase V6: Quartz-molybdenite veins. Quartz is the dominant mineral and appears as anhedral crystals with major to trace fine interstitial anhedral flourite and lesser minor to rare amounts of interstitial sericite. Molybdenite develops as anhedral to subhedral aggregates, flakes and blebs interstitial to quartz and flourite and tending to

concentrate evenly toward the selvedge of the vein. It also forms random disseminations throughout. When present, native bismuth and bismuthinite occur as fine irregular blebs or stringers interstitial to quartz and flourite. Bismuthinite may form locally as rims around native bismuth centres or as irregular composite grains. Rare cassiterite occurs as very fine scattered anhedral zoned crystals.

Phase V7A: Quartz-wolframite veins. Quartz is the main mineral in the vein occuring as fine anhedral crystals. In larger veins some euhedral quartz and wolframite develop normal to wall rock contacts (plate 16). Fluorite occurs as euhedral to subhedral crystals interstitial to quartz and may on occasion enclose quartz and wolframite. Wolframite develops as aggregates of anhedral to euhedral crystals or as even disseminations of fine elongate blades. In large veins wolframite blades may contain fine inclusions of composite native bismuth and bismuthinite (Plate 17).

If present molybdenite forms finer anhedral to subhedral isolated flakes and small aggregates disseminated throughout the vein or more commonly as fine aggregates disseminated or congregating along the country-rock contact. Molybdenite also occurs locally intergrown with wolframite. When present native bismuth and bismuthinite occur as fine anhedral grains interstitial to quartz and flourite and locally intergrown with molybdenite. When present siderite appears as isolated anhedral grains interstitial to quartz. In thicker veins (5cm +) cassiterite occurs as isolated anhedral grains interstitial to quartz. Larger isolated irregular aggregates of anhedral topaz develop locally generally towards the centre of veins. Illite with or without siderite develops in clots locally towards the centre of veins particularly in small vughy zones where euhedral quartz has grown from the vein walls (Plate 18). Rare tourmaline is noted as isolated zoned needles. At least two pulses of this phase have been identified.

Phase V7B: Quartz-wolframite-sericite veins. This vein phase is generally mineralogically the same as V7A but contains fine sericite and cuts across earlier quartz-wolframite veins. Sericite occurs as aggregates and clots at times enclosed by quartz or interstitial to

quartz and flourite. The sericite has been identified as phengite by P. Jackson using an electon microprobe. Siderite may partially replace sericite locally. At least 2 pulses of this phase have been identified.

Phase V8: Quartz-siderite-arsenopyrite-tourmaline veins (Plate 19, 20). This phase is very heterogeneous mineralogically and specific points in a particular vein may show a major amount of each constituent mineral. Quartz is present as fine anhedral to euhedral crystals and quite often occurs preferentially developed against an early quartz rich vein it cuts across, growing in from the wall of the vein. Arsenopyrite develops interstitial to quartz as isolated subhedral crystals or as large granular patchy masses with small amounts of fine anhedral topaz. Minor amounts of chalcopyrite and pyrite are integrown with arsenopyrite. Flourite occurs as fine to coarse anhedral crystals intergrown and interstitial to quartz and often enclosing acicular and prismatic tourmaline. Fine needles of tourmaline also develop in large isolated anhedral crystals of siderite. Siderite forms large irregular aggregates across the width of the vein as well as very fine thin rims along the border of the vein intergrown with fine sericite, tourmaline and flourite. Siderite as fillings in fine cross-cutting fractures and as rims around illite has also been noted. Sericite generally develops as a fine local matrix with intergrown tourmaline and quartz. Illite occurs as irregular masses interstitial to quartz and often replacing muscovite and rarely containing fine needles of native bismuth or tourmaline (Plate 18). Rare cassiterite and wolframite form isolated subhedral grains.

Some of the siderite replacement observed within the porphyry (Plate 7) and within the veins (Plate 21) may be attributed to this phase. Siderite replacement also appears to be partially related to a later as yet poorly defined event.

Phase V9: Quartz-topaz-pyrite veins. Where topaz predominates it forms elongate radiating subhedral crystal growths subnormal to the vein side-wall with interstitial quartz and flourite and a vein-centre zone composed of grey and purple anhedral flourite, pyrite, lesser

chalcopyrite and arsenopyrite, illite, cassiterite and locally vughy enhedral siderite (Plate 22). Topaz may appear cloudy with incipient fine alteration to sericite. In small quartz dominant veins, quartz forms anhedral crystals intergrown and interstitial with anhedral topaz. Some topaz shows inclusions of quartz. Minor anhedral flourite and siderite is interstitial to quartz and topaz and forms as congregations or disseminated in small clots and agregates throughout. Fine anhedral to subhedral cassiterite is distributed irregularly in broad patches throughout the vein generally intergrown with quartz, topaz and minor siderite. Anhedral pyrite showing locally well developed alteration rims of marcasite occurs intergrown with lesser irregular chalcopyrite and arsenopyrite. It also occurs localized towards the centre of the vein. Illite forms soft masses interstitial to quartz and topaz, and infilling any small vughy area developed by enhedral quartz, topaz or flourite clusters. Tourmaline forms rare needles. Beryl has been tentatively identified in topazized porphyry as a hand specimen collected at the surface porphyry stockpile of rock originally from the 25 level decline porphyry exposure. Rare pyrrhotite with pyrite rims have been noted from deep intersections of topazized porphyry. Much of the pyrite may have been pyrrhotite originally.

Heavy topaz-pyrite replacement (alteration) of the porphyry centre has been attributed to this vein phase.

Phase V10: Sulphide veins. Arsenopyrite, chalcopyrite, sphalerite and pyrite occur as a coarse intergrowth of anhedral cyrstals and comprise the bulk of the vein. Minor to rare amounts of siderite, quartz, tourmaline and flourite are interstitial to the sulphide minerals. Marcasite forms rims around pyrite locally and occurs as inclusions in siderite.

Phase V11: Flourite veins. Essentially massive purple, green and lesser grey flourite. Minor to rare siderite appears as anhedral crystals intergrown with flourite or as fine aggregates forming a thin rim on the edge of the vein.

Scheelite has been identified in a few thin sections. It forms very fine subhedral crystals surrounding and intergrown with wolframite. In one case it was observed as isolated crystals interstitial to quartz. In larger hand specimens it is not detected under ultra-violet light probably because of its fine grain size. From the number of thin sections observed and the number of times it has been identified it would probably represent less than 2% of all tungsten within the stockwork system.

Whether scheelite forms from a vein reaction with the wall-rock or through inherent chemical changes within the vein itself through natural crystallization is yet to be established.

P. Jackson (1982) has also identified wolframite partially replacing scheelite from the khaki biotite zone of deep Halls B lens. In this case scheelite may have been a component of the original amphibole tin lode which was later 'greisenized' to biotite-flourite lode.

2.2.5 Zoning within Individual Vein Phases

In the early stages of exploration, flourite was seen to be common in veins some distance from the porphyry yet depleted on approaching the porphyry although levels of other minerals (gangue and ore) remained unchanged. It became apparent that either different veins types were spatially related to the porphyry or that some form of mineralogical zonation was active during the migration and consolidation of the stockwork system. For a given vein phase the ratio of specific minerals would vary within that vein phase depending on its spatial location within the system. The character of each vein phase within the stockwork is implied to change mineralogically away from the centre of the hydrothermal focus (considered to be the porphyry) and may be a simple reflection of the stability of minerals under certain conditions of chemistry, temperature and pressure.

Zoning trends are shown for some of the significant vein phases and are generally operative within several hundreds of metres from the porphyry.

Phase No.	Changes away from the porphyry centre
V4 and V5	Decrease in sericite Increase in flourite
V6	Decrease in wolframite Increase in flourite, bismuthinite, native bismuth, (topaz?).
V7	Decrease in wolframite Increase in flourite, molybdenite, bismuthinite, native bismuth, topaz, sericite, illite, chalcopyrite, arsenopyrite and cassiterite.
V9	Decrease in chalcopyrite Increase in arsenopyrite, molybdenite, bismuthinite, native bismuth and wolframite
V10	Decrease in pyrite Increase in arsenopyrite and sphalerite.

It should be stressed again that this is an impression gained during logging core from different zones within the system.

Ideally specific vein phases should be traced through underground exposures where vein relationships can be clearly established but as very little development exists in the vicinity of Foley Zone this cannot be done.

Zoning of this type within a specific vein phase makes a contribution to the overall zoning around the system particularly between bismuth and molybdenum.

2.2.6 Metal Zoning

The spatial location of metals within the system is distinct; being essentially related to one or more specific vein phases and/or the abundance of those vein phases (Diag. 21).

Molybdenite, bismuthinite and native bismuth occur as an outer shell in the stockwork zone and are generally related to the abundance of phase V6 veins. Strong wolframite mineralization occurs inside and overlapping this, closer towards the porphyry and is a result of the abundance of later V7 veins. Cassiterite-chalcopyrite mineralization related to phase V9 veins is confined to a central zone within and above the quartz porphyry. Very weak tin assay "ripples" appear some distance outside the molybdenum halo. In many cases these are not attributed to isolated V9 veins but to differentiated (zoned) V7 veins. Some contribution to molybdenum assays is made through the differentiation of V7 wolframite bearing veins. These veins show slight enrichment in molybdenite and bismuthin-native bismuth away from the porphyry and may compound high molybdenum-bismuth assays attributed to V6 veins or generate additional small molybdenum-bismuth peaks even further out.

In many cases specific assay peaks are attributed to compounded contributions from several different vein phases although the proportion of the contribution may be highly variable and one vein phase may predominte.

Where the correlatable high grade tungsten zones occur south of the porphyry e.g. section 5000E, vein orientations in these areas are variable (Plate 26) suggesting that the mineralization intersected from hole to hole vertically is not interconnected by the same set of veins. Rather disconnected metal rich veins are though to precipitate in response to some hydrothermal condition spatially related to the porphyry. This may not be so for the central cassiterite-chalcopyrite zone. Veins intersected in drill

core above the porphyry show some parallel development of vein orientation and may be interconnected vertically above and below each other (Plate 23.)

2.2.7 Multiple Veining

One of the early diamond drill holes (C1637) drilled across the top of the porphyry intersected large expanses of very weakly layered siliceous rock. Because quartz was so dominant the porphyry was thought to be overlain by a quartz cap-rock similar to that at Panasqueira, (Kelly and Rye 1979). Closer inspection revealed this zone to have suffered numerous multiple invasions of quartz to the extent that up to 80% of the rock was veined (Plate 24). A large number of apparently single veins are composed of multiple intrusion of successive vein phases (Plate 25).

Most quartz veins show some silicification of the wall-rock contact. They may also show preferential precipitation of certain mineral species towards the centre of the vein. Thin narrow discontinuous vughs or interstitial contacts where crystals that have met on growing from the side-wall contacts are also apparent. Later veins therefore tend to exploit vein centres rather than the welded quartz vein-country rock contact. In certain examples at least 5 successive pulses have formed one resultant vein structure (Plate 25).

2.2.8 Summary Evolution of Veins

A general sequence of veining events can be summarized as follows begining with the introduction of the oldest veins.

1. Barren quartz veins (V2, V3)
2. Sericite-rich (greisen forming) veins (V4 and V5)

3. Molybdenum, bismuth and tungsten bearing quartz veins (V6, V7A, V7B)
4. Topaz-cassiterite rich quartz (greisen forming) veins (V9)
5. Sulphide rich veins (V10)
6. Flourite-siderite rich veins (V11)

Provided the appropriate elements are present the zoning of specific vein phases in general mimics the overall zoning evolution of the vein system. Wolframite rich quartz veins of phase V7 become progressively enriched in flourite, topaz, cassiterite and sulphides away from the centre of the system. This trend is observed in the sequential evolution of nearly all veins. Some exceptions exist. Molybdenum-rich phase V6 precedes tungsten rich phase V7 where zoning of V7 leads to molybdenum and bismuth rich quartz tungsten veins away from the porphyry. Like the structural law that small scale structures mimic larger ones, isolated or single mineralogical changes within one event can often mimic large over-all mineralogical changes.

2.2.9 Vein Density

Vein density levels outside the mineralized zone (approximate 0.2% WO_3 cut-off) are generally less than 10% of the total rock. Within the mineralized zone vein densities increase from 10% to up to 80% on the immediate quartz porphyry contact. Highest vein densities are always observed immediately adjacent to and immediately above the porphyry. This is due to two factors.

1. The earlier barren quartz vein phases (V2 and V3) together with the later tungsten bearing vein phases (V7) are localized along the country rock-porphyry contact. The contact may have been a channelway for fluids rising from depth and some veins may have developed from the contact initially. The southern (footwall) contact shows slightly higher vein densities than

the northern contact area and may therefore have been slightly more significant in this regard.

2. Fluids responsible for porphyry alteration (sericite and topaz forming) have migrated some short distance into the country-rock from the porphyry and have compounded already established quartz veins near the contact.

2.2.10 Vein Orientation

2.2.10.1 Drill Core

Unfortunately no underground exposure of high grade mineralization with high vein densities exists. All high grade areas have been located through diamond drilling alone, however some observations of core are significant.

Generally speaking most intersections of higher grade mineralization adjacent to the porphyry show vein orientations to be non-parallel to each other. Core angle intersections for a given drill hole may be grouped into approximate populations which probably represent an influence by geometric structures (e.g. joints) within the country rock. Nearly all angles observed are variably oblique to the length of the core and therefore represent various components of strike and dip. Where drill hole intersections occur directly above the porphyry centre and some distance projected up-dip then these veins (generally stage V9) show development parallel to each other whilst those adjacent (generally stages V3, V6, V7) are non-parallel. On orienting core these parallel veins would have dips and strikes consistant with the approximate dip and elongation of the entire quartz porphyry and mineralized zone.

One vertical hole C1615, was studied (Diag. 22) to determine whether measured dips tended to occur in sets. From the diagram it becomes apparent that the dip of most veins is in

excess of 45 degrees and a strong population between 60 and 80 degrees exists. This is consistent with attitudes of veins mapped underground (Diag. 23) where dominant sets of veins are moderate to steeply dipping (around 75 to 85 degrees). The small population of very shallow dipping veins to the right of the diagram is also consistent with underground mapping trends where flat lying veins were observed. Hole C1615 was drilled closely above and through the porphyry and vein dips there, show some similarity to those actually mapped underground further away from the porphyry.

2.2.10.2 Underground Exposure

The absence of good extensive underground exposure in the immediate vicinity of strongly mineralized rock prevents a detailed investigation of vein orientations. However where mineralized veins appear above the system on 17 B-South Drive, 21 Battery Access Drive (Diag. 24) and 20-22 level decline the areas have been mapped. A small proportion of veins were highly irregular, contorted and not apparently controlled by any specific structure. Some were pinched unevenly and formed tumescent protuberances which defied accurate measurement. These were obviously not plotted on the stereo-net but their existance should be kept in mind. Poles to planes of veins were plotted on the projected upper hemisphere of a Wullf net (Diag. 23). The area was covered by a 2% area grid and contours measuring concentrations at 10, 8, 6 and 3 poles per 2% area constructed.

The largest population of veins A. form steeply dipping veins sub-parallel and slightly oblique to the projected trend of the quartz porphyry. Some of these veins form in distinct joints within the country rock, others as slightly more irregular fractures sub-parallel to the porphyry and possibly related to weak deformation associated to the intrusion of the porphyry itself. A small number of late topaz-pyrite veins

(Phase V9) make a minor contribution to this field directly up-dip of the porphyry. Populations of veins exploiting steep oblique joints within the country rock occur at C. and F. with possible exploitation of bedding or near-bedding structures at D. Flat lying veins (Plate 27) are well developed and represented at E. These veins are mainly early phase V3 where mineralization is absent or occurs in isolated clots and pockets along the vein.

These flat veins may develop tension gash and "stoping" features locally (Plate 28). As one vein lenses out at the tension gash junction another probably directly related though not apparently connected forms above or below the level of the adjacent vein. There has been a tendency for the adjacent vein to form above the previous vein when moving towards the projected centre of the porphyry (Plate 29). Isolated veins may be contrary to this but a mean of 4 or 5 observations close together seems to establish this trend. The feature has been primarily observed across the width above the porphyry on 21 level and insufficient exposures are present to establish what happens down dip or along strike.

2.2.10.3 Implications for Diamond Drilling

From detailed mapping of veins it became apparent that most of the mineralization formed in steep to moderately dipping veins and that the large flat and quite often thick veins were earlier barren or very poorly mineralized phases (V2 and V3) containing very minor to trace levels of wolframite and molybdenite.

If this pattern is valid throughout the entire system then drilling should be orientated towards drilling flat and moderately inclined holes to intersect the maximum number of steep and inclined mineralized veins. These flat veins which

would not be tested with near horizontal drill holes appear to make little contribution to the overall bulk assay. Probably less than 10% of all total metal values are tied up in these veins. Near vertical holes should therefore be avoided if reliable assessment of grade is paramount (this is also consistent with the anisotropy found in the variograms discussed later).

2.2.11 Vein Size

Early in the exploration programme hole C1615 was selected and all veins down to 1 mm thickness were logged. Vein-size distribution and vein number distribution graphs were constructed (diag. 25, 26, 27). No apparent relationship between all vein phases and their size distribution could be established conclusively although more underground exposures could show certain trends.

Almost 80% of veins were less than 1 cm in size (Diag. 25). When their thickness is taken into consideration veins less than 1 cm thick represent about one-third of all vein material and veins less than 2 cm represent almost half the total vein material (Diag. 26). Of veins less than 1 cm in thickness almost half are less than 4 mm (Diag. 27).

Almost a quarter of total vein material is 10 cms or larger in thickness. Some of the flat lying early stage V3 veins fit into this large-size distribution, together with steeply dipping mineralized stages V6 and V7. A small anomalous population of veins exists between 8 and 9 cms.

The vein size distribution for drill hole C1608 (Diag. 28) has also been completed. The distribution shows similarities to hole C1615 with smaller size veins being very dominant. The small population of veins between 8 and 9 cms in hole C1615 is not apparent in hole C1608 although a population between 5 and 6 cms

in hole C1615 is expanded to 5 and 7 cms in hole C1608. Veins in excess of 10 cms appear more significant in hole C1615 than hole C1608.

Obviously there are some marked differences in specific populations between the two examples shown. A more global appraisal would have to be attempted to establish size distributions in different areas within the deposit. However the continuous presence of high numbers of very small veins e.g. less than 2 cms seems more than likely.

Diagram 29 shows the vein size distribution down hole C1713 which was drilled across the width of the system. Very small veins and some barren veins were not incorporated. No relationship between vein size and distance from the porphyry is apparent.

2.2.12 Vein Grades

The high grade intersection of hole C1754 was studied to assess tungsten grade variations within the veins. This hole was selected because it carried significant high grade mineralization and mineralized veins could be easily identified from within composite veins. Overall vein densities were measured per 2.5 m assay length of core, the proportion of mineralized veins noted and the overall grade of mineralized veins only calculated. The country rock is assumed to contain no grade.

From the results (Table 2) several features become apparent. About three quarters of all veins in this region were mineralized. The calculated average vein grade is just over 4% with specific grades ranging from 1.7% WO_3 to 21.3% WO_3. The highly variable nature of vein grades is shown in diagram 30.

TABLE 2

CALCULATED VEIN GRADES - DDH C1754

INTERVAL	TOTAL VEIN %	MINERALIZED VEIN %	ASSAY % WO_3	MIN. VEIN/ TOTAL VEIN %	CALCULATED VEIN GRADE % WO_3
130-132.5	10.2	7.2	1.530	70.6	21.3
132.5-135	24.2	8.2	0.150	33.9	1.8
135-137.5	18.8	14.2	0.410	75.5	2.9
137.5-1240	26.3	24.5	0.825	93.2	3.4
140-142.5	14.0	10.8	0.465	77.1	4.3
142.4-145	13.0	10.0	0.335	76.9	3.4
145-147.5	16.3	14.0	0.845	85.9	6.0
147.5-150	22.9	14.2	0.445	62.0	3.1
150-152.5	18.0	16.2	0.575	90.0	3.6
152.5-155	17.5	15.0	0.285	85.7	1.9
155-157.5	9.2	7.7	0.295	83.7	3.8
157.5-160	12.2	10.1	0.270	82.8	2.7
160-162.5	15.3	5.9	0.420	38.6	7.1
162.5-165	8	4.7	0.260	58.8	5.5
165-167.5	16.2	12.0	0.205	74.1	1.7
167.5-170	35.8	34.0	0.730	94.9	2.1
170-172.5	12.3	8.1	0.460	65.9	5.7
172.5-175	10.7	14.7	0.735	71.0	5.0
175-177.5	15.1	8.0	0.425	53.0	5.3
177.5-180	4.7	4.4	0.285	93.6	6.4
180-182.5	14.3	10.3	1.365	72.0	13.2
182.5-185	6.9	6.8	0.300	98.6	4.4
Mean	16.0	11.8	0.53	74.5	4.4

2.3 Wall Rock Alteration

Wall-rock alteration was not studied in detail although several types have been identified.

1. Bleaching: Thin bleaching is attributed to varying amounts of sericite, siderite, silica or clay minerals forming a fine grained matrix interstitial to the framework grains of the sediment. Thin narrow zones (from several mm to cms) adjacent to or cross-cut by veins (Plate 30,31) as well as large broad areas (several metres wide) particularly within the sandstone show bleaching (Plates 32, 33).

2. Brown: Biotite alteration develops adjacent to veins often parallel to the vein contacts and to a lesser extent irregularly in large masses across the vein contacts. It forms as fine flakes and grains with or without sericite interstitial to the quartz framework of the sediment. Some veins show the preferential development of biotite alteration in fine grained brown shale with little or no development in adjacent sandstones. Larger veins may also develop large coarse brown flakes on the contact of the vein and within the vein matrix itself to the extent that biotite becomes a significant component (up to 50%) of the vein. Biotite may also develop where quartz veins pinch or swell irregularly.

   It could be suggested that biotite forms from sericite bearing veins by deriving certain elements (Iron?) from the country-rock.

3. Black: Tourmaline develops as fine crystals and needles together with lesser quartz, flourite and biotite to form a matrix around the quartz framework of the sediment. This dark grey to black alteration occurs in broad patches across the sediment host and to a lesser extent associated with accompanying peripheral bleaching. It often forms black borders immediately adjacent to quartz veins (Plate 32). In many instances the alteration may develop along linear boundaries (healed joints?) and not directly associated

with veining. Tourmaline also appears to develop over earlier biotite alteration.

4. Green: Chlorite develops rarely as fine pale green bands, parallel to the contact of certain small veins. It can be associated with silicification of the matrix of the host sediment and under thin section has been observed to alter earlier tourmaline alteration.

5. Flourite: Thin irregular ribbons, veinlets and broad shapeless masses of flourite altered shale appear in areas close to Henry's stratigraphic position where shale becomes the dominant host rock. Sub-parallel development of biotite and quartz form interstitial to the flourite and large nests of biotite may be visible near the country rock contact, with localized brown colouration within the country-rock.

   Early phase V3 quartz veins cut this alteration so this type is considered to be an earlier event in the formaiton of the Foley system. The strong flourite-biotite metasomatism of Henry's lode in the vicinity of Foley Zone and studied by P. Jackson (1982) is proabably this same event. Where tungsten mineralized flourite-biotite altered lode occurs (Plate 34) it is suggested that the tungsten mineralization may be superimposed subsequent to an earlier flourite alteration event. This early flourite alteration does not appear to manifest itself elsewhere as a vein phase although new exposures may prove otherwise. This may also be equivalent to what some Russian authors (Sokolov and Komarov 1968) describe as 'mica-flourite greisens' after skarn.

6. Grey: Silicification of country-rock is not apparent in hand specimen but thin sections of the same specimens will reveal siliceous impregnation into the country rock matrix several mms. from the quartz vein contact. Some silicification forms in association with the development of chlorite and biotite. In one specimen molybdenite formed parallel continuous stringers 2-3 mm either side of a quartz vein within the country-rock itself.

Fluids have cryptically migrated into the country-rock and in uncommon cases carried mineralization with them.

Except for flourite metasomatism of tin lode, wall-rock alteration of adjacent sandstones has little direct application to outside exploration. Large pervasive haloes like those observed around porphyry copper systems are not apparent.

2.4 Hydrothermal Brecciation

Hydrothermal breccias are generally uncommon within Foley Zone. Drill holes spanning 150m across a width of stockwork and porphyry may only intersect one or two narrow bands (up to 15cm wide) of hydrothermal breccia and then only in the country rock immediately adjacent to the porphyry or on the porphyry contact itself (Plate 35).

The matrix of the breccias is composed of very fine intergrown tourmaline, sericite, quartz and flourite. Tourmaline occurs as fine green needles intergrown with quartz and sericite imparting a grey to dark green colour to the matrix. Rock fragments may be rounded quartz grains, porphyry phenocrysts, grey sericite rich greisenized prophyry, dark brown to blue tourmalinized shale, pale cream to yellow bleached siderite altered sandstone, irregular barren quartz fragments, and yellow and brown composite altered sandstone fragments.

In places tungsten bearing quartz veins (phase V7) are cut by the breccia. Other breccias in turn are cut by quartz-siderite-tourmaline-arsenopyrite-pyrite veins of V8 stage and sericite rich V4 stages. The relationship with the quartz vein phases in not clearly understood but some academics (T. Kwak. pers. comm.) suggest that they form in the later stages of hydrothermal activity and represent an evolutionary accumulation of volatiles precipitating hydrous minerals.

Angular country rock and quartz vein fragments have been observed in a vughy layered pyrite-marcasite rock (Plate 36) whose total width may not exceed 20 cms. Underground exposures show them to be situated on open joints or minor shears and their origin is probably related to very late stage precipitation of sulphides from iron-rich groundwaters.

2.5 Tin Lode Mineralization and Foley Zone

2.5.1. Relationship

Quartz veins of nearly every phase have been observed to cut across Henry's lode. Clearly, in contradiction to P. Collins (1981. P 373), the veins of Foley Zone and the associated greisen alteration of the porphyry post date the consolidation of tin lode.

According to some Russian authors (Sokolov and Komarov 1968) where skarns and greisens occur together, skarn type mineralization is often followed by greisen development. Korzhinskii (1964) and Zhrarikov (1970) suggest that skarns originate chemically from highly alkaline solutions and as their high temperature silicate assemblages and magnetite (if present) precipitate, the metasomatic solutions acquire an acidic nature evolving into acid solutions compatible with later greisen development.

Although pyroxene, garnet and calc-silicate minerals traditionally associated with skarn deposits are yet to be identified at Cleveland, the deeper Hall's lode bodies contain amphibole and magnetite assemblages similar to those found in classic calcic skarns (Diag. 31). Some petrological evidence exists at Cleveland for the replacement and alteration of probable early amphibole by late chlorite and sulphides (P. Jackson, 1982). It may be feasible to suggest that much of the chlorite-sulphide-cassiterite lode at higher elevations formed after earlier amphibole rich rock. At Lost River Alaska (Dobson 1982) the formation of early

048

high temperature skarn is followed by the development of hydrous skarn with base metal sulphides and cassiterite. Greisenization in part proceeds after the development of skarn alteration. Some Russian deposits also show quartz-tourmaline-cassiterite and quartz-sulphide-cassiterite mineralization to be associated with classic skarn assemblages. The sulphide-cassiterite assemblages appear to post date the consolidation of skarn and occur at higher elevations towards the skarn-carbonate contacts.

If some of the deeper tin-lode mineralization is considered to be almost skarn-like then the development of greisen after skarn is consistant with Russian models.

The relationship therefore between greisenized quartz porphyry dykes, greisenized granitoid plugs, associated vein stockworks, skarn, sulphide-tin replacement bodies is clearly established. Hydrothermal fluids may evolve from one plutonic source to produce a suite of ore-bodies. Chemically basic hydrothermal solutions may form magnesian and then calcic skarns after carbonate hosts proximal to granitoids. If solutions have the capacity to evolve further, then more hydrous sulphide-rich fluids form, sometimes associated with earlier skarn but more often as isolated deposits distal to parent plutons with probable peripheral low temperature silver-lead, antimony sulphide vein deposits. Continued evolution generates fluorite-rich greisen forming solutions which focus around earlier acid intrusions generating stockwork deposits.

Therefore any deposit having one form of mineralization stands a good chance of containing the associated other types.

2.5.2. Wolframite Bearing Henry's Lode

The eastern part of the main Foley mineralized zone cuts across narrow low grade tin lode (Henry's). Despite the low observed vein density within the lode, tungsten grades are still considerable (Diag. 32). Close inspection reveals fine and coarse

wolframite, bismuth minerals and molybdenite in a metasomatized lode matrix of green, brown and khaki biotite, flourite, sellaite, quartz and carbonate (Plate 37). The implication is that fluids have reacted with the lode rather than crystallize out as a specific vein, just as fluids have reacted with the original porphyry to produce alteration. In isolated cases late stage topaz veins have strongly topazized the lode (Plate 38).

Tungsten grades within the lode are high where the lode projects to intersect the higher grade southern side of the porphyry and appear to decrease in grade away from this zone mimicking the equivalent drop in stockwork vein grade next to it.

Tin grades within the lode are generally very low with bulk grades not exceeding 0.11% Sn. High levels of flourite and complementary low tin grades suggest the flourine metasomatism may have caused some re-distribution of tin.

2.5.3. Genetic Implications

The overall sequence of events to have generated mineralization at Cleveland Mine is suggested as follows:

1. Intrusion of granite pluton at depth with localized cupola. (No direct evidence exists but in comparison to other deposits e.g. Lost River, Alaska - Dobson 1981, this is more than likely).

2. Intrusion of quartz porphyry dyke(s) along an E-W trending structure above cupola. (No evidence for timing exists. The intrusion may easily post-date early tin-lode formation).

3. Early amphibole-magnetite tin lode formation after limestones at depth.

4. Late alteration of amphibole to form chlorite-quartz-sulphide-tourmaline-cassiterite lode lenses.

5. Fluorine metasomatism of deeper tin lode lenses generating biotite-fluorite lode ("greisenized skarn") with possible re-distribution of some cassiterite. (P. Jackson 1982 has suggested from thin section observations that the fluorine metasomatic event generating biotite in the lode pre-dates the main sulphide forming phase. More than one flourite phase may therefore be present or the event persisted for a relatively longer period of time overlapping the sulphide formation.

6. Foley Zone veins phases Vl to Vll with associated greisenization of porphyry dyke and possible late siderite alteration.

7. Late argillic alteration of porphyry along shears, precipitation of pyrite in minor joints and solution breccias, and alteration of lode pyrrhotite to pyrite.

2.6 Comparison with Similar Deposits

Cleveland tin lode and Foley Zone mineralization show similarities to other mineralized systems within Tasmania and overseas.

At Mt. Bischoff sulphide-cassiterite dolomite replacement mineralization abuts sericitized and topazized quartz porphyry dykes. Unlike Cleveland Mine, chalcopyrite does not occur to any large extent in the sulphide lodes or within the cassiterite rich centre of the porphyry where as at Cleveland Mine low levels up to Ø.1% Cu occur in the porphyry and an average Ø.25% Cu is recovered from tin lode. Isolated quartz wolframite veins have been identified just north of the summit at Mt. Bischoff. Published fluid inclusion data (Groves, Martin, Murchie, Wellington, 1972)

051

reveal highest temperature of formation to have occurred near the summit and to my knowledge no attempt has been made to locate tungsten stockwork mineralization below this focus.

High grade sulphide-cassiterite mineralization forms at Renison Bell. The lode contains a high proportion of sulphides with only minor amounts of quartz as gangue. The nearest equivalent mineralization at Cleveland occurs in lode lenses near to surface. The greisenized Pine Hill adamellite 2 km south of the mine workings contains minor tin mineralization and may be the equivalent to Foley Zone at Renison. A porphyry dyke branches off the Pine Hill adamellite and passes within 1 km of the mine workings.

Greisen deposits occur world wide and are important hosts for economic accumulations of tin, tungsten, beryllium, molybdenum, bismuth, lithium, tantalum, niobium, arsenic, rare earths and zirconium. Quartz vein stockworks associated with granitoids and greisens are less common but still make a substantial contribution to global metal supply. Deposits at Panasqueira, Portugal (Kelly and Rye, 1979), Mt. Pleasant, New Brunswick, (Dagger 1972), Mt. Carbine Queensland (Plumridge 1975) and Jiangxi Province China (Kwak, pers. comm.) all show similarities to Foley Zone stockwork mineralization. However even more striking examples exist in Kazakhstan Province in Eastern Russia (Scherba 1970) where a complicated stockwork of veinlets exists in aluminosilicate rocks above the ledge of a granite intrusion (Diag. 33). The following summarized sequence of formation of veinlets (over the top of the granite ledge) during the ore stage is shown. Suggested Foley Zone vein phase equivalents are given in brackets.

1. Quartz, molybdenite (V6)
2. Molybdenite
3. Quartz, topaz: weak greisenization (V9)
4. quartz, cassiterite (V9)

5. K-feldspar (V4)
6. Quartz, K-feldspar (V4)
7. K-feldspar, quartz: weak greisenization (V4)
8. Quartz, molybdenite (V5)
9. Quartz, muscovite (V4)
10. Quartz, wolframite (V7)
11. Molybdenite
12. K-feldspar, quartz, Fe-Cu-Zn-Pb-As sulphides (V8)
13. Quartz sulphide veins (V10)
14. Quartz pyrite, quartz sericite, quartz fluorite, quartz carbonate (V11)

The zoning pattern shows similarities to Foley Zone although molybdenum in Foley Zone occurs outside of the main tungsten and tin zone contrary to generally excepted zoning sequences where molybdenum is expected closer to the granite. It is possible that the high level of flourite within the quartz molybdenite phase and within the entire system in Foley Zone are responsible for the apparent inconsistancy.

Quartz-sulphide (Fe-Cu-Zn-Pb-As) veins are very poorly developed on the outer periphery of the stockwork system of Foley Zone but their location may be reflected in the metal zoning patterns within the tin lode itself established by K.G. Palmer in the mid 1970's.

Beryl in hand specimen and phenakite in thin section have been identified by T. Kwak (pers. comm.). Beryllium distribution within the system is at present unknown but thought to be very low. The occurrence of beryl in topazized porphyry infers it is localized within the centre of the porphyry and associated with vein phase V9.

According to Scherba (1970), the metal bearing veins are products

of greisenization, in general they come soon after greisenization and are spatially related to it.

2.7 Academic Work

Dr. Teunis Kwak, Lecturer in Geology at La Trobe University in Victoria has made regular visits to the mine. His primary interest is skarn mineralization although most of his work has centred around the quartz-porphyry intrusion within Foley Zone and to a lesser extent the stockwork surrounding it. Dr. Kwak's association with the mine staff commenced in early 1981 and although no formal paper or submission on Foley Zone has been generated by him, he has been responsible for recognizing the extent of topaz alteration in the porphyry and was the first to identify beryl. He has also been responsible for assisting in generating a conceptual understanding of the tin lenses at the mine.

Peter Jackson a student under the direct supervision of Dr. Kwak recently completed an Honours Thesis, part of which detailed progressive hydrothermal alteration of Henry's lode lens adjacent to the quartz porphyry and similar alteration in Lower Hall's B lens. According to Jackson the original amphibole and chlorite skarn has been progressively altered to biotite, tourmaline, sulphides, fluorite and carbonate with a consequent redistribution of cassiterite away from the alteration. This alteration in Lower Hall's B lens is not geometrically related to the Foley Zone porphyry, and another deeper source further north is implied.

3. EXPLORATION IMPLICATIONS

3.1 Assay Results

3.1.1. Major Metals

A full set of 1:500 scale working sections, plans and longitudinal projection are attached with this report (see List of Illustrations).

Minerals of economic significance within the zone are wolframite, molybdenite, bismuthinite and native bismuth, cassiterite and chalcopyrite.

In most cases the entire length of drill hole was split by diamond saw and assayed at 2.5m length intervals. Assays are for total tin, soluble tin, copper, tungstic oxide, molybdenum sulphide, bismuth and specific gravity. Prior to the calculation of resources using computer based methods, a 0.2% WO_3 cut-off was applied to significantly mineralized intersections and a large zone surrounding the porphyry was defined. For a given cut-off any small high grade zone peripheral to the bulk mineralized area would have to carry the low grade seperating them before being included into a continuous intersection. A 0.4% WO_3 cut-off was also applied to intersections that carried higher grades. A small zone on the footwall (southern) side of the porphyry was also defined.

3.1.2. Trace Elements

Hole C1615, drilled vertically through the porphyry was assayed for gold, silver, flourite and uranium.

Silver levels are low but show an excellent relationship with copper, suggesting silver occurs within the chalcopyrite lattice or more likely as an intergrown silver sulphide mineral. A central zone in the porphyry averages 3 g/t with assays to 7 g/t.

The majority of the stockwork is less than the detection limit of 1 g/t with one sample containing up to 3 g/t. In this case silver may occur in alloy form with visible native bismuth in a vein associated with molybdenite and wolframite.

Gold levels in nearly all cases were below the detection limit of 0.01 ppm. Small peaks uo to 0.1 ppm were observed in stockwork samples showing good correlation with molybdenum, bismuth and tungsten suggesting gold may also occur associated with native bismuth in alloy form.

Gold was observed by P. Jackson (pers.comm.) in specimens from the centre of the porphyry. Samples from the porphyry intersection in drill hole C1713 were submitted to Amdel for assay but all values returned less than 0.01 ppm.

Flourite was determined by selective ion electrode technique (Amdel) in several drill holes. In one drill hole C1615, the mean value for flourite in stockwork was 3.97% CaF_2 and in porphyry 1.73% CaF_2. Similar bulk values appear for other holes. Increases in bulk flourite are observed away from the porphyry despite the general drop in vein density (Diag. 34). This is consistant with zoning concepts in which flourite visibly increases in several metal bearing vein phases away from the porphyry.

Flourite levels are very high in greisenized Henry's lode. DDH C1608 drilled across through lode on Halls Ga section recorded an average of 14% flourite over 14m horizontally with individual samples up to 25% flourite.

Uranium levels are moderately high in the porphyry averaging 13 ppm. Although granite rocks world wide average 4 ppm uranium, a survey of 32 Tasmanian granitoids by Heier and Lamber (1978) gave an average of 10.4 ppm with a spread of 1-27 ppm. The levels of uranium assayed in the porphyry will not constitute any problems

as has been found with associated radon gas in Cornish tin mines (ref. G. McArthur - File Note 1981).

A scan of 15 elements (K, Ce, Cd, As, Ag, Zr, Zn, Ti, Ta, Sb, Pb, P, Nb, Mn, La) by I.C.P. method (Amdel) was carried out on samples from hole C1642 drilled over the top of the porphyry intrusive, to see if any dispersion of minor elements was present (Diag. 35). The Henry's tin lode intersection was revealed by anomalous trends of numerous elements. Unfortunately only very weak anomalous trends in titanium, lead and strong trends in arsenic formed over the projected centre of the system. Weaker but still significant peaks in arsenic were noted on either side of the projected centre and occur with coincident tin and copper suggesting an association with isolated late phase V9 veins containing topaz-cassiterite-pyrite-chalcopyrite and minor arsenopyrite. The overall results were disappointing.

A sample of porphyry and stockwork from the surface stockpile was submitted for a semi-quantitative spectrographic scan of 47 elements (see Appendix B). In most cases the stockwork sample reported slightly higher values than the porphyry sample. No unexpected trends were observed.

Sulphide and oxide flotation concentrates were produced from metalllurgical tests carried out by C.M.S. in Burnie on core from drill hole C1637. These results represent a concentration of some trace and minor elements. Elements with chalcophile affinities generally reported to the sulphide concentrate in values over 1% (see Appendix D). A tantalum value of 110 ppm was noted in the oxide concentrate.

3.1.3. Assay Repeatability

Reject samples assayed at Cleveland Assay Laboratory were despatched to Amdel Laboratories and results compared (see Appendix B). Excellent correlation existed between assays with relative differences of mean values being 0.4% for WO_3, 1.3% for Bi and 3.1% for MoS_2.

Pulp samples from drill hole C1754 were submitted for re-assay at the Cleveland Assay Laboratory. The drill hole showed a large spread of values with some very high tungsten assays and was therefore thought suitable for testing. Again good correlation exists between assays (see Appendix B) with relative differences of mean values being 0.1% for WO_3, 8.3% for MoS_2, 4.7% for Bi, 17.0% for total Sn and 6.0% for Cu. Values for total tin are higher than expected. Tin is determined on the X.R.F. unit unlike copper, molybdenum and bismuth which are assayed on A.A.S. The bulk mean value for tin is almost 0.04% and individual assays are rounded off to the nearest 0.01% possibly explaining the variation.

3.2. Geostatistics (by G.J. McArthur)

3.2.1. Compositing

For the purpose of a first-pass look at Foley Zone geostatistics, 10-metre composites were made up from the raw 2.5-metre assay intervals using the HP1000 program CMP3D which accesses assays previously stored in the ASTEC Foley database.

595 10-metre composites resulted from 28 diamond drill holes,, each with SnT, Cu, WO_3, MoS_2 and Bi in ppm.

3.2.2. Distributions

Distributions have been calculated for all elements on 10-m composites and accumulative log-probability graphs plotted for each (see Appendix C). As would be expected all elements approximate lognormality (plot is linear). The similarity of the Snt and Cu plots and the MoS_2 and Bi plots indicates these elements correlate (as supported by geological evidence). The noticeable change of gradient in the WO_3 plot is due to the effects of mixed populations and indicates that tungsten is represented by a low-grade population (mainly less than 0.1% WO_3) and a high grade population (above 0.1% WO_3). This may well be the statistical reflection of two mineralizing phases, but further detailed confirmatory work would be necessary.

Analysis of the 10-m composites also indicates a strong "proportional effect" where high grade regions tend to show a corresponding high variance on standard deviation.

A plot of WO_3 standard deviation versus WO_3 mean grade for 100m cubes over the entire deposit was constructed (see Appendix C). This is a general characteristic of lognormal populations and any irregularities introduced because of the proportional effect can be overcome by the use of "related variance" and "relative variograms".

3.2.3. Variograms

Three-dimensional variograms were calculated for the 10m composites on all 5 elements using the VAR3D program. However because of unacceptable fluctuations in the experimental variograms, only WO_3 could be modelled satisfactorily for the 3 principal directions. Snt, Cu, MoS^2 and Bi could only be modelled in the isotopic case ignoring direction.

Priorities showing the experimental data and the chosen spherical model are included.

The models can be summarized as below:

ELEMENT	DIRECTION	NUGGET EFFECT* C	SILL* C+C	RANGE a
Snt	Isotropic	0.18	2.48	100m
Cu	Isotropic	1.60	2.65	100m
WO_3	Isotropic	0.15	0.60	115m
	Down dip	0.15	0.60	150m
	Along strike	0.15	0.60	120m
	Across Dip	0.15	0.60	70m
MoS_2	Isotropic	0.45	0.79	120m
Bi	Isotropic	0.15	0.63	80m

* Stated as relative gamma values.

The anisotropy ratios for WO_3 are supported by geological observation. As in the sulphide tin lenses, Cu is extremely variable and unpredictable.

3.2.4. Kriging

A three-dimensional "block" model was calculated by Kriging an array of points on a cubic 10-metre grid over the whole deposit down to 850 R.L. This was done using the KRG3D program for all 5 elements.

6300 estimates were generated between 4850N-4990N, 4880E-5080E, 850RL-1040RL. Plotting of various planes within the model was particularly instructive when compared to the interpreted geolgy. SnT and Cu correlate closely and concentrate in the centre of the porphyry intrusive, while MoS_2 and Bi show classic annular zoning with peak values on the periphery. This work was completed very late in the project and warrants more detailed examination.

The Kriged estimates were used as the basis for the ore resource calculation.

3.3. Geological Resource

The geological resource has been calculated using the 3-D Kriged estimates on a 10-m grid throughout the deposit down to 850 R.L. (32 L).

The assumption has been made that the grade of each 10m cube is equal to the Kriged estimate at the centre of the block. This is not strictly valid but does not introduce a large error. Block Kriging was not available at the time of calcuation.

The resource is simply computed by counting the number of "blocks" exceeding a certain cutoff and then multiplying by the tonnage per block which is always 10 x 10 x 10 x 2.87 (S.G.) = 2870 tonnes.

To ascertain the effect of varying cutoff in such a large disseminated deposit, tonnages have been computed for several

cutoffs form 0-0.5% WO_3 in 0.025% WO_3 intervals; also arranged level by level (see Appendix C).

TABLE 4

GEOLOGICAL RESOURCE SUMMARY - DOWN TO 850 RL

INDICATED STATUS

CUTOFF %WO_3	TONNAGE	%WO_3	%SnT	%Cu	%MoS_2	%Bi
0.20	3.80 x 10	0.28	0.05	0.03	0.02	0.02
0.30	1.23 x 10	0.35	0.05	0.04	0.02	0.02
0.40	0.14 x 10	0.43	0.05	0.03	0.02	0.02

3.4. Ground Conditions

All core from recent drilling was photographed on 35mm colour slide before being cut in half for assay. In the event that ground conditions are to be studied in detail prior to mining, some measurements (RQD) from colour slides of core will be possible.

Indirect evidence for reasonably good ground conditions has been evident in the general easy drilling for core within the stockwork and porphyry. Overall core recovery in well mineralized areas has been in excess of 95%. Excellent ground conditions could be anticipated in the porphyry itself. In a few instances continuous unbroken 3m lengths of core were pulled out of the core barrel.

A quantified statement based on measured fact cannot be expressed as no detailed work has been carried out in regard to ground conditions. Some small areas of instability are to be expected within the stockwork zone. Clay, sericite and siderite altered (bleached) patches within the sandstone have been recorded as broken core in several intersections which may be up to 10m wide horizontally. These bleached zones should be singled out if

mining the deposit is considered. Limited underground exposure of this type of alteration has shown them to be irregular and not necessarily related to any predictable structure. However detailed studies may prove otherwise.

3.5 Groundwater and Gas Problems

In July 1981, the deep hole C1633 intersected large volumes of carbon dioxide gas and water at a depth of approximately 500m. below sea-level. At one stage the hole generated 0.4% carbon dioxide within the decline development, the legal limit being 0.5%. Water flow was of the order of 2 litres per second and capped pressures fluctuated from 300 Kpa to 550 Kpa. Water and gas not previously encountered in tin lode drilling became a significant problem around Foley Zone. Stephen Hancock from Australian Groundwater Consultants (A.G.C.) was called in to assist in controlling the problem. Certain on site tests were carried out by him and cemented collar pipes and quick-fitting valves were recommended for all holes on collaring. Extremely efficient and convenient aluminium packers (plugs) were ordered from Van Ruth Products in Kalgoorlie and kept ready should cemented collar pipes fail.

In December 1981 a report (see Appendix E) from A.G.C. was presented to the company tabling the results of previous tests and concluding that groundwaters around the prophyry were seperate from those elsewhere in the mine. The porphyry rock itself was thought to act as a barrier as high pressures in particular were noted on the northern side. Some aspects of the report however were in error, inaccurately presented and contradictory and it was decided not to commit any large additional work to A.G.C. in the future. Since then sufficient 'in-house' experience had been obtained by the staff and drilling contractors on the mine to overcome most practical problems.

The high level of preparedness should be maintained if additional drilling is anticipated.

3.6. Photometric Sorting

I accompanied Mill Superintendant Brent Hampel as an observer during preliminary photometric sorting tests carried out by Ore Sorters Ltd at Thomastown Victoria in July 1981. Photometric sorting is based on the differentiation of reflectance characteristics displayed by various rock types and has been used successfully at Mt. Carbine Queensland where large mineralized white veins contrast with darker barren country-rock.

Rock which had been stockpiled after the intersection of quartz porphyry and stockwork on 25 level decline was crushed on the mine site and sent over to Melbourne for preliminary ore-sorting. Batches of particle size range 15mm to 65mm and 65mm to 110mm containing stockwork and another of porphyry were tested. The detailed metallurgical tests are given in the Appendix. Several geological observations of the stockwork sample were made.

Veins were fused to the country-rock along the contact and would tend to break in the centre rather than at the contact. Even composite veins suffering multiple quartz invasions appeared fused to each other and did not seperate along internal vein contacts. Sericite selvedges which assist in the liberation of the vein in other deposits were generally absent although some examples of breaking along molybdenite rich selvedges was evident.

A large proportion of the mineralized veins were very thin (<2cms) and in the smaller particle size sample of stockwork (15mm to 65mm) most rock particles were still composites of vein and country-rock before and after crushing. The rocks would have to be crushed to a smaller size for sorting to be more effective although this would have implications for mill throughput.

065

A significant proportion (visually 10% to 30%) of very lightcoloured sandstone, shale and chert was noted to be accepted with quartz veins and quartz veined country-rock (Plates 39, 40). These bleached rocks carried no apparent mineralization.

Composite quartz veined country rock samples would sit on the flat surfac e of the centre of the vein and show the darker sub-rounded country-rock up to the light sensors.

Overall results were not encouraging. Refer to C.M.S. report (see Appendix D) for further details.

066

4. FUTURE EXPLORATION

4.1. General Exploration Approach

Nearly all hydrothermal deposits in the workld show some form of metal or mineralogical zoning. Quite often this zoning is a simple reflection of basic chemical or thermal conditions prevailing at the time of mineral precipitation. The classic zoning sequences established by Rundquist (1982) and others should be appreciated by all geologists working with or searching for hydrothermal orebodies. The pioneering geochemical work on metal zoning within the tin lode carried out by K.G. Palmer in the early 1970's made the greatest contribution to the discovery of Foley Zone. It was unfortunate that full-time manpower was not available in the earlier stages of the mines development. The deposit (Foley Zone) may have been discovered earlier and parts possibly mined at a time of higher metal prices.

It is therefore suggested that resources (manpower, time, funds) be made available to collect fundamental geological information (bulk mineralogy, chemistry, petrology, structure) in a systematic fashion throughout the entire ore-body to facilitate general understanding. In nearly all cases the information will be relevant indirectly to the practical exploitation of the deposit. For example, it may be possible to predict good or bad metallurgical behaviour from mineralogical work or imply bad ground conditions from structural work. Too often we blunder into problem areas when pressure for mine production is high and little supporting knowledge exists. Academics and students may be called in to do the work but in most cases their interests are narrow and diverge from having practical relevance. Specialized skills and knowledge are also not retained through external "imports" of temporary personnel.

More sophisticted geophysical, geochemical and conceptual techniques will be needed in the future as conventional

067

exploration tools successfully test only near surface targets for mineralization. In particular a conceptual approach to exploration requiring a detailed understanding of the localization and appearance of target orebodies is essential.

4.2. Exploration Potential at Cleveland

Several lines of evidence indicate the existence of a second mineralizing intrusive in the mine at 300 to 400m below sea level around N section (see Diag. 36).

1. A specimen located at 24 level Henrys (M Section) submitted for petrological description (Amdel 1981) revealed a metasomatic rock composed of quartz-biotite and flourite. Similar lode appears in isolation on 24 level Halls at O and P sections (1. on diagram). The rock is interpreted as greisenized lode and appears over 100m north of greisenized lode associated with Foley Zone.

2. P. Jackson in 1982 recognized a biotite alteration zone within deep lode lens in the mine. Brown biotite alteration was observed to form up to 50m horizontally from the quartz porphyry in Henry's lode around 25 level. Khaki-green biotite developed from 50m. to at least 100m. horizontally from the porphyry. Brown biotite which forms closer to the porphyry was also observed in several holes intersecting Halls B lens below R.L. 900. At 25 level near the porphyry it forms horizontally to the same or lesser extent (not greater) than khaki-green biotite. Therefore the occurrence of khaki-green biotite in Halls lode over 200m. in depth suggests that the brown biotite zone below may form for only 200m. or less before it makes contact with another porphyry thought to localize it. This would imply another porphyry intrusive to lie at approximately 600m. R.L. or higher around N section (2. on diagram).

068

3. Although the relationship between bismuth in the tin lode and Foley Zone is not exactly established, early geochemical data by K.G. Palmer (Diag. 10) show tin lode indirectly above the projeced Foley Zone to contain in excess of 300 ppm Bi. Where semi-quantitative Bi assays have been reported from Halls B lens north of N section just above R.L. 1000, values around 50 ppm Bi only have been noted. Such low values have been observed at higher elevations at the extreme north and south end of the mine and probably across the eroded top over 400m away. If bismuth dispersion in the tin lode is somehow related to Foley Zone type mineralization then the low value around R.L. 1000 suggests that another porphyry intrusive would be at least 400m below at about 600m. R.L. or deeper (3 on diagram).

4. A 0.5% Sn 'saddle' in the lode at 9 level elevation appears north of N-section just above R.L. 1000 in Halls B lens and in A, C and D lens showing a Foley strike trend. The direct relationship between tin grades in the lode and Foley Zone type alteration is still not clearly established. P. Jackson (page 86) suggest that flourine metasomatism (greisenization) of tin lode may be responsible for some tin re-distribution. The large 0.5% Sn 'saddle' sits approximately 300m. above the Foley porphyry. The lesser developed 'saddle' north of N section may therefore represent the effect of another porphyry at least to R.L. 750 or deeper (4 on diag.).

5. Nearly 0.2% WO_3 was intersected in hole C969 over 100m. north of the Foley porphyry at just below R.L. 600. Considering the rapid drop in tungsten grade at higher elevations north of the porphyry, this anomalous mineralization is thought to be related to another system possibly further north (5 on diag.).

Evidence therefore exists to suggest that another porphyry has intruded around N section, the top of which may be between R.L. 600 and R.L. 800. A diamond drill hole to intersect a target at about R.L. 600 is recommended.

069

4.3 Recommended Further Drilling

Further drilling within the zone could proceed in two areas.

1. Mineralization within close reach of current mining development that is above 30 level (R.L. 890m.) should be further investigated to allow for a more confident estimate as to its actual mining potential. Drilling to date has been on 40m. spaced section which is too wide a spacing to correlate intersections confidently. This is born out by the changes in shape of the 0.4% WO_3 cutoff zone shown on 5000E and 4960E sections. Infill drilling between these sections that is at 20m. spacing will confirm continuity of the mineralized zone.

2. The intersection of stockwork and porphyry in drill hole C1633 indicates that mineralization continues to deep levels. Unfortunately drill hole C1633 had to be abandoned (gas & water) before it could penetrate the southern (footwall) stockwork where higher grades are generally located. A series of holes above C1633. (R.L. 500) and below the area which has currently been defined that is below 850-R.L. should be attempted. It may be possible to double the entire tonnage potential of the zone although the bulk grade cannot be estimated with any confidence.

ACKNOWLEDGEMENTS

I wish to acknowledge P. Jackson and Dr. T.A.P. Kwak for their assistance with petrological aspects of Foley Zone. discussions with Peter and Teunis have broadened my interest in tin and tungsten deposits, and developed an appreciation of hydrothermal systems generally.

I thank Gary McArthur, Senior Mine Geologist for his skilled contribution in the field of geostatistics and ore-reserves. It was pleasant to know that certain geological conclusions were supported and re-inforced by statistical measurements. The rest of the Geology Department including Tony Hespe for stimulating discussions and Mark Fleming, Andrew Maher, Lindsay Stonehouse and Eric Brooke are acknowledged for their continued support.

I also thank Paul Vlasich and Kate Taylor for draughting most of the diagrams with speed and skill despite their enormous workload.

071

REFERENCES

Amdel 1981 - - Petrology of Twenty Samples from the Cleveland Tin Mine, Luina, Tasmania. Report No. G5 5945/81.

Blissett, A.H. 1962 - Zeehan: Tasmania Geol. Survey, Explan. Rept., 1 - mile Geol. Map Series K/55-5-50.

Collins, P.L.F. 1981 - The Geology and Genesis of the Cleveland Tin Deposit, Western Tasmania: Fluid Inclusion and Stable Isotope Studies. Economic Geology Vol. 76 pp 365 - 392.

Cox, R. - The Economic Geology of the Cleveland and Magnet Mines, Tasmania. (Unpublished Ph.D. Thesis, University of Sydney).

Dronseika, E.V. 1981 - Proposed Detailed Exploration for Foley Zone from 24 Level Platform. (Unpublished internal memorandum.)

Dagger, G.W. 1972 - Genesis of the Mount Pleasant tungsten-molybdenum-bismuth deposit, New Brunswick, Canada: Inst. Mining Metallurgy Trans, sec B, V-81 p.B73 - B102.

Dobson, C.D. 1982 - Geology and Alteration of the Lost River Tin-Tungsten-Fluorine Depost, Alaska: Econ. Geol. vol. 77. pp.1033-1052.

Groves, D.I., Martin, E.L., Murchie, H., Wellington, H.K., 1972 - A Century of Tin Mining at Mount Bischoff 1871-1971. Geol. Survey Bull. No. 54. Tasmania Dept. of Mines Publication.

Heler, K.S. and Lamber, I.B. 1978 - A Compilation of potassium uranium and thorium abundances and heat productivities of Aurstralian rocks. Technical report, R.S.E.S. Australian Nation University.

072

Jackson, P.G. 1982 - The Mineralogy, Mineral Zonation and Hydrothermal Alteration in the Lower Hall's B Lens, Cleveland Mine, Tasmania. (Unpublished B.Sc. (Hons.) Thesis, Latrobe University.)

Kelly, W.C. & Rye, R.O. 1979 - Geologic, Fluid Inclusion, and Stable Isotope Studies of the Tin-Tungsten Deposits of Panasqueira, Portugal: Econ. Geol. Vol. 74. pp.1721-1822.

Kingsbury, C.J.R. 1965 - Cassiterite and Wolframite Veins at Aberfoyle and Storey's Creek Tasmania, in Geology of Australian Ore Deposits, Vol. 1. Eighth Common Mining and Met. Congress.

Korzhinski, D.S. 1964 - An Outline of Metasomatic Processes. Internat. Geol. 6: pp.1713-1734, 1920-1952, 2169-2198.

Palmer, K.G. 1978 - Cleveland Mine, Geological Work Proposals. (Unpublished internal report.)

Plumridge, C.L. 1975 - Mt. Carbine tungsten reef swarm in Knight, C.L. (Ed.) 'Economic Geology of Australia and Papua New Guinea, Vol. 1: Metals. Aust. Inst. Min. Metall: 762-764.

Roberts, C.I. 1981 - Foley Zone. Task Force Master Plan. (Unpublished internal memorandum.)

Rubenach, M. 1983 - The Tasmanian ultramfic-gabbro and ophiolite complexes: (Unpublished Ph.D. thesis, Univ. Tasmania.)

Rundquist, D.V. 1982 - Zoning of Metallization Associated with Acid Magmatism, in Metallization Associated with Acid Magmatism, J. Wiley and Son Ltd.

Scherba, G.N. 1970 - Greisens: Internat. Geol. Rev. V.12, p.114-150, 239-255.

Sokolov, G.A. & Komarov P.V. 1968 - On the relationsip between Metalliferous Greisens and Skarns: Internat. Geol. Cong. 23rd, Pragne 1968, Proc. V.7, p.305-312.

Zharikov, V.A. 1970 - Skarns: Internat. Geol. Review, V.12, p.541-559, 619-647, 760-775.

074

U of M | A.O. | C.G. | E.O. | D.S.M.E
Registrar
Received 2 - SEP 1983 | E & IL
Answered
DEPT. OF MI...
REF. No. 8034/83

GEOLOGICAL ASSESSMENT OF THE FOLEY ZONE MINERALIZATION AT CLEVELAND MINE, TASMANIA.

APPENDICES

A. PETROLOGY

B. MAJOR AND MINOR METAL ASSAYS

C. GEOSTATISTICS

D. METALLURGY

E. GROUNDWATER

...ED

APPENDIX A.

PETROLOGY

076

72 077

PETROLOGY OF FIFTEEN ROCKS FROM THE CLEVELAND MINE

Cleveland Tin Limited
Tasmania

3/43/6/0-GS4859/81 May 1981

077

The Australian
ral Development
Laboratories

n Street, Frewville,
outh Australia 5063
e Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
Box 114 Eastwood
SA 5063
In reply quote:

72 078

amdel

12 May 1981

GS 3/43/6/0

Cleveland Tin Limited,
LUINA, Tas. 7321.

Attention: Mr G. McArthur

REPORT GS 4859/81

YOUR REFERENCE:	Order No. 14584 and Goods Outwards 09784 dated 30 March 1981
MATERIAL:	15 rock samples
LOCALITY:	Cleveland Mine
IDENTIFICATION:	183729-43 inclusive
DATE RECEIVED:	3 April 1981
WORK REQUIRED:	Petrography and mineragraphy (15 MA1.3 and 15 MA2.1/2.2)

Investigation and Report by: Frank Radke
Electron-probe Microanalysis by: Peter Schultz

Manager, Geological Services Division: Dr Keith J. Henley

Keith Henley.

for Norton Jackson
Managing Director

jd/21

lant: Osman Place
Thebarton S.A.
Telephone 43 8053
anch Laboratories:
Perth W.A.
elephone 325 7311
Melbourne Vic.
elephone 645 3093

PETROLOGY OF FIFTEEN ROCKS FROM THE CLEVELAND MINE

1. SUMMARY

Fifteen samples submitted by Cleveland Tin Limited for petrographic and mineragraphic examination were given the following rock names:

Sample and TS No.		Rock Name
183729;	PTSC32569	Quartz-veined and tourmalinized sandstone
183730;	PTSC32570	Quartz-veined and tourmalinized sandstone
183731;	PTSC32571	Mineralized quartzite
183732;	PTSC32572	Mineralized quartzite
183733;	PTSC32573	Mineralized quartzite
183734;	PTSC32574	Biotite-fluorite rock
183735;	PTSC32575	Quartz-fluorite-mica rock
183736;	PTSC32576	Mineralized fine-grained sandstone
183737;	PTSC32577	Biotite rock
183738;	PTSC32578	Biotite-quartz-fluorite rock
183739;	PTSC32579	Biotite(?)-fluorite rock
183740;	PTSC32580	Biotite-quartz-fluorite rock
183741;	PTSC32581	Altered fine-grained sandstone (quartz-biotite-fluorite rock)
183742;	PTSC32582	Metasomatic quartz-fluorite-biotite rock
183743;	PTSC32583	Carbonate-bearing greisen

All of the above samples are considered to represent fine-grained detrital sediments which have suffered metamorphism and associated pervasive metasomatism. At least some of the rocks still retain what are considered to represent recrystallized detrital textures but in other rocks the quartz all appears to be of a metasomatic origin. The rocks which contain abundant biotite are considered to be rocks with a significant argillaceous component which has been replaced by biotite. The major metasomatic minerals are quartz, fluorite and carbonate. In the first two samples (183729-30) abundant tourmaline is also present and could be of metasomatic origin although it is also possible that these could represent original boron-rich sediments.

molybdenite along with minor amounts of chalcopyrite and sphalerite in some samples.

The bismuth in these samples occurs mainly as bismuthinite but in one sample (183750) which was examined with a electron microprobe, bismuth was also noted as metallic bismuth and as a complex bismuth lead copper sulphosalt. In the mineragraphic descriptions the complex sulphosalts had been included with bismuthinite and much more detailed probe analyses would be required to fully determine what species these minerals exist. It is considered unlikely that this would be only of an academic interest since most of the bismuth occurs in bismuthinite. Although metallic bismuth was only identified positively in sample 183750, other samples contain what is believed to be metallic bismuth.

2. INTRODUCTION

Fifteen samples were submitted by Cleveland Tin Limited for petrographic and mineragraphic examination. In particular, information on the tungsten and bismuth mineralization was requested.

3. PETROGRAPHY AND MINERAGRAPHY

Polished thin sections were cut of all of the samples and examined by reflected light and transmitted light microscopy. In addition, one sample was examined with the electron microprobe to confirm mineral identities. All of the samples were also tested under ultraviolet light but no indication of scheelite was detected although some of the rocks contain a fluorescent orange apatite. This apatite was positively identified by X-ray diffraction powder photography.

Sample: 183729; PTSC32569

Rock Name:
Quartz-veined and tourmalinized sandstone

Hand Specimen:
This rock consists of a very fine-grained dark grey to black rock containing pale grey quartz-rich veins up to about 1 cm in size. One set of veins which contains a finely intergrown pale tan mineral has a subparallel orientation and these are transected by an apparently later vein which contains more abundant mineralization.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Vein quartz	40
Quartz grains	25
Tourmaline	20
Carbonate	5
Fluorite	3
Wolframite	2
Pyrrhotite	2
Molybdenite	1
Pyrite	1
Rutile	1
Cassiterite	trace-1
Zircon	trace
Bismuthinite	trace
(?)Bismuth	trace

In thin section the very fine-grained pale grey to black rock can be seen to consist of angular quartz grains between 0.05 and 0.4 mm in size intergrown with interstitial tourmaline. Most of the tourmaline has a pale brown pleochroic colour although locally the tourmaline exhibits a pale green pleochroic colour or a clear coloration. The angular quartz grains appear to be of detrital origin preserving their original detrital shapes.

The paler coloured veins consist mainly of a granular, quartz mosaic with a somewhat variable grain size ranging from 0.1 to 1 mm. Most of the mineralization is concentrated in these quartz veins. The minerals present at minor to trace levels in these veins include carbonate, fluorite, wolframite, pyrrhotite, molybdenite, cassiterite, bismuthinite and probable metallic bismuth. The wolframite forms elongate, tabular crystals up to 2 mm in length while the molybdenite forms small flaky crystals and aggregates up to 0.8 mm in size. Locally minor cassiterite was noted particularly associated with molybdenite as anhedral grains up to 0.8 mm in size. Most of the cassiterite has a somewhat zoned clear to reddish-brown coloration. Both the fluorite and carbonate tends to form angular interstitial fillings and often occur marginal to disseminated opaque grains. Minor bismuthinite was noted locally as small crystals up to 0.2 mm in size which occur either intergrown with the granular quartz or intergrown with molybdenite.

The pyrrhotite forms anhedral crystals up to 2 mm in size which are intergrown with the granular quartz veins. Pyrrhotite is also disseminated through the tourmaline-rich rock as small anhedral crystals up to 0.1 mm in size. Locally narrow veins are partially lined with pyrrhotite. All of the pyrite in this rock is a marginal alteration product of pyrrhotite and generally

occurs around larger pyrrhotite crystals. Locally small individual pyrite crystals are also present but these contain textural features indicating that they represent completely altered pyrrhotite crystals. The pyrite after pyrrhotite generally has a somewhat lamellar-appearing texture which most likely represents a remnant cleavage in the original pyrrhotite.

Minor rutile is disseminated through the tourmalinized sediment as small crystals up to 0.2 mm in size. Traces of zircon also form small disseminated crystals up to 0.1 mm in size.

This is a quartz-rich detrital sediment whose original matrix, which could possibly have represented argillaceous material, has been completely replaced by tourmaline considered to be of metasomatic origin. The rock also contains abundant quartz veins which appear to be of at least two generations with the later quartz vein containing more abundant mineralization which includes cassiterite, wolframite, molybdenite and various other sulphides as well as carbonate and fluorite.

Sample: 183730; PTSC32570

Rock Name:
Quartz-veined and tourmalinized sandstone

Hand Specimen:
This rock consists mainly of milky grey vein quartz containing large angular fragments of a darker grey rock which are up to several centimetres in size. The quartz contains intergrown black, prismatic minerals which were identified as wolframite.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Vein quartz	50
Tourmaline	20
Quartz grains	15
Carbonate	5
Fluorite	3
Wolframite	2
Molybdenite	1
Muscovite/sericite	1
Pyrite/marcasite	1
Rutile	1
Cassiterite	trace
Bismuthinite	trace
Chalcopyrite	trace
Bismuth	trace

This rock consists mainly of a quartz-rich mosaic with a typical grain size between 0.2 and 1.5 mm. Most of this quartz represents quartz-rich veins which enclose a tourmalinized sediment. This tourmalinized sediment would be the dark grey to black angular fragments noted in hand specimen.

These fragments now consist of quartz grains between 0.05 and 0.3 mm in size which generally have subangular to subrounded shapes with a modified detrital-appearing texture. These quartz grains are intergrown with interstitial tourmaline which generally has a pale green to pale yellowish-brown, weakly pleochroic colour. Locally larger, somewhat prismatic tourmaline crystals up to 0.5 mm in size are intergrown with the quartz-rich veins. This tourmaline generally has a somewhat more intensely pleochroic green colour.

Other gangue minerals intergrown with the quartz-rich veins are carbonate and fluorite which form quite large crystals up to 1.5 mm in size as well as muscovite/sericite which tends to form finely divided flaky aggregates located interstitially between the granular quartz. Minor carbonate was also noted locally intergrown with the tourmalinized sandstone fragments.

Wolframite is intergrown with the quartz-rich veins as elongate, prismatic crystals up to 4 mm in length. Molybdenite forms well developed flakes up to 1 mm in size which locally forms slightly larger flaky aggregates. Bismuthinite is intergrown with some of the flaky molybdenite aggregates as interstitial fillings up to 0.3 mm in size. Minor bismuthinite also occurs disseminated as small interstitial fillings between the granular quartz. Traces of bismuth were noted locally as small inclusions within

083

some bismuthinite crystals. Minor cassiterite was noted locally as anhedral to subhedral crystals up to 0.4 mm in size which typically has somewhat zoned, reddish-brown colours. The quartz veins also contain some intergrown iron sulphides as anhedral grains up to 0.4 mm in size. These iron sulphides generally consist of finely intergrown pyrite and marcasite and many exhibit remnant textures indicating they represent completely altered pyrrhotite crystals. These remnant textures include a porous character and lamellar-appearing textures. Traces of chalcopyrite were noted locally as very small disseminated crystals below 0.1 mm in size which are generally intergrown with other sulphides.

Minor rutile is disseminated through the tourmalinized sandstone as small crystals up to 0.2 mm in size.

This rock is quite similar to sample 183729 in mineralogy, texture and origin but does have a higher proportion of a mineralized quartz veining.

Sample: 183731; PTSC32571

Rock Name:
Mineralized quartzite

Hand Specimen:
A massive rock containing milky-grey quartz grains up to 5 mm in size disseminated through a dull white, finer-grained matrix.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	85
Carbonate	5
Fluorite	5
Pyrite/marcasite	4
Rutile	1
Wolframite	trace
Chalcopyrite	trace
Bismuthinite	trace

This rock consists mainly of a granular quartz mosaic with a typical grain size of about 0.15 mm through which much larger quartz grains up to several millimetres are disseminated. The larger quartz grains have somewhat modified detrital-appearing shapes with rounded characters.

Both fluorite and calcite occur interstitially between the quartz grains as infillings and patches up to 0.5 mm in size. Locally the calcite also occurs marginal to disseminated pyrite crystals.

The pyrite which is disseminated through the rock forms anhedral crystals up to 1 mm in size and contains minor amounts of finely intergrown marcasite. Most, if not all, of the pyrite is a replacement product of pre-existing pyrrhotite and exhibits textures including fine lamellar textures indicating such an origin. Locally traces of wolframite were noted as small prismatic crystals up to 0.2 mm in length. Traces of chalcopyrite and bismuthinite are also disseminated through the rock as anhedral grains below 0.1 mm in size. The rock contains minor disseminated rutile as small crystals up to 0.1 mm in size.

This rock is considered to represent a quartz-rich detrital sediment which still retains a somewhat vague remnant detrital texture of a bimodal character despite the crystallization to produce a quartz-rich mosaic. Evidence of mineralization includes the presence of interstitial chlorite and carbonate as well as pyrrhotite which has been completely replaced by pyrite and marcasite. Traces of wolframite, chalcopyrite and bismuthinite were also noted.

085

Sample: 183732; PTSC32572

Rock Name:
Mineralized quartzite

Hand Specimen:
A massive, mottled-appearing rock with a milky-grey to dull white colour which contains some disseminated milky-grey quartz crystals. The rock contains disseminated sulphide as small grains below 1 mm in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	85
Carbonate	5
Pyrite/marcasite	5
Fluorite	3
Chalcopyrite	1
Cassiterite	trace-1
Stannite	trace-1
Bismuthinite	trace

This rock consists mainly of a granular quartz mosaic with a typical grain size of 0.2 mm through which somewhat larger quartz grains up to several millimetres are disseminated. The larger quartz grains have somewhat modified rounded shapes and appear to be of detrital origin and similar to the large quartz grains in sample 183731. Much of the finely granular quartz has a secondary, vein-like appearance and at least locally tends to form somewhat elongate, prismatic shaped crystals. Locally the rock contains very finely granular, cherty-appearing aggregates of quartz. Both carbonate and fluorite are disseminated through the rock as interstitial fillings between the quartz grains which have vein-like to angular shapes and are up to 0.5 mm in size. Cassiterite is also disseminated through the rock as small crystals up to 0.5 mm in size which typically have a somewhat zoned reddish-brown colour.

The major sulphide in this rock is pyrite which forms anhedral grains and aggregates up to 0.5 mm in size which tend to occur interstitially between the granular quartz. As in the pre-existing samples the pyrite is considered to represent a replacement product of pre-existing pyrrhotite since it exhibits lamellar textures as well as a poorly polished, porous-appearing character typical of secondary pyrite after pyrrhotite. Minor marcasite is locally intergrown with the pyrite as small polycrystalline aggregates. The rock contains some disseminated chalcopyrite as anhedral grains up to 0.5 mm in size. At least locally the chalcopyrite is intergrown with cassiterite and stannite. The cassiterite tends to form subhedral crystals while the stannite forms anhedral crystals up to 0.3 mm in size. Traces of bismuthinite were noted locally as small anhedral grains up to 0.2 mm in size.

This is a mineralized quartz-rich rock quite similar to sample 183731 in mineralogy, texture and origin.

086

72 087

Sample: 183733; PTSC32573

Rock Name:
Mineralized quartzite

Hand Specimen:
A massive, pale grey to white coloured rock containing black dissmineated patches up to a few millimetres in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	85
Carbonate	5
Fluorite	3
Muscovite/sericite	3
Wolframite	2
Pyrite/marcasite	2
Chalcopyrite	trace

This rock consists mainly of a relatively fine-grained (typical grain size between 0.1 and 0.3 mm) quartz mosaic which has a recrytallized character. The rock contains a small proportion of larger quartz grains up to 1 mm in size which have somewhat modified rounded shapes. Both carbonate and fluorite tend to occur interstitially between the granular quartz as vein-like structures although locally large patches up to 1 mm in size of both minerals are present.

The rock contains disseminated wolframite as elongate, prismatic crystals up to 2 mm in length which locally form aggregates up to several millimetres in size. Minor pyrite is also disseminated through the rock as anhedral grains and aggregates up to 0.5 mm in size. As in the previously described samples, the pyrite shows textural features indicating it is a replacement product of pre-existing pyrrhotite. Minor marcasite is locally intergrown with the pyrite as finely divided polycrystalline aggregates. Traces of chalcopyrite are also disseminated through the rock as anhedral grains up to 0.2 mm in size.

This rock contains some interstitial fillings of finely divided sericitic material which often occur intergrown with interstitial carbonate and appear to have been partially replaced by carbonate. Minor finely divided muscovite flakes also occur around the outer margins of some large quartz grains and appear to define a recrystallized outer margin.

This is a mineralized quartzite somewhat similar to the two previously described mineralized quartzites in mineralogy, texture and origin. There is some evidence that the carbonate in this rock has replaced pre-existing finely divided muscovite/sericite. Ore minerals observed in this sample consist of wolframite and chalcopyrite.

087

Sample: 183734; PTSC32574

Rock Name:
Biotite-fluorite rock

Hand Specimen:
A massive, dark grey to black rock with a very fine grain size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Biotite	80
Fluorite	15
Quartz	3
Pyrrhotite	1
Chalcopyrite	trace
Bismuthinite	trace
(?)Bismuth	trace

This rock consists of randomly orientated biotite flakes generally between 0.1 and 0.4 mm in size intergrown with interstitial fluorite. Most of biotite has a pleochroic green colour but locally the rock has a band comprised of slightly finer-grained biotite with a pleochroic, reddish-brown colour. The fluorite forms anhedral grains up to 0.2 mm in size located interstitially between the biotite flakes.

Pyrrhotite is concentrated in a band which is approximately 1 mm wide located adjacent to the contact of the brown and green coloured biotite. The pyrrhotite forms anhedral disseminated grains up to 0.2 mm in size intergrown with the biotite and fluorite. Minor chalcopyrite is also intergrown with this band mainly as granular intergrowths with pyrrhotite although some chalcopyrite also occurs as individual, anhedral grains.

Minor bismuthinite is disseminated through the rock as very finely divided anhedral grains generally below 0.05 mm in size which tends to be concentrated in patches up to 0.4 mm in size. Some of this bismuthinite contains another phase which tarnishes easily and could represent metallic bismuth.

This is an unusual biotite-rich rock containing a moderate proportion of fluorite and is most likely of metasomatic origin.

038

72 089

Sample: 183735; PTSC32575

Rock Name:
Quartz-fluorite-mica rock

Hand Specimen:
A massive, fine-grained rock with a pale greenish-grey to tan colour. The rock contains traces of a fluorescent orange mineral identified as apatite by X-ray diffraction powder photography.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	50
Fluorite	20
Muscovite	15
Carbonate	7
Biotite	5
Wolframite	1
Rutile	1
Limonite	1
Apatite	trace
Bismuthinite	trace
Pyrrnotite	trace
Chalcopyrite	trace

This rock consists mainly of granular quartz with a typical grain size between 0.3 and 1 mm intergrown with fluorite and disseminated mica flake The sphalerite forms anhedral grains up to 0.5 mm in size which are disseminated through the rock and locally tends to be concentrated in vei like structures. Finely divided muscovite flakes below 0.1 mm in lengt are also disseminated through the rock and many are included within large quartz grains.

The rock contains degraded biotite flakes up to 0.8 mm long which have been replaced largely by carbonate although some also show marginal replacement by muscovite. Remnants of biotite are still present in many cases and have a weakly pleochroic, reddish-brown colour. These remnant biotite flakes show replacement by finely granular carbonate arou their margins and along cleavage traces and many finely granular carbonat patches have a remnant lamellar character indicating they represent compl replaced biotite flakes. The carbonate is also present as very narrow fracture and vein fillings below 0.1 mm wide. The rock contains minor limonite which also tends to form narrow fracture and vein fillings and finely divided intergrowths with carbonate.

Wolframite is disseminated through the rock as prismatic crystals and poly crystalline aggregates up to 1 mm in size. Traces of rutile form small disseminated grains below 0.3 mm in size. Minor apatite was noted as small disseminated crystals up to 0.5 mm in size.

The rock contains minor disseminated sulphide comprised mainly of pyrrhot which forms anhedral grains up to 0.3 mm in size. Traces of chalcopyrite are intergrown with some of the pyrrhotite. Traces of bismuthinite als form anhedral disseminated grains up to 0.1 mm in size.

This is a quartz-rich rock which is believed to be of an essentially meta somatic origin comprised of secondary quartz intergrown with fluorite and mica. The original rock contained moderate amounts of a weakly pleochi biotite but this has been largely replaced by carbonate.

Sample: 183736; PTSC32576

Rock Name:
Mineralized fine-grained sandstone

Hand Specimen:
A very fine-grained dull white to pale tan coloured rock with a somewhat fragmental texture containing some narrow, darker brown coloured veins below 1 mm in width as well as wider dark grey coloured veins up to several millimetres in width. This rock also contains traces of a fluorescent orange mineral identified as apatite by X-ray diffraction powder photography.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	60
Carbonate	15
Sericite/clay	13
Fluorite	5
Tourmaline	3
Wolframite	2
Bismuthinite	1
Ilmenite	trace-1
Rutile/leucoxene	trace-1
Pyrite	trace
Pyrrhotite	trace
(?)Bismuth	trace

This rock consists mainly of a relatively fine-grained (typical grain size about 0.1 mm) quartz-rich mosaic containing minor amounts of other minerals and veining. The granular quartz contains some interstitial finely divided sericited as well as finely intergrown sericite and clay and at least locally this interstitial material comprises a moderately high proportion of the sample. Overall most of the rock appears to be a very fine-grained quartz-rich sediment which has a recrystallized, granular nature.

The rock is cut by a very wide vein filled largely with fluorite but which also contains some coarser-grained quartz crystals up to 0.5 mm in size, some of which exhibit well developed prismatic shapes. This vein would represent the wider dark grey vein noted in hand specimen. The rock is also cut by several narrower veins filled with very finely granular, turbid carbonate which would represent the darker coloured brown veins noted in hand specimen. These carbonate filled veins transect the wider quartz and fluorite-rich vein. The rock is also cut by one relatively wide quartz-rich vein approximately 2 mm in width. Minor carbonate is intergrown with this quartz-rich vein as angular, interstitial fillings up to 1 mm in size. This vein also contains a concentration of wolframite as prismatic crystals up to 1 mm in length. Traces of ilmenite also occur in this vein as elongate, prismatic crystals with acicular shapes which show some marginal alteration to leucoxene.

Minor tourmaline is disseminated through the sandstone as small crystals up to 0.2 mm in size which have a pleochroic green to brownish colour. Minor rutile is also disseminated through the fine-grained sedimentary rock as small grains up to 0.1 mm in size.

Sulphides present in this rock consist of bismuthinite, pyrite and pyrrhotite

all of which form small, anhedral grains below 0.2 mm in size. The pyrrhotite and pyrite tend to be disseminated through the fine-grained quartz-rich sandstone and most of the pyrite is believed to be a replacement product of pre-existing pyrrhotite. Bismuthinite occurs both disseminated through the fine-grained sandstone and as slightly larger grains and granular aggregates in the quartz and quartz-fluorite veins. Some larger bismuthinite aggregates contain intergrown material with a corroded-appearing, poorly polished character which could represent metallic bismuth.

This is a very fine-grained sedimentary rock with a recrystallized granular texture which shows evidence of mineralization and veining.

091

72 092

Sample: 183737; PTSC32577

Rock Name:
Biotite rock

Hand Specimen:
A very fine-grained dark grey to black rock containing localized sulphide patches up to several millimetres in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Biotite	55
Quartz	20
Carbonate	10
Fluorite	5
Pyrite	4
Pyrrhotite	2
Sericite	1
Chalcopyrite	1
Leucoxene	1
Molybdenite	trace-1
Ilmenite	trace
Sphalerite	trace

This rock consists mainly of small biotite flakes up to 0.2 mm in length intergrown with granular quartz which has a typical grain size between 0.1 and 0.2 mm. The biotite flakes exhibit a random orientation and have a pleochroic green to brownish green colour. In thin section there is a vague hint of banding produced by slight variations in the proportions of biotite and quartz within bands up to several millimetres wide. Minor amounts of fluorite are disseminated through the rock as small grains up to 0.2 mm in size which are intergrown with the biotite and quartz. Sericite also occurs locally mainly as very finely divided inclusions within quartz grains. The rock contains patches of very finely granular carbonate up to 1 mm in size which contain moderate amounts of opaque material giving them an opaque to translucent character in thin section. In polished section these patches can be seen to contain moderate amounts of finely intergrown leucoxene as anhedral grains and locally myrmekitic-appearing intergrowths. These carbonate-rich patches also contain concentrations of molybdenite as small flaky-appearing crystals up to 0.1 mm in length. Locally minor chalcopyrite and pyrite are intergrown with the granular carbonate aggregates. In addition to these aggregates, carbonate also occurs as narrow fracture and vein fillings below 0.1 mm wide which also generally have a turbid character.

The large sulphide-rich patch noted in hand specimen consists mainly of pyrite and pyrrhotite. The pyrite has a massive, well polished character but contains cores of pyrrhotite suggesting that the pyrite is a replacement product of pyrrhotite and has suffered recrystallization to eliminate the lamellar and porous-appearing textures typical of pyrite after pyrrhotite. Only locally does some of this pyrite show vague lamellar textures typical of pyrite after pyrrhotite. The outer margins of the pyrrhotite cores typically contain very finely divided myrmekitic intergrowths of pyrite which is also believed to represent a recrystallization texture of partially replaced pyrrhotite. Minor chalcopyrite is locally intergrown with the partially replaced pyrrhotite as anhedral grains up to 0.3 mm in size. Traces of chalcopyrite also occur as anhedral disseminated grains up to 0.2 mm in size. Locally traces of sphalerite were noted as granular intergrowths

with chalcopyrite. Minor ilmenite was noted as small, elongate crystals up to 0.1 mm in size.

This is a biotite-rich rock which is believed to represent an original argillaceous sediment which has been subjected to metamorphism and probably metasomatism to produce the existing biotite-rich assemblage.

Sample: 183738; PTSC32578

Rock Name:
Biotite-quartz-fluorite rock

Hand Specimen:
A massive, dark grey to black rock containing some irregular paler grey to dull white coloured patches up to about 1 cm in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Biotite	45
Quartz	25
Fluorite	20
Carbonate	5
Sericite	2
Zeolite	1
Leucoxene	1
Pyrite	trace-1
Molybdenite	trace
Zircon	trace

This rock consists mainly of randomly oriented biotite flakes up to 0.2 mm in length intergrown with smaller amounts of granular quartz. The granular quartz forms recrystallized mosaic with individual grains up to 0.15 mm in size. The biotite flakes have a pleochroic brown colour and generally exhibit a random orientation.

The paler coloured patches noted in hand specimen consist mainly of fluorite and quartz with minor amounts of disseminated biotite. The fluorite forms very large crystals up to several millimetres in size which locally contain included quartz crystals up to 0.4 mm in length. Some of these included quartz crystals exhibit moderately well developed prismatic shapes. Locally these pale grey coloured patches consist mainly of relatively coarse-grained (typical grain size between 0.3 and 0.5 mm), granular quartz mosaics with smaller amounts of intergrown fluorite.

The rock contains minor amounts of sericite as very finely divided flakes which are generally included within quartz grains intergrown with biotite. Both carbonate and fluorite forms narrow fracture and vein fillings up to 0.3 mm in length. One fluorite-filled vein also contains moderate amounts of a weakly birefrigent mineral considered to be a zeolite.

Minor pyrite is disseminated through the rock mainly as crystals up to 0.15 mm in size, some of which exhibit euhedral shapes. Unlike most of the pyrite in the pre-existing samples which appears to be a replacement produce of pyrrhotite, this pyrite appears to be of primary origin. Minor molybdenite is also disseminated through the rock as small flakes below 0.1 mm in length. Accessory leucoxene forms anhedral disseminated grains and aggregates up to 0.1 mm in size.

This is a biotite-rich rock believed to represent a metamorphosed and metasomatized argillaceous sediment which contains moderate amounts of fluorite and quartz believed to be of metasomatic origin.

Sample: 183739; PTSC32579

Rock Name:
Biotite(?)-fluorite rock

Hand Specimen:
A massive dark greenish-grey to black coloured rock containing some small pale grey coloured patches up to a few millimetres in size. The rock also contains disseminated sulphide as well as some moderately large sulphide-rich patches up to about 1 cm in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Pale green phyllosilicate (?)biotite	60
Fluorite	20
Quartz	5
Carbonate	5
Pyrrhotite	5
Marcasite/pyrite	2
Chalcopyrite	1
Sphalerite	trace-1
Bismuthinite	trace-1
Wolframite	trace-1
Molybdenite	trace
Tourmaline	trace

This rock consists mainly of randomly oriented mica flakes generally about 0.1 mm in size which are intergrown with fluorite and smaller amounts of quartz and carbonate. The phyllosilicate has a very pale green, weakly pleochroic and is believed to represent a biotite although it could represent another weakly pleochroic mica with high birefringence. The fluorite is disseminated through the rock as irregular patches up to several millimetres in size with a relatively coarse grain size. Most of the quartz forms finely granular aggregates up to 0.3 mm in size which are intergrown with the biotite or occur as inclusions within large fluorite crystals. Traces of tourmaline are disseminated through the rock as prismatic crystals up to 0.3 mm in size which have a pleochroic green colour.

The large sulphide-rich patch consists mainly of pyrrhotite and consists of a polycrystalline aggregate comprised of small pyrrhotite crystals generally below 0.5 mm in size. The pyrrhotite exhibits some replacement by finely intergrown pyrite and marcasite which has a lamellar texture. The chalcopyrite is also locally intergrown with the pyrrhotite as anhedral grains up to 0.3 mm in size. Traces of sphalerite and bismuthinite were also noted intergrown with chalcopyrite and pyrrhotite typically as anhedral grains below 0.2 mm in size. Minor pyrrhotite is also disseminated through the rock as small anhedral crystals below 0.1 mm in size.

Both the wolframite and molybdenite tend to be disseminated through the rock as indidividual grains and polycrystalline aggregates up to 0.2 mm in size.

This is a biotite-rich rock somewhat similar to most of the previously described biotite-rich rocks although the biotite in this sample has a very pale green, weakly pleochroic colour.

Sample: 183740; PTSC32580

Rock Name:
Biotite-quartz-fluorite rock

Hand Specimen:
A dark brown to grey coloured rock with some irregular paler-grey coloured mottling.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Biotite	35
Quartz	35
Fluorite	25
Carbonate	1
Wolframite	1
Pyrite	1
Tourmaline	trace-1
Bismuthinite	trace-1
Chalcopyrite	trace
Galena	trace
Pyrrhotite	trace
Bismuth	trace

This rock consists mainly of a relatively coarse-grained (typical grain size between 0.4 and 1 mm) mosaic of quartz and feldspar which is intergrown with randomly oriented biotite flakes typically below 0.2 mm in length. The biotite flakes form flaky aggregates up to 1 mm in size and individual flakes included within larger fluorite and quartz crystals. All of the biotite has a very pale brown, weakly pleochroic colour. Traces of tourmaline were also noted as small prismatic crystals up to 0.3 mm in size which have a pleochroic green colour. Minor carbonate was noted locally as interstitial fillings as well as narrow fracture and vein fillings.

The major opaque minerals are wolframite and pyrite both of which form disseminated crystals. The wolframite crystals are up to 0.5 mm in length and tend to have elongate, prismatic shapes while the pyrite tends to form anhedral disseminated grains below 0.2 mm in size. A small proportion of the disseminated pyrite forms euhedral to subhedral crystals. Minor bismuthinite was noted locally as interstitial fillings up to 0.1 mm in size. Some of the bismuthinite contains minor amounts of a metallic phase believed to be metallic bismuth intergrown as marginal intergrowths and inclusions. Minor chalcopyrite and galena are also disseminated through the rock as interstitial fillings up to 0.1 mm in size. Traces of pyrrhotite were noted as small anhedral grains up to 0.1 mm in size, some of which are intergrown with wolframite.

This is an essentially metasomatic rock now comprised mainly of biotite, quartz and fluorite.

Sample: 183741; PTSC32581

Rock Name:
Altered fine-grained sandstone (quartz-biotite-fluorite rock)

Hand Specimen:
A massive, fine-grained rock with a pale tan to brown coloration which contains some pale grey veins up to about 1 mm wide. Traces of fluorescent orange apatite occur within some of the paler coloured veins.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	50
Biotite	30
Fluorite	15
Carbonate	2
Rutile	1
Wolframite	trace-1
Pyrite	trace-1
Apatite	trace
Amphibole	trace

This rock consists mainly of a fine-grained quartz and biotite intergrowth comprised of a recrystallized quartz mosaic with a typical grain size between 0.05 and 0.15 mm intergrown with biotite flakes up to 0.15 mm in length. The biotite flakes have a pale, reddish-brown moderately pleochroic colour and typically have a random orientation. The rock contains larger fluorite-rich patches up to 1 mm in size comprised of individual fluorite crystals.

Much of the fluorite is also concentrated in discontinuous vein-like structures up to several millimetres wide. The rock is transected by granular quartz veins up to 1 mm in width which would represent the paler coloured vein noted in hand specimen. This quartz is believed to be of secondary origin and further secondary quartz is locally intergrown with the fluorite-rich patches. Some of this quartz forms well developed prismatic crystals up to 0.3 mm in length. Traces of apatite were noted within some quartz-rich veins as prismatic crystals up to 0.2 mm in size. Traces of pleochroic green amphibole also occur in some quartz-rich veins as small acicular crystals up to 0.1 mm in length. Minor carbonate was noted locally as interstitial fillings between granular quartz.

The rock contains minor disseminated wolframite as somewhat skeletal-appearing crystals up to 0.3 mm in size. Traces of rutile are also disseminated through the rock as small crystals up to 0.2 mm in size. Pyrite forms small, anhedral disseminated crystals up to 0.1 mm in size.

This rock is believed to represent a fine-grained quartz-rich sandstone with an argillaceous matrix which has been converted largely to biotite. The rock has also suffered metasomatic replacement by fluorite and quartz associated with minor amounts of other minerals.

Sample: 183742; PTSC32582

Rock Name:
Metasomatic quartz-fluorite-biotite rock

Hand Specimen:
A massive, fine-grained rock with a mottled coloration ranging from a dark brown to grey, to a pale grey. The rock is cut by a vein several millimetres wide filled largely with pale grey material. Locally this vein also contains apatite with an orange fluorescence.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	50
Fluorite	20
Biotite	15
Muscovite/sericite	5
Carbonate	5
Apatite	1
Cassiterite	1
Wolframite	1
Rutile	1
Pyrite	trace

This rock consists of a relatively coarse-grained (typical grain size between 0.3 and 1 mm) quartz mosaic intergrown with coarse-grained fluorite and somewhat smaller biotite flakes. The fluorite forms large crystals up to 1.5 mm in size which are intergrown with the quartz while the biotite tends to form flakes up to 0.3 mm in size with random orientation and a pale reddish-brown, weakly pleochroic colour. The rock also contains small amounts of disseminated muscovite flakes generally below 0.1 mm in size. At least some of the muscovite appears to be a reaction product of pre-existing biotite. Locally the biotite forms radiating aggregates up to 0.5 mm in diameter.

The vein noted in hand specimen consists largely of granular quartz but also locally contains concentrations of interstitial apatite and carbonate. Locally the vein also contains cassiterite as crystals up to 1 mm in size which have a zoned reddish-brown colour. In one portion of the vein wolframite is associated with cassiterite as prismatic, elongate crystals up to 1.5 mm in size.

Minor carbonate is also disseminated through the rock as very finely granular aggregates which appear to be a replacement product of mica. Traces of rutile were noted as small disseminated crystals up to 0.1 mm in size. Minor disseminated pyrite is also present as anhedral crystals below 0.05 mm in size.

This rock appears to consist of coarse grained quartz of metasomatic origin along with smaller amounts of fluorite and biotite. The rock is cut by a vein which locally contains intergrown cassiterite and wolframite as well as concentrations of apatite and carbonate.

Sample: 183743; PTSC32583

Rock Name:
Carbonate-bearing greisen

Hand Specimen:
A medium-grained, grey coloured rock with a mottled coloration ranging from a pale grey to a somewhat darker grey. The rock contains minor amounts of disseminated apatite which has a fluorescent orange colour.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	55
Fluorite	20
Carbonate	15
Muscovite/sericite	10
Rutile	trace-1
Chalcopyrite	trace-1
Cassiterite	trace
Pyrite	trace
Bismuthinite	trace
Apatite	trace

This rock consists mainly of relatively coarse-grained (typical grain size between 0.2 and 1 mm) quartz mosaic intergrown with fluorite, carbonate and muscovite/sericite. The quartz mosaic consists of anhedral quartz grains which appear to be of secondary origin. The fluorite forms very large crystals up to several millimetres in size which are intergrown with the quartz and locally contain inclusions of quartz. The carbonate occurs as interstitial fillings as well as narrow veinlets up to 0.3 mm wide. The muscovite is disseminated through the rock mainly as finely divided interstitial fillings below 0.1 mm in size. At least some of the carbonate appears to have a somewhat fibrous character and is thought to represent biotite flakes which have been completely replaced by carbonate. Locally the muscovite/sericite forms flaky patches up to 1 mm in size.

Rutile is disseminated through the rock as very small grains below 0.1 mm in size which tend to be concentrated in the muscovite/sericite-rich areas. Traces of cassiterite form very small disseminated crystals up to 0.1 mm in size which typically have euhedral to subhedral shapes. Chalcopyrite was noted as one moderately large anhedral grain approximately 0.3 mm in size. Traces of bismuthinite were also noted locally as small interstitial fillings below 0.05 mm in size. Minor pyrite forms small disseminated crystals, some of which are associated with bismuthinite. Traces of apatite form disseminated crystals up to 0.2 mm in size.

This is a metasomatic rock comprised largely of quartz and is quite similar to sample 183742 (PTSC32582) except that this sample contains no remaining biotite and most of the biotite is believed to have been replaced largely by carbonate and to a lesser extent by muscovite/sericite. Due to the more intense alteration effects, this rock has been termed a greisen.

099

72 100

PETROLOGY OF TWENTY SAMPLES FROM THE CLEVELAND TIN MINE, LUINA, TASMANIA.

Cleveland Tin Limited,
Tasmania.

3/43/6/0-GS5945/81 August 1981

The Australian
al Development
Laboratories

27-29 Fleming Street
Aitkenvale, Townsville
Queensland 4814
Phone (077) 75 1377
Cables: Amdel
In reply quote:

72 101

amdel

12th August, 1981.

GS 3/43/6/0

Cleveland Tin Limited,
LUINA. 7321.
Tasmania.

Attention: E.V. Dronseika.

REPORT GS 5945/81.

YOUR REFERENCE:	Order No. 16158 dated 24th June, 1981 and covering letter from E.V. Dronseika.
MATERIAL:	20 Rock and Core Samples.
IDENTIFICATION:	183744-63.
DATE RECEIVED	10th June, 1981.
WORK REQUIRED:	Petrography and Mineragraphy (18MA1.3, 14MA2.2, 1)

Investigation and Report by: Frank Radke.

Manager, Geological Services Division: Dr. Keith J. Henley.

for Norton Jackson
Managing Director.

Head Office:
ington Street, Frewville
South Australia 5063,
Telephone (08) 79 1662
Telex: Amdel AA82520
Pilot Plant:
Osman Place
Thebarton, S.A.
Telephone (08) 43 8053
Branch Laboratories:
Melbourne, Vic.
elephone (03) 645 3093
Perth, W.A.
elephone (09) 325 7311

101 PETROLOGY OF TWENTY SAMPLES FROM THE CLEVELAND TIN MINE, LUINA, TASMANIA.

72 102

1. SUMMARY.

Twenty samples were submitted by Cleveland Tin Limited for petrographic and mineragraphic examination. Those samples petrographically examined were given the following rock names:

Sample and T.S. No.	Rock Name.
183744: PTSC33214	Mineralized quartz amphibole rock
183745: PTSC33215	Quartz-Biotite rock
183747: PTSC33216	Quartz-Biotite rock
183748: PSD6712	Wolframite, Bismuthinite and molybdenite bearing quartz vein
183749: TS33217	Greisen
183750: TSC33218	Topaz bearing greisen
183751: PTS33219	Tourmaline and topaz bearing greisen
183752: PTS33220	Tourmaline and topaz bearing greisen
183753: PTS33221	Tourmaline and topaz bearing greisen
183754: PTS33222	Topaz greisen
183755: PTS33223	Topaz greisen
183756: TSC33224	Carbonate bearing greisen
183757: PTS33225	Carbonate bearing topaz greisen
183758: TSC33226	Greisen
183759: TSC33227	Tourmaline and carbonate bearing topaz greisen
183760: TSC33228	Topaz greisen
183761: TSC33229	Greisen vein in micaceous meta-siltstone
183762: PTS33230	Banded amphibolite
183763: PTS33231	Danalite-amphibole-pyrrhotite rock

Most of the above samples are either lode samples, for instance 183744, 745, 747 762, 763 or a quartz rich intrusive rock containing quartz eyes which has been termed a quartz porphry in the field (samples 183749-60).

All the quartz porphyry samples have been termed greisens and consist mainly of granular quartz intergrown with other typical greisen minerals such as topaz, tourmaline, muscovite, and fluorite as well as carbonate. Some sulphide mineralization is also present in the greisens and typically consists of pyrrhotite, showing moderate to pervasive replacement by pyrite, along with minor amounts of chalcopyrite and localized concentrations of arsenopyrite and/or stannite. Wolframite is common in many of the greisen samples and cassiterite was noted in some.

The greisen alteration is very pronounced in these samples and forms a granular quartz rich matrix containing the other greisen minerals. The only remnants from an earlier igneous rock are the quartz eyes which would represent remnant quartz phenocrysts. In virtually all of the samples carbonate appears to be a later formed mineral than most of the other greisen minerals, and in many cases carbonate has replaced a pre-existing phyllosilicate which in most cases appears to be muscovite/sericite although in some rocks the carbonate could have replaced pre-existing chlorite. In some samples carbonate occurs as angular, interstitial fillings similar in character to fluorite suggesting that the fluorite could also be of slightly later origin.

The lode specimens contain amphibole and biotite as the major mafic minerals and some lode specimens have high tourmaline contents which account for their dark green colour. Many of the lode specimens also show the replacement of mafic minerals by carbonate and this could be related to the carbonate replacement of the greisen samples.

In sample 183746 the main sulphide mineral near the contact of the sulphide vein in sandstone was identified as marcasite. In sample 183748 the sulphide minerals

.../2.

occuring interstitially between wolframite laths consist of both bismuthinite and molybdenite, both of which were positively identified with a scanning electron microscope. Bismuthinite commonly contains small bismuth inclusions.

2. INTRODUCTION.

This report contains the petrographic and mineragraphic descriptions of twenty samples from the Cleveland tin mine at Luina, Tasmania, which were collected during my visit on 9th and 10th June, 1981.

3. PETROGRAPHY AND MINERAGRAPHY.

All of the normal thin sections described in this report have been stained with an alizarin red-S solution which distinguishes calcite from other carbonates by staining it pink. None of the carbonate in the stained sections has been affecte indicating it is not calcite but it could be dolomite or siderite. At least some of this carbonate has moderate amounts of intergrown limonitic material with a translucent reddish brown colour suggesting that the carbonate could be an iron carbonate such as siderite. The polished thin sections have not been stained with the alizarin red-S solution and it is considered unlikely that any of the carbonate in these samples would be calcite.

Sample: 183744: PTSC33214

Location:
Lode specimen from 24 Hall's Drive North. 5 m south of Qa section.

Rock Name:
Mineralized quartz-amphibole rock.

Hand Specimen:
Very fine grained dark green coloured rock containing sulphide patches up to several millimetres in size. Likewise slightly paler coloured patches and vein like structures were noted.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Amphibole	45
Quartz	35
Fluorite	5
Pyrite	5
Pyrrhotite	5
Carbonate	3
Sericite	2
Chalcopyrite	trace-1
Cassiterite	trace-1
Sphalerite	trace
Titanium mineral	trace

This sample consists mainly of pheochroic green amphibole intergrown with quartz. The dark coloured portions of the rock consist mainly of amphibole with a somewhat fibrous character which at least locally forms aggregates with a radiating texture. Within this portion of the rock much of the amphibole has a limonitic, brownish coloured, degraded appearing character. These areas contain a much higher proportion of amphibole with only a relatively small amount of interstitial quartz.

The quartz forms quite large crystals up to 3 mm in size which are concentrate in the slightly paler portions of the rock. The quartz within these areas contains abundant intergrown amphibole as elongate, crystals with prismatic cross sections. The somewhat veinlike character of these paler coloured portions of the rock suggests that they have developed later and produced a recrystallization of the amphibole into the well developed elongate, acicular crystals.

Localized minor fluorite and carbonates present in the rock as anhedral grains up to approximately 1 mm in size. Both the fluorite and carbonate tend to form intergrowths with quartz and also tend to contain acicular amphibole crystals as inclusions. Locally minor finely divided sericite forms irregular patches some of which are intergrown with carbonate.

The major sulphides in this rock are pyrite and pyrrhotite both of which form large patches up to several millimetres in size. Most of the pyrite has a somewhat lamellar appearing internal texture suggesting that it represents completely pyritized pyrrhotite. This pyrite rich area is intergrown with the amphibole rich portion of the rock. The pyrrhotite forms anhedral crystals intergrown with the more quartz rich portion of the rock and much of the pyrrhotite tends to form interstitially between large amphibole crystals. Some of this pyrrhotite shows localized replacement

by secondary pyrite. The replacement of pyrrhotite by pyrite is hightly localized with most pyrrhotite showing no evidence of replacement but with localized patches up to 0.8 mm in size showing complete replacement by pyrite. Minor charcopyrite tends to be concentrated in the pyrrhotite rich area as anhedral grains up to 0.2 mm in size which are generally located marginal to larger pyrrhotite crystals. Minor chalcopyrite is also disseminated through the rock as anhedral grains up to 0.1 mm in size. Traces of sphalerite occur locally as small anhedral grains up to 0.05 mm in size which are generally associated with chalcopyrite.

Minor cassiterite is disseminated through the rock as crystals up to 0.2 mm in size which generally have a zoned, reddish-brown colouration in transmitted light. Cassiterite commonly occurs marginal to large pyrrhotite crystals or intergrown with the quartz and amphibole. Traces of a finely divided titanium mineral, possibly leucoxene or anatase are disseminated through the rock as small grains and aggregates up to 0.1 mm in size.

This is a metasomatic or contact metamorphic rock comprised mainly of quartz and amphibole with smaller amounts of pyrite and carbonate. It appears that the original rock was quite mafic and consisted mainly of amphibole, but later replacement by coarse, granular quartz and minor amounts of fluorite and carbonate occured. It is also likely that the pyrrhotite and cassiterite were introduced at this time. The pyrite in this rock has textural features indicating that it was formed by replacement of pre-existing pyrrhotite and is most likely of supergene origin. The better development of pyrite in the more amphibole rich portion of the rock could be due to a more porous nature of this particular region.

Sample: 183745: PTSC33215.

Location:
Lode specimen from 24 Henry's Drive North.

Rock Name:
Quartz-Biotite Rock.

Hand Specimen:
A dark green coloured rock containing abundant disseminated quartz eyes.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	40
Biotite	35
Pyrrhotite	15
Fluorite	10
Chalcopyrite	trace-1
Pyrite	trace-1
Leucoxene	trace-1
Cassiterite	trace

This rock is comprised mainly of granular quartz with a typical grain size between 0.1 and 0.3 mm intergrown with biotite flakes up to 0.4 mm in length. The biotite has a pale reddish brown pleochroic colour with a zoned character containing a pleochroic greenish colour at its margins. The quartz forms anhedral crystals which contain remnants of fibrous inclusions of finely divided biotite which form a lamellar structure in the quartz and suggest that most if not all of the quartz was introduced as a replacement product of pre-existing biotite flakes.

Fluorite is also disseminated through the rock as anhedral crystals to 0.4 mm in size which are intergrown with the granular quartz and biotite flakes.

Pyrrhotite is disseminated through the rock as anhedral grains and granular aggregates up to 0.5 mm in size. Minor chalcopyrite occurs locally as small grains up to 0.1 mm in size which are generally intergrown marginal to pyrrhotite. The pyrrhotite is very fresh but locally shows minor marginal replacement by pyrite. Minor leucoxene is also disseminated through the rock as small, prismatic crystals up to 0.15 mm long which most likely represent completely altered ilmenite crystals. Traces of cassiterite were noted as disseminated crystals up to 0.1 mm in size.

This is considered to be a metasomatic rock in which the original biotite has been replaced largely by quartz with smaller amounts of fluorite. The sulphide mineralization consisting mainly of pyrrhotite and minor chalcopyrite as well as the cassiterite was most likely introduced during this mineralization episode. The pyrite is a much later replacement product of pyrrhotite.

Sample: 183746: PSD6713.

Location:
Surface stockpile.

Hand Specimen:
This sample contains a sulphide rich vein and a banded pale tan to grey coloured, fine grained sandstone. Along the contact of the sulphide vein with the sandstone is a narrow vein approximately 1 mm wide consisting of a green coloured sulphide. The identy of this sulphide was specifically queried.

Polished Section:
The sulphide rich band is comprised of a polycrystalline pyrite aggregate consisting of anhedral crystals generally about 0.5 mm in size. Most of the pyrite has a very weakly developed anisotropic character suggesting that it could have a small amount of another cation such as cobolt or nickel substituted for the iron. Electron probe microanalysis would be required to confirm this. Near the contact of the pyrite with the sandstone a polycrystalline marcasite band is present and this would represent the green, sulphide mineral noted in hand specimen. Within this region there are also localized patches of polycrystalline marcasite intergrown with the pyrite. At the contact of the sulphide vein with the sandstone some pyrite froms interstitial fillings between non-opaque grains and locally narrow vein fillings parallel to the main vein are also present. Within these areas minor marcasite is also intergrown with the pyrite.

Within the non-opaque rich portion of the rock (i.e. sandstone) minor pyrrhotite is present as anhedral disseminated grains up to 0.3 mm in size. Some of the pyrrhotite shows marginal replacement by supergene pyrite and locally small pyrite grains considered to represent completely replaced disseminated pyrrhotite were noted in this area. Both the pyrite and pyrrhotite tend to occur as interstitial fillings between non-opaque grains. Most of the pyrrhotite and supergene pyrite after pyrrhotite also generally has intimately intergrown carbonate. Carbonate is also present as angular, interstitial fillings within this area.

Minor rutile is disseminated through the sandstone as anhedral grains up to 0.2 mm in size. Traces of ilmenite were noted locally as small, elongate crystals up to 0.1 mm in length.

Sample: 183747: PTSC33216.

Location:

Lode specimen from 25-26 Decline near quartz-porphyry. Collected on surface vein stockpile.

Rock Name:

Quartz-Biotite Rock.

Hand Specimen:

A dark grey coloured rock with a vague banded character containing bands of varying shades of grey from a medium grey to a very dark grey as well as some sulphide rich bands. All of the bands have a somewhat irregular character, and are quite course, generally between 0.5 and 1 cm in width.

Polished Thin Section:

An optical estimate of the constituents gives the following:

	%
Quartz	40
Biotite	30
Magnetite	10
Pyrite	10
Carbonate	5
Fluorite	3
Pyrrhotite	2
Chalcopyrite	trace-1
Molybdenite	trace
Sphalerite	trace
Rutile/Leucoxene	trace

This rock has a highly variable mineralogy in the different bands thus the above list of mineral proportions would depend largely on the proportions of various bands included within the thin section. The medium to grey coloured bands consist mainly of a granular quartz mosaic with a typical grain size between 0.5 and 3 mm, intergrown with a much smaller amount of biotite. The darker coloured bands consist mainly of randomly oriented biotite flakes up to 1 mm in length intergrown with magnetite. Both carbonate and fluorite also tend to occur in these bands. The sulphide rich bands also occur within the biotite rich portions of the rock.

Within the biotite rich areas, the biotite exhibits a colour zonation with reddish brown cores and green margins. It appears that the original biotite had a brown to reddish brown colour but a subsequent alteration has produced the pleochroic green colour. Many of the biotite flakes consist only of pleochroic green biotite. The biotite flakes within the granular quartz rich area are up to 0.5 mm in length and typically have a pleochroic brown or reddish brown colour although a small proportion have a pleochroic green colour or a very narrow outer margin with a pleochroic green colour. Most of the biotite in this quartz rich area occurs as inclusions within the larger quartz grains and more rarely as flakes located along margins of quartz grains. The quartz also contains very finely divided inclusions which appear to be fine elongate, acicular shaped crystals which possibly represent altered amphibole crystals. None of the original minerals is present and the interpretation of these shapes is somewhat tentative.

The fluorite forms anhedral crystals up to 1 mm in size which are intergrown with the biotite mainly as interstitial fillings. Minor quartz also occurs as interstitial fillings with the biotite. The carbonate tends to form polycrystalline aggregates up to 1 mm in size which occur both as interstitial fillings between biotite flakes and as irregular patches as well as marginal concentrations around sulphide patches and bands.

The major sulphide in this rock is pyrite which forms large patches up to several millemetres in size. Most of the pyrite has a massive character but locally, particularly around the margins of pyrite aggregates fine lamellar textures are present in the pyrite. These lamellar textures are typical of pyrite which has replaced pyrrhotite and it is considered likely that most of the pyrite in this rock is a replacement product of pyrrhotite but the large proportion of it has been recrystallized to produce the existing massive character. Minor pyrrhotite occurs as inclusions within the larger pyrite aggregates and typically have somewhat angular appearing shapes up to 0.3 mm in size. Other sulphides present at trace level are chalcopyrite, molybdenite and sphalerite. The chalcopyrite typically forms anhedral crystals up to 0.5 mm in size located marginal to pyrrhotite rich areas. In many cases the chalcopyrite is intergrown with granular carbonate rich areas. The sphalerite occurs only as anhedral grains up to 0.1 mm in size typically associated with chalcopyrite. The molybdenite forms flaky aggregates up to 0.2 mm in size which are located interstitially between the biotite flakes in the biotite rich portion of the rock marginal to the quartz rich area.

The rock also contains a magnetite rich band several millimetres wide comprised of polycrystalline magnetite with a typical grain size of 0.2 mm. Individual magnetite crystals can be distinguished by very narrow interstitial non-opaque fillings in between the individual anhedral magnetite crystals. Minor sulphide was also noted locally interstitially between the magnetite crystals and consists of both pyrite and pyrrhotite. All of the pyrite located interstitially between the magnetite has textures indicating it represents pre-existing pyrrhotite which has been replaced by pyrite. minor pyrrhotite showing marginal replacement by pyrite also locally occurs around the outer margins of the magnetite rich bands as anhedral grains up to 0.2 mm in size. Locally small molybdenite flakes were also noted marginal to the magnetite rich bands. Traces of finely divided rutile and leucoxene were noted as interstitial fillings within the quartz rich areas. The leucoxene typically pseudomorphs elongate, prismatic crystals which are believed to represent altered ilmenite crystals. Minor pyrite and pyrrhotite also occur disseminated through the quartz rich portion of the rock as anhedral grains to 0.3 mm in size.

This is essentially a metasomatic rock with a mineralogically banded character. It is considered likely that the mafic minerals are the earliest minerals now present to form. These consisted mainly of biotite but there is some textural indication that the present quartz has largely replaced acicular amphibole crystals. This alteration has also produced a colour change in the biotite from reddish brown to green. Other minerals considered to be of metasomatic origin which occur within the biotite rich areas of the rock are magnetite, pyrrhotite, carbonate and fluorite as well as minor sulphides such as chalcopyrite, molybdenite and sphalerite. The marginal concentrationof these minor sulphides around the major iron sulphide rich areas suggests that they formed slightly later than the bulk of the iron sulphide. The present iron sulphide is comprised mainly of pyrite but it is considered likely that this has been formed by a replacement of pre-existing pyrrhotite and at least locally remnant textures indicating such an origin are present.

Sample: 183748: PSD6712.

Location:
~~316~~, 112.9 m.

Rock Name:
Wolframite, Bismuthinite and Molybdenite bearing Quartz Veins.

Hand Specimen:
A milky grey quartz vein within a darker grey host rock. The thin section was cut to include most of the quartz vein within an area showing marked sulphide mineralization.

Polished Section:
Opaque constituents comprise approximately 15% of the rock. An optical estimate of the relative proportions give the following:

	%
Wolframite	70
Bismuthinite	15
Molybdenite	10
Pyrite	2
Chalcopyrite	1
Leucoxene	1
Bismuth	trace

The major opaque mineral in this rock is wolframite which forms elongate, prismatic crystals up to several millimetres in length which are intergrown with the granular quartz vein. Minor wolframite was also noted in the host rock, mostly as somewhat irregular anhedral shaped crystals up to 0.5 mm in size. A very small number of slightly prismatic wolframite crystals were also noted in the host rock.

The major sulphide minerals present are bismuthinite and molybdenite both of which were positively identified with the scanning electron microscope. Bismuthinite is used in this description to include any bismuth sulphide and would include true bismuthinite as well as other bismuth sulphides with differing stoichiometries. Most of the bismuthinite and molybdenite is located within interstitial areas between concentrations of prismatic wolframite crystals. Smaller amounts of bismuthinite are disseminated through the quartz vein as anhedral, interstitial fillings up to 0.3 mm in size. At least locally, minor bismuthinite is concentrated as small anhedral grains below 0.1 mm in size along the margins of the quartz vein and host rock. Minor metallic bismuth occurs as small inclusions within some bismuthinite crystals. This was detected both optically and with the scanning electron microscope. These inclusions are typically of micron size.

Both pyrite and chalcopyrite form very small anhedral grains below 0.1 mm in size which tend to occur locally near the margin of the granular quartz vein where it is in contact with the host rock. In many cases these finely divided sulphide grains are intergrown with carbonate patches. Carbonate also occurs as narrow vein and fracture fillings within the granular quartz vein which locally transect wolframite crystals to produce a slightly fractured character. Minor carbonate also occurs as interstitial fillings between the granular quartz in the quartz vein.

Minor leucoxene was noted as small disseminated aggregates up to 0.2 mm in size within the host rock.

This polished section was cut to include a mineralized quartz vein containing wolframite, bismuthinite and molybdenite. Minor wolframite mineralization also occurs in the host rock.

Sample: 183749: TSC33217.

Location:
C1615, 89.3 m.

Rock Name:
Greisen.

Hand Specimen:
A massive, pale grey coloured rock with a pale greenish coloured mottling and some milky grey quartz veins and patches.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	65
Muscovite	30
Carbonate	5
Opaques	1

This sample consists of a quartz mosiac intergrown with finely divided muscovite flakes. Most of the quartz has a typical grain size of 0.15 mm but much larger quartz grains and polycrystalline quartz aggregates up to 3 mm in size are disseminated through the rock and would represent quartz grains seen in hand specimen. The rock also contains vein-like structures of polycrystalline quartz up to several millimetres wide which generally has a relatively coarse grain size ranging up to 2 mm.

Most of the muscovite forms small flakes approximately 0.1 mm in length which have a random orientation and are generally intergrown with the finer grained quartz. Locally, patches of muscovite form flaky aggregates up to several millimetres in size. The muscovite rich areas would represent the pale green mottling noted in hand specimen.

Carbonate is disseminated through the rock as interstitial fillings which are localized in patches up to 1 mm in size which are generally formed of individual fillings below 0.1 mm in size. Within each carbonate patch most of the carbonate is in optical continuity indicating it represents a single carbonate crystal. A trace of carbonate was also noted as somewhat prismatic shaped crystals up to 0.3 mm in size. Minor opaques are disseminated through the rock as anhedral grains and elongate, lath shaped crystals up to 0.2 mm in size.

This is a typical appearing greisen consisting mainly of quartz and muscovite which contains some quartz veins with little or no intergrown muscovite. The rock also contains disseminated quartz grains and polycrystalline quartz aggregates with no intergrown muscovite which most likely represents remnant quartz phenocrysts.

Sample: 183750: TSC33218.

Location:
C1615, 96.3 m.

Rock Name:
Topaz bearing greisen.

Hand Specimen:
A very fine grained reddish brown coloured rock containing milky grey patches and vein like structures.

Thin Section:
An optical estimate of constituents gives the following:

	%
Quartz	60
Topaz	20
Carbonate	10
Muscovite	10
Tourmaline	trace
Opaques	1

This rock is comprised mainly of a granular quartz mosiac with a typical grain size of between 0.2 and 0.8 mm. The quartz also contains intergrown finely divided muscovite and interstitial carbonate as well as disseminated topaz in polycrystalline aggregates up to 1 mm in size. Some of the polycrystalline quartz contains no intergrown muscovite or carbonate and this would represent the milky grey quartz noted in hand specimen. This quartz generally has a somewhat coarser grain size with the localized formation of straight grain margins and triple points. A finer grained quartz is typically intergrown with muscovite flakes up to 0.2 mm in length and interstitial carbonate. Locally large quartz crystals up to 3 mm in size are present and most likely represent remnant quartz phenocrysts from the original rock.

The carbonate is concentrated in patches up to several millimetres in size and is always located interstitially between the granular quartz. All of the carbonate has a remnant fibrous appearing character indicating that it has replaced a pre-existing phyllosilicate. Much of the carbonate contains remnants of fine muscovite/sericite flakes suggesting that it has in fact replaced much of the original muscovite in the rock. The carbonate typically exhibits a slightly translucent reddish brown colour which would account for the reddish brown colour in the hand specimen and this is considered to be due to finely divided iron oxides which tend to be concentrated along grain margins within the polycrystalline carbonate aggregates. The carbonate was not positively identified but is considered likely that it is siderite due to the prevalence of finely intergrown iron oxides.

The topaz forms anhedral crystals which are disseminated through the rock as polycrystalline aggregates up to 1 mm in size. Both carbonate and sericite are locally concentrated marginal to the topaz rich aggregates and also form interstitial fillings within the topaz rich aggregates. Traces of pleochroic green tourmaline were also noted within the topaz rich aggregates as prismatic crystals up to 0.3 mm in size.

Minor opaques are disseminated through the rock as prismatic crystals up to 0.2 mm in length.

This is a quartz rich greisen which also contains moderate amounts of topaz. It also contains an interstitial carbonate believed to be siderite and there is textural evidence indicating that the siderite has replaced pre-existing muscovite.

Sample: 183751: PTSC33219.

Location:
C1615, 113.8 m.

Rock Name:
Tourmaline and Topaz bearing Greisen.

Hand Specimen:
A dark greenish grey coloured rock containing angular fragmental appearing patches with a paler greenish to paler milky grey colour. The rock is also cut by some narrow veins up to 1 mm wide with a slightly paler grey colour.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	40
Tourmaline	20
Topaz	15
Muscovite/sericite	13
Carbonate	10
Fluorite	1
Pyrite	1
Chalcopyrite	trace
Wolframite	trace

This rock is comprised mainly of granular quartz intergrown with tourmaline and finely divided sericite as well as disseminated topaz rich patches. Most of the quartz has a typical grain sized between 0.1 and 0.3 mm and forms a granular mosiac. A small proportion of the quartz is concentrated in veins up to 1 mm wide as polycrystalline aggregates which would represent the paler grey veins noted in hand specimen. These veins consist almost exclusively of quartz. A small number of large quartz grains up to several millimetres in size are disseminated through the rock and generally exhibit somewhat anhedral appearing shapes although a few have vague subhedral shapes. These larger quartz grains represent phenocrysts in the original rock.

The tourmaline forms prismatic shaped crystals up to 0.2 mm in length which have a pleochroic green colour and are intergrown with the granular quartz. Some of the tourmaline crystals exhibit slight variations in the degree of green colouration and some also exhibit very narrow overgrowths with a pleochroic orange colour. The topaz is concentrated in patches up to 1 mm in size as finely granular aggregates with a typical grain size of 0.1 mm. Traces of fluorite are also locally present as crystals up to 0.8 mm in size.

The finely divided muscovite/sericite flakes occur mainly as interstitial fillings between the granular quartz although locally patches up to 1 mm in size consisting of finely divided muscovite/sericite flakes are present. The carbonate also occurs in patches up to 1 mm in size and much of the carbonate exhibits a remnant, fibrous texture suggesting that it has replaced a pre-existing phyllosilicate such as muscovite/sericite. At lease some of the carbonate contains remnants of finely divided muscovite/sericite flakes suggesting that they are remnants of pre-existing phyllosilicates.

Minor pyrite is disseminated through the rock as anhedral grains up to 0.2 mm in size. A small proportion of the pyrite has a very finely granular colloform appearing texture. Other pyrite forms well developed grains. Chalcopyrite occurs locally as disseminated grains up to 0.3 mm in size which tend to be concentrated in slightly larger patches. Minor wolframite is also disseminated through the rock as prismatic crystals up to 0.3 mm in length.

This is a quartz rich greisen whose major alteration phase consists of the development of quartz, muscovite/sericite as well as topaz and tourmaline. There is evidence of a later quartz veining and possibly a still later development of carbonate as a replacement product of a pre-existing phyllosilicate (probably muscovite/sericite). Minor sulphide and wolframite mineralization is disseminated through the rock as intergrowths with the greisenous matrix.

Sample: 183752: PTSC33220.

Location:
C1615, 113.8 m.

Rock Name:
Tourmaline and Topaz bearing Greisen.

Hand Specimen:
A greenish grey coloured rock containing paler grey coloured patches as well as some irregular, reddish brown to orange coloured patches.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	40
Tourmaline	25
Topaz	10
Carbonate	10
Muscovite/sericite	8
Fluorite	3
Pyrite	3
Arsenopyrite	1
Chalcopyrite	trace
Stannite	trace

This rock is comprised mainly of granular quartz intergrown with tourmaline and smaller amounts of other minerals. Most of the quartz has a typical grain size of about 0.15 mm but much larger quartz grains up to several millimetres in size are disseminated through the rock. There larger quartz grains would represent remnant quartz phenocrysts from the original rock and at least a few exhibit vague, subhedral shapes although most exhibit anhedral shapes. Quartz also occurs as narrow fracture and vein fillings up to 0.8 mm wide which consist of polycrystalline quartz with a typical grain size of 0.1 to 0.3 mm intergrown with virtually no other minerals.

The tourmaline which is intergrown with a quartz rich matrix forms xenomorphic grains as well as elongate, prismatic crystals up to 0.5 mm in size. All of the tourmaline has a pleochroic green to yellowish green colour although many tourmaline crystals have a slight zonation with darker coloured cores and paler coloured margins. Topaz is disseminated through the rock as granular aggregates as well as localized prismatic crystals some of which form vague, radiating aggregates. Much of the topaz shows incipient alteration to very finely divided sericitic material. Sericite also occurs as narrow interstitia fillings between the granular quartz.

Carbonate forms large interstitial fillings up to 1 mm in size some of which are intergrown with prismatic quartz crystals. A small proportion of the carbonate retains a vague remnant fibrous character suggesting that it has replaced a pre-existing phyllosilicate. Fluorite also occurs locally as interstitial fillings up to 1 mm in size typically intergrown with prismatic quartz crystals.

The major sulphide in this rock is pyrite which forms anhedral disseminated grains up to 3 mm in size. Some of the pyrite has a poorly polished, colloform appearing character but most forms well polished massive crystals. Minor amounts of arsenopyrite are intergrown with the pyrite as subhedral, prismatic crystals up to 1 mm in size. Traces of chalcopyrite are disseminated through the rock as anhedral grains up to 0.2 mm in size. Minor stannite was noted locally as intergrowths with non-opaque gangue which are generally associated with disseminated chalcopyrite.

This rock is quite similar in mineralogy texture and origin to sample 183751 (PTSC33219).

72 116

Sample: 18753: PTS33221.

Location:
Ci615, 113.8m.

Rock Name:
Tourmaline and topaz bearing greisen.

Hand Specimen:
A grey coloured rock with a vaguely banded and mottled character in shades of pale to medium grey. The rock contains moderate amounts of disseminated sulphide as patches up to several millimetres in size.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Tourmaline	15
Carbonate	15
Topaz	10
Muscovite/sericite	5
Pyrite	5
Arsenopyrite	2
Fluorite	2
Wolframite	1
Chalcopyrite	trace

This rock is comprised of a granular quartz mosiac intergrown with small amounts of tourmaline, carbonate, topaz and muscovite/sericite. Most of the quartz has a typical grain size of between 0.1 and 0.3 mm although larger quartz grains and polycrystaline aggregates of quartz up to several millemetres in size are present. Most of these larger quartz grains have anhedral shapes and are believed to represent remnant quartz phenocrysts. Most of the quartz forms anhedral shaped crystals but locally some quartz forms euhedral to subhedral crystals with well developed hexagonal cross sections as well as vague terminations. The rock contains some paler grey coloured veins which consist mainly of granular quartz mosiacs intergrown with at most only very small proportions of other minerals.

The tourmaline forms pleochroic green crystals up to 0.3 mm. in size which occur interstitially between the granular quartz and as prismatic crystals. Although all of the tourmaline has a pleochroic green colour, most has a slight zonation ranging from a dark to a paler green. Topaz is concentrated in polycrystalline aggregates up to 0.5 mm in size and generally forms small crystals up to 0.3 mm in size which have anhedral shapes. The muscovite/sericite tends to occur interstitially between the granular quartz as very finely divided, flaky aggregates up to 0.3 mm in size.

Both the carbonate and fluorite tend to occur as patches up to several millemetres in size, typically intergrown with euhedral to subhedral, prismatic quartz crystals. Some of the carbonate rich patches also contain concentrations of intergrown tourmaline. Locally the carbonate exhibits a translucent, reddish brown colour believed to be due to very finely divided iron oxides concentrated along grain margins. Some of the carbonate also has a fibrous appearing texture suggesting that it has replaced a pre-existing phyllosilicate.

The two major sulphides in this rock are pyrite and arsenopyrite. Pyrite forms large anhedral patches up to several millemetres in size which appear to have a polycrystaline character with incipient development of euhedral crystals faces around their outer margins. Some pyrite also occurs as colloform appearing aggregates with a poorly polished character which occur both as individual patches up to 1.0 mm in size and marginal to the better

developed pyrite. Minor pyrite also occurs as very fine lamellar intergrowths within a granular carbonate. These areas could represent anhedral pyrrhotite crystals which have been replaced by carbonate and pyrite. Arsenopyrite forms euhedral to subhedral, prismatic crystals up to 2.0 mm in size.

Minor wolframite is disseminated through the rock as elongate, prismatic crystals up to 0.3 mm in size. Traces of chalcopyrite form anhedral disseminated grains up to 0.15 mm in size.

This is a greisen similar in mineralogy texture and origin to the previously described tourmaline and topaz bearing greisens, but it also contains a moderate degree of sulphide mineralization in the form of arsenopyrite and pyrite.

Sample: 183754: PTS33222.

Location:
C1615, 139.1m.

Rock Name:
Topaz Greisen.

Hand Specimen:
A pale grey to greenish grey coloured rock containing disseminated sulphides as well as some narrow darker grey veins and patches.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	40
Topaz	35
Carbonate	10
Muscovite/sericite	5
Pyrite	5
Tourmaline	2
Fluorite	2
Wolframite	1
Cassiterite	trace-1
Charcopyrite	trace-1
Stannite	trace
Pyrrhotite	trace

This rock consists mainly of a granular quartz and topaz mosiac with a typical grain size of approximately 0.1 to 0.2 mm This rock also contains larger disseminated quartz crystals up to 2.0 mm in size which typically exhibit anhedral to subhedral shapes and are considered to represent remnant quartz phenocrysts. Minor quartz also occurs as narrow granular quartz veins up to 1.0 mm in width. Both the matrix quartz and topaz form anhedral grains and the topaz also shows incipient alteration to very finely divided sericite which imparts a slightly turbid character to it. Minor muscovite/sericite also occurs as interstitial fillings up to 0.3 mm in size comprised of finely divided, flaky aggregates.

Carbonate is disseminated through the rock as interstitial fillings up to 0.5 mm. in size and as discontinuous fracture fillings marginal to quartz veins. Carbonate is also concentrated marginal to disseminated sulphides. Minor fluorite also occurs mainly as interstitial fillings up to 0.3 mm. in size. Tourmaline is disseminated through the rock as prismatic crystals up to 0.5 mm in size which have a pleochroic colour ranging from green to orange. Locally tourmaline is concentrated in areas where it is intergrown with fluorite or carbonate as well as with prismatic quartz crystals. Some tourmaline forms larger grains with poikilitic quartz inclusions.

Minor cassiterite is disseminated through the rock as interstitial fillings up to 0.2 mm in size. In plane light most of the cassiterite has a somewhat zoned, reddish brown colour. Wolframite forms disseminated, prismatic crystals up to 0.2 mm in length which tend to be concentrated in the quartz rich veins although some wolframite is also disseminated through the rock.

The most abundant sulphide is pyrite which is disseminated through the rock as anhedral grains and patches as well as discontinuous fracture fillings. Some of the pyrite forms subhedral to anhedral disseminated crystals and other pyrite occurs as colloform appearing aggregates. Minor pyrite also occurs as lamellar intergrowths with granular carbonate and both this pyrite as well as the colloform pyrite represent a replacement product of pre-

72 119

existing pyrrhotite. A trace of remnant pyrrhotite was noted within one grain as an anhedral grain surrounded by pyrite. Minor chalcopyrite is disseminated through the rock as anhedral grains up to 0.2 mm. in size. Traces of stannite were also noted locally mainly as anhedral grains associated with chalcopyrite.

This is a greisen containing a much higher proportion of topaz and a much lower proportion of tourmaline than most of the previously described greisens. Both wolframite and cassiterite were noted in this sample and the wolframite in particular tends to be concentrated in quartz rich veins.

Sample: 183755: PTS33223.

Location:
C1615, 153.2m.

Rock Name:
Topaz Greisen.

Hand Specimen:
A milky grey coloured rock with some slightly darker grey mottling as well as disseminated pyrite and a disseminated black mineral.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Topaz	35
Quartz	30
Carbonate	12
Tourmaline	10
Muscovite/Sericite	5
Pyrite	5
Fluorite	2
Chalcopyrite	1
Stannite	trace-1
Wolframite	trace

This rock consists mainly of a relatively fine grained quartz and topaz intergrowth. Most of the quartz is intergrown with topaz as a fine grained matrix and has a typical grain size of 0.1 to 0.2 mm but many larger quartz crystals up to 1 mm in size are disseminated through the rock and most likely represent remnant quartz phenocrysts. Some of these larger crystals have subhedral shapes and all contain very finely divided inclusions of muscovite/sericite in their outermost margins. The topaz in this rock forms crystals up to 1 mm in size some of which contain poikilitic quartz inclusions. Most of the topaz shows incipient alteration to very finely divided muscovite/sericite which imparts a slightly turbid character to it. Muscovite/sericite also occurs locally as interstitial fillings between the quartz and topaz grains.

Tourmaline is disseminated throught the rock mainly as anhedral to subhedral, prismatic crystals up to 1 mm in size. Some of the larger tourmaline crystals poikilitically enclose quartz grains. Most of the tourmaline has a pleochroic green colour although some tourmaline crystals have cores with a pleochroic blue colour and outer margins with a pleochroic orange colour. The tourmaline would be the black mineral noted in hand specimen.

Carbonate is disseminated through the rock as interstitial fillings up to 0.5 mm in size. Carbonate also tends to be concentrated around the margins of disseminated sulphide grains. At least some of the carbonate has a very locally developed translucent reddish brown colour believed to be due to very finely divided iron oxide inclusions which are concentrated along fractures. Minor fluorite is also disseminated through the rock as interstitial fillings up to 0.3 mm in size. Both the fluorite and carbonate tend to fill angular interstices between quartz and topaz crystals.

The major sulphide mineral in this rock is pyrite which forms disseminated crystals and polycrystalline aggregates up to approximately 1.5 mm in size. Polycrystalline pyrite aggregates have irregular shapes although their outer margins show localized development of crystal faces. A small proportion of the pyrite has a very finely granular, colloform appearing character which

produces a very poor polish. This pyrite at least locally occurs marginal to the well developed polycrystalline pyrite aggregates. Minor chalcopyrite is disseminated through the rock as anhedral grains up to 0.5 mm in size. Stannite occurs locally as marginal intergrowths with chalcopyrite. Traces of wolframite are disseminated through the rock as small prismatic crystals up to 0.2 mm in length.

This is a greisen consisting mainly of topaz and quartz which also contains small amounts of other minerals.

Sample: 183756: TSC3324.

72 122

Location:
C1615, 181.5m.

Rock Name:
Carbonate bearing greisen.

Hand Specimen:
A pale greenish grey coloured rock containing disseminated grey quartz crystals as well as irregular reddish brown coloured patches and some small disseminated black crystals.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	50
Muscovite	30
Carbonate	15
Tourmaline	4
Opaques	1

This rock consists mainly of a greisenous matrix comprised of granular quartz intergrown with finely divided muscovite flakes through which larger quartz crystals considered to represent remnant quartz phenocrysts are disseminated. The matrix quartz has a typical grain size of between 0.1 and 0.3 mm while the larger disseminated quartz crystals are up to several millemetres in size. The larger quartz crystals typically exhibit anhedral shapes although some with vague subhedral shapes are also present. Most of the large disseminated quartz crystals contain very finely divided inclusions of muscovite along their outermost margins.

Most of the muscovite/sericite flakes are below 0.2 mm in length although some quite large muscovite flakes up to several millemetres in length are present. Many of the larger muscovite flakes have been partially replaced by granular carbonate while some carbonate also occurs as elongate, prismatic shaped patches which could represent almost completely replaced muscovite. It is considered likely that these partially replaced muscovite flakes would appear to be the feldspar phenocrysts suggested to be present in hand specimen. Carbonate also occurs as angular, interstitial fillings some of which have a remnant fibrous texture suggesting that they represent replaced muscovite.

Tourmaline is disseminated through the rock as anhedral to elongate, prismatic crystals up to 1.0 mm in length. Some of the larger tourmaline crystals contain poikilitic quartz inclusions. Most of the tourmaline crystals are zoned with pleochroic blue cores and pleochroic yellowish green outer margins. Minor opaques are disseminated through the rock as small grains up to 0.1 mm in size.

This is a moderately typical greisen in which some of the original muscovite has been replaced by carbonate.

Smaple: 183757: PTS33225.

Location:
C1616, 207.0 m.

Rock Name:
Carbonate bearing topaz greisen.

Hand Specimen:
A finely mottled rock with a milky grey to dull white colour which also contains some large grey quartz crystals.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Topaz	25
Carbonate	20
Pyrite	6
Muscovite/sericite	3
Tourmaline	1
Chalcopyrite	trace
Stannite	trace

This rock consists mainly of granular quartz intergrown with smaller amounts of topaz and carbonate which forms a matrix through which much larger quartz crystals up to several millemetres in size are disseminated. The granular quartz forms a well developed mosiac with a typical grain size between 0.1 and 0.3 mm Some of the larger quartz crystals have vague euhedral to subhedral shapes but most have anhedral shapes and all contain small amounts of very finely divided sericitic material in their outer margins. The topaz forms elongate, prismatic crystals which locally are developed into radiating aggregates. Most of the topaz shows at least some incipient alteration to very finely divided sericite and this incipiently altered topaz is believed to be the dull white mineral noted in hand specimen. Minor sericite also occurs as irregular interstitial fillings up to 0.3 mm in size which has a finely divided somewhat flaky character.

Carbonate is disseminated through the rock with interstitial fillings up to 0.5 mm in size. The carbonate also tends to be concentrated around the margins of anhedral opaque grains. Minor tourmaline forms anhedral to subhedral, prismatic crystals up to 0.5 mm in size which have a pleochroic green colour.

The main sulphide in this rock is pyrite which forms polycrystalline aggregates up to 1.0 mm in size which have somewhat irregular shapes. Although most of the pyrite is anhedral local vague crystal shapes are present both at the margins and inside pyrite aggregates. Both chalcopyrite and stannite are also disseminated through the rock as anhedral grains up to 0.3 mm in size. Usually the chalcopyrite and stannite are associated with each other and are located in close proximity to pyrite.

This is a topaz bearing greisen. Most of the topaz tends to form elongate, prismatic crystals rather than anhedral crystals which most of the topaz in the previously described rocks occurred as. As in most of the previously described greisens the rock contains carbonate which is most likely of a slightly later alteration stage

Sample: 183758: TSC33226.

72 124

Location:
C1615, 207.0m.

Rock Name:
Greisen.

Hand Specimen:
This sample has a somewhat variable character containing one portion with a coarse pegmatitic appearance consisting of what appear to be dull white feldspa pseudomorphs intergrown with milky grey quartz. This area is separated from a greenish grey coloured area with reddish brown mottling by a darker grey quartz rich appearing band several millemetres wide.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	55
Muscovite/sericite	30
Carbonate	10
Tourmaline	2
Opaques and semi-opaques	2

Although this sample has a highly variable character in hand specimen in thin section, the various regions has a similar mineralogy and texture, being comprised mainly of granular quartz intergrown with finely divided muscovite/sericite. Throughout the rock the quartz has a typical grain size between 0.1 and 0.8 millemetres and forms a mosiac of anhedral grains.

Locally the muscovite forms relatively large flakes up to 1.0 mm in length, but most of the muscovite forms flakes approximately 0.15 mm in size. In some places aggregates of very finely divided muscovite/sericite with a random orientation are present. The dull white patches in the pegmatitic appearing portion of the rock consist mainly of very finely divided muscovite/sericite patches. The larger muscovite flakes are generally concentrated in the portion of the rock with the reddish brown mottling. This portion of the rock also contains a higher amount of carbonate which occurs mainly as very finely divided interstitial fillings. These fillings contain moderate amounts of translucent, reddish brown limonitic material and would be the cause of the reddish coloured patches in this part of the rock. Some of the large muscovite flakes in this area also show incipient replacement by finely granular carbonate which forms lamellae oriented along cleavage traces.

Tourmaline occurs as elongate, prismatic crystals up to 0.5 mm in size which have a pleochroic yellowish green colour. The tourmaline is concentrated in the coarser grained pegmatitic portion of the rock. Minor opaques are disseminated through the rock as anhedral grains and granular aggregates up to 0.1 mm in size.

This is a typical quartz and muscovite bearing greisen which shows great textural variation in hand specimen caused mainly by a difference in grain size and a higher proportion of limonite stained carbonate in the mottled reddish brown area.

72 125

Sample: 183759: TSC33227.

Location:
C1615, 217.8m.

Rock Name:
Tourmaline and Carbonate bearing Topaz Greisen.

Hand Specimen:
A fine grained rock of a variable colour ranging from a dark or greenish grey to a paler grey with some reddish brown mottling.

Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Topaz	25
Carbonate	15
Tourmaline	10
Sericite	3
Chlorite/clay	2
Cassiterite	trace
Biotite	trace
Opaques	trace-1

This rock consists essentially of a quartz and topaz mosiac comprised of anhedral grains of typical size between 0.1 and 0.5 mm. The rock also contains some larger disseminated quartz grains up to several millimetres in size which appear to be remnant quartz phenocrysts. These large quartz crystals typically have anhedral shapes although a few with vague subhedral shapes were noted and most of these large crystals also contain finely divided inclusions of sericitic material in their outer margins.

Tourmaline is disseminated through the rock as anhedral grains as well as localized euhedral to subhedral, prismatic crystals. Most of the euhedral tourmaline has a pleochroic orange colour but these euhedral tourmaline crystals commonly exhibit overgrowths of pleochroic green to bluish green tourmaline which has an irregular shape. Virtually all of the anhedral tourmaline also has a pleochroic green to bluish green colour. There appears to be two generations of tourmaline in this rock with the euhedral, yellowish orange pleochroic tourmaline being earlier formed than the anhedral tourmaline with a pleochroic green or bluish green colour.

The rock contains moderate amounts of disseminated carbonate as interstitial fillings up to approximately 1 mm in size. Locally this carbonate contains finely intergrown iron oxides which impart a reddish brown, translucent character which would account for the reddish brown patches and in hand specimen. Much of the carbonate has a remnant fibrous texture indicating that it has replaced a pre-existing phyllosilicate. Some of this carbonate is intergrown with a very pale green, weakly pleochroic chlorite and it is considered to be largely a replacement product of this chlorite. Locally the sample contains small flaky aggregates of a weakly birefringent clay or chlorite mineral. Minor sericite is also disseminated through the rock as small flakes which occur interstitially between the granular quartz and feldspar, as narrow fracture fillings and as an incipient alteration product of topaz. Traces of biotite were noted as small well developed flakes up to 0.1mm in size which have a pleochroic brown colour and are totally included within large quartz crystals where they have been protected from further alteration. Traces of cassiterite were noted as small anhedral grains up to 0.1 mm in size which are intergrown with carbonate.

Minor opaques are disseminated through the rock as anhedral grains up to 0.2 mm in size.

This is a topaz bearing greisen showing evidence of two generations of tourmaline development as well as the replacement of chlorite by carbonate.

Sample: 183760: PTSC33228.

Location:
C1615, 234.0 m.

Rock Name:
Topaz Greisen.

Hand Specimen:
A pale grey coloured rock containing moderate amounts of disseminated sulphide.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Quartz	45
Topaz	25
Tourmaline	10
Carbonate	5
Fluorite	5
Pyrrhotite	5
Pyrite	3
Sericite	1
Chalcopyrite	1
Cassiterite	1
Stannite	trace
Wolframite	trace
Sphalerite	trace
Bismuthinite/Bismuth	trace

This rock is comprised of a quartz and tourmaline mosaic with a typical grain size between 0.2 and 0.8 mm. Most of the quartz forms anhedral grains but locally subhedral, prismatic quartz crystals are present. Some larger disseminated quartz grains up to 1.5 mm in size are also disseminated through the rock and probably represent remnant quartz phenocrysts. These larger quartz grains also typically exhibit anhedral shapes. The topaz also forms anhedral grains, and also shows incipient alteration to very finely divided sericite.

Tourmaline is disseminated through the rock as crystals up to 1 mm in size some of which have euhedral prismatic shapes although some forms anhedral, interstitial fillings. Most of the tourmaline has a pleochroic green or yellowish green colour but some tourmaline with a pleochroic blue or pleochroi orange colour is also present. Unlike sample 183759 there does not appear to be any paragenetic sequence between the tourmaline with differing pleochroic colours.

Carbonate is disseminated through the rock as angular, interstitial fillings up to 0.8 mm in size. Some carbonate tends to be concentrated marginal to disseminated opaque sulphides but most is intergrown with the quartz and topaz. Some of the carbonate has remnant fibrous textures suggesting that it has replaced a pre-existing phyllosilicate. Fluorite also forms angular, interstitial fillings up to 1 mm in size. The fluorite and to a lesser extent the carbonate tends to be intergrown with somewhat euhedral appearing quartz grains. Traces of biotite were noted as small flakes up to 0.1 mm in size with a pleochroic brown colour which are completely included within large quartz grains believed to be remnant quartz phenocrysts.

Minor cassiterite is disseminated through the rock as angular crystals up to 0.1 mm in size which are generally located interstitially between the granular quartz and topaz although some cassiterite was also noted as intergrowths

with carbonate. The cassiterite exhibits a zoned colouration in shades of pale brown to reddish brown. Minor wolframite was noted as elongate, prismatic crystals up to 0.1 mm in length.

The major sulphide in this rock is pyrrhotite which forms anhedral disseminated grains and aggregates up to 2.0 mm in size. Most of the pyrrhotite shows some marginal replacement by pyrite. This pyrite exhibits fine, colloform appearin textures as well as lamellar textures all of which are typical of pyrite after pyrrhotite. Chalcopyrite is also disseminated through the rock as anhedral grains up to 1 mm in size. Some of the chalcopyrite forms granular intergrowths with pyrrhotite. Stannite forms anhedral disseminated grains up to 0.5 mm in size which are generally intergrown with chalcopyrite although some stannite was also noted intergrown with non-opaque gangue minerals in the vicinity of disseminated pyrrhotite. Minor sphalerite forms anhedral disseminated grains up to 0.3 mm in size which are typically intergrown with chalcopyrite. Traces of bismuthinite were noted as small interstitial fillings up to 0.1 mm in size located between non-opaque grains. Some of the bismuthinite contains small inclusions of metallic bismuth.

This is a topaz rich greisen which also contains moderate amounts of tourmalin carbonate and fluorite. The rock also contains a relatively high sulphide content consisting mainly of pyrrhotite and pyrite after pyrrhotite.

Sample: 183761: TSC33229.

72 129

Location:
C1615, 239.7 m.

Rock Name:
Greisen Vein in Micaceous Meta-siltstone.

Hand Specimen:
This sample contains a greenish grey coloured band approximately 3 cm wide in a very fine grained, brown rock.

Thin Section:
In thin section the greenish coloured vein was seen to consist of a greisen while the brownish coloured rock is a fine grained, argillaceous meta-sediment which has been termed a micaceous meta-siltstone, and an optical estimate of the mineralogy of these two lithologies is as follows:

Greisen		Micaceous Meta-siltstone	
Quartz	70	Biotite	35
Muscovite	10	Muscovite	30
Topaz	10	Quartz	30
Tourmaline	5	Fluorite	3
Carbonate	1	Tourmaline	1
Fluorite	1	Opaques	1
Cassiterite	trace-1		
Opaques	2		

The greisen consists of a granular quartz mosiac with a typical grain size between 0.2 and 1 mm intergrown with smaller amounts of topaz, muscovite and tourmaline. The topaz forms anhedral grains up to 0.8 mm in size which are distributed through the greisen vein. The muscovite forms flakes up to 0.3 mm in size which are generally located interstitially between the granular quartz. Locally the muscovite shows incipient alteration to a very weakly birefringent clay mineral. Tourmaline also occurs as interstitial fillings below 0.2 mm wide. Most of the tourmaline forms anhedral crystals although some euhedral to subhedral, prismatic tourmaline crystals are present. The tourmaline typically exhibits a pleochroic green or a pleochroic reddish orange colour.

Minor carbonate occurs within the greisen mainly as narrow fracture and vein fillings below 0.1 mm wide or as very fine interstitial fillings. The carbonate typically has a very finely granular, turbid character. Fluorite also occurs as interstitial fillings up to 0.3 mm in size. Traces of cassiterite are disseminated through the greisen as anhedral crystals up to 0.5 mm in size. Opaques are concentrated along one margin of the greisen where it is in contact with the fine grained meta-sediment. These opaques typically exhibit elongate, prismatic shapes typical of wolframite and are considered to consist mainly of wolframite.

The fine grained meta-sediment consists mainly of biotite flakes intergrown with muscovite and finely granular quartz. The biotite has a moderately pleochroic reddish brown colour and exhibits a very weakly developed lepidoblastic foliation. The quartz has a very fine grain size below 0.05 mm and most likely represents fine grained detrital quartz.

The fine grained meta-sediment is cut by granular quartz veins up to 0.3 mm wide which also contain larger biotite flakes up to 0.3 mm in length. The fluorite is concentrated marginal to a vein and locally within the vein as irregular patches up to 0.5 mm in size. Minor fluorite is also disseminated through the fine grained meta-sediment. Disseminated tourmaline crystals up to 0.1 mm in size with elongate, prismatic shapes are present in the meta-sediment.

The sample contains a quartz rich greisen vein transecting a biotite rich meta-sediment. Both this fluorite and tourmaline in the meta-sedimentary rock are considered to be of metasomatic origin.

Sample: 183762: PTSC33230.

Location:
C1545, 266.4m.

Rock Name:
Banded amphibolite.

Hand Specimen:
A very dark greenish grey coloured rock with a vague banded character defined by magnetite and pyrrhotite.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Amphibole	70
Quartz	10
Carbonate	5
Fluorite	5
Magnetite	5
Pyrrhotite	5
Cassiterite	1
Chalcopyrite	trace-1

This rock consists mainly of randomly oriented amphibole crystals intergrown with smaller amounts of other minerals. Most of the amphibole forms somewhat elongate, fibrous crystals up to 0.4 mm long which have a random orientation. Locally the amphibole crystals form aggregates with vague radiating textures. The amphibole has a pleochroic green to yellowish green colour.

The quartz, carbonate and fluorite form polycrystalline aggregates in patches up to several millimetres in size which typically have a grain size up to 0.5 mm. The quartz in particular tends to contain very finely divided fibrous amphibole inclusions and forms granular intergrowths with carbonate

The major opaque minerals are pyrrhotite and magnetite both of which tend to be concentrated as granular aggregates within vague bands which virtually defines the banded character visable in hand specimen. The pyrrhotite forms anhedral crystals while the magnetite tends to form subhedral to euhedral crystals although some anhedral magnetite crystals are also present. In some places magnetite tends to form around the margins of pyrrhotite but some bands comprisedmainly of magnetite crystals are also present. Minor chalcopyrite is also disseminated through the rock as anhedral grains up to 0.3 mm in size which are typically intergrown with pyrrhotite.

The rock contains disseminated cassiterite as anhedral grains up to 0.5 mm in size which typically occur interstitially between the amphibole crystals. Minor wolframite is also present as elongate prismatic crystals up to 0.15 mm in length.

This is an amphibole rich rock containing quartz, carbonate and fluorite all of which are considered to be of metasomatic origin. The pyrrhotite and magnetite as well as the cassiterite are most likely associated with this mineralization.

Sample: 183763: PTS33231.

Location:
C1525, 247.2m.

Rock Name:
Danalite-Amphibole-Pyrrhotite rock.

Hand Specimen:
A massive, dark green coloured rock containing abundant intergrown pyrrhotite as well as a dark purple coloured danalite rich area.

Polished Thin Section:
An optical estimate of the constituents gives the following:

	%
Danalite	25
Amphibole	20
Pyrrhotite	20
Quartz	15
Carbonate	15
Biotite	4
Chalcopyrite	1
Sphalerite	trace
Wolframite	trace

This sample has a highly variable mineralogy as was noted in hand specimen and the above list mineral proportions would depend largely on the region of this sample selected for hand specimen. One portion of the rock consists mainly of danalite intergrown with fibrous to acicular amphibole. Optically this danalite is very similar to garnet forming isotropic, anhedral crystals up to several millimetres in size which form a mosiac within which the amphibole occurs both as elongate, acicular inclusions and as angular interstitial fillings.

Another portion of the rock consists mainly of granular quartz intergrown with similar acicular to fibrous amphibole and anhedral pyrrhotite. In this region the quartz typically has a grain size of 0.5 mm while the amphibole forms elongate crystals up to several millimetres in length. The pyrrhotite forms anhedral grains in a granular aggregate up to 1 mm in size which tend to coalesce into an irregular network.

Most of the amphibole has a pleochroic green colour but some of the larger amphibole crystals have paler brown coloured cores. Locally the amphibole shows pervasive replacement by finely divided carbonate which still retains the fibrous to acicular character of the original amphibole. The finely divided amphibole inclusions both within the danalite and the quartz suggest that these minerals have also probably replaced pre-existing amphibole. There is a carbonate replacement which occurred subsequent to this and includes replacement of inclusions as well as localized areas where larger amphibole crystals are partially or completely replaced. Minor biotite is also locally intergrown with the amphibloe as pleochroic green flakes up to 0.5 mm in size.

Although pyrrhotite is the major sulphide is this rock minor chalcopyrite is intergrown with the pyrrhotite as anhedral grains up to 0.3 mm in size. Traces of sphalerite were also noted locally with anhedral grains up to 0.2 mm in size which are intergrown with chalcopyrite and pyrrhotite. Some portions of the rock contains chalcopyrite with finely divided, vermiform inclusions of pyrite. Traces of wolframite occur as elongate, prismatic crystals up to 0.4 mm in length.

This is an essentially metasomatic appearing rock which contains abundant amphibole showing evidence of replacement by danalite and quartz along with the associated development of pyrrhotite and later replacement by carbonate.

133

The Australian
Mineral Development
Laboratories

Flemington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

72 134

amdel

16 November 1982

GS 3/43/6/0

Cleveland Tin Limited,
LUINA, Tas. 7321.

Attention: E. Dronseika

REPORT GS 2825/83

YOUR REFERENCE: Order 22447 dated 4 November 1982

MATERIAL: Mineral sample

IDENTIFICATION: C1811/93.8 m

DATE RECEIVED: 10 November 1982

WORK REQUIRED: Identification of soft green mineral

Investigation and Report by: Dr Roger Brown

Chief - Geological Services Section: Dr Keith J. Henley
Manager, Mineral and Materials Sciences Division: Dr William G. Spencer

Keith Henley

for Norton Jackson
Managing Director

jd/1

Head Office:
Flemington Street, Frewville
South Australia 5063,
Telephone (08) 79 1662
Telex: Amdel AA82520
Pilot Plant
Osman Place
Thebarton, S.A.
Telephone (08) 43 8053
Branch Laboratories:
Melbourne, Vic.
Telephone (03) 645 3093
Perth, W.A.
Telephone (09) 325 7311
Townsville
Queensland 4814
Telephone (077) 75 1377

SOFT GREEN MINERAL

1. INTRODUCTION

A small chip of mineral material received from Cleveland Tin Limited included various minor minerals (fluorite?, amphibole?, tourmaline?) but the main component was a soft, pale green massive mineral which was to be identified.

2. PROCEDURE

An X-ray powder diffractometer trace was recorded and interpreted.

3. RESULT

The material is muscovite. The crystallinity is poor, as indicated by the broad diffraction peaks, and in many respects this would be better termed dioctahedral illite.

135

72 136

La Trobe University,
Bundoora, 3083.

14 December 1982

Mr. E. Dronseika,
Cleveland Tin Ltd.,
Luina, Tas. 7321.

Dear Ed,

Enclosed are the thin section descriptions as requested. One of the polished sections (1634, 145.4m) was difficult to prepare because of the irregular shape of the sample and some of the opaque minerals were ground off during preparation. A second section is being prepared and described.

The invoice is included with the samples and thin sections which have been returned via surface mail. The total cost for the 19 thin sections and descriptions is $360.00

If you have any queries regarding the samples, do not hesitate to contact me.

Yours faithfully,

P. Jackson

Sample number: 1811, 133.3m

Rock name: Lode

Mineralogy

quartz	34%
fluorite	20%
wolframite	18%
biotite	15%
sellaite	5%
topaz	2%
tourmaline	2%
siderite	2%
bismuth	2%
bismuthinite	trace
sphalerite	trace
cassiterite	trace

Thin section description

Quartz occurs as fine to medium anhedral to subhedral crystals, including biotite and opaque minerals.

Fluorite occurs as medium to coarse anhedral crystals poikilitically enclosing biotite, tourmaline, bismuth, bismuthinite, quartz and trace cassiterite.

Wolframite occurs as coarse blades (up to 6mm across) and as aggregates of fine elongate crystals in the matrix.

Biotite (pleochroism colourless to pale brown) occurs as aggregates of fine crystals, often included in quartz, fluorite, sellaite and as isolated flakes included in topaz.

Sellaite is present as medium anhedral crystals (up to 3mm across) poikilitically enclosing biotite, quartz, topaz and minor tourmaline.

Sample number: 1811, 100.8m

Sample name: Quartz-rich vein

Mineralogy

quartz

topaz

opaque minerals

fluorite (minor)

siderite (minor)

cassiterite (minor)

muscovite (minor)

Thin section description

The vein is comprised largely of quartz with lesser topaz and opaque minerals. Fluorite, siderite, muscovite and cassiterite are minor occurring mineral phases. A number of fractures occur within the vein orientated parallel to the vein. Most of the topaz and muscovite occur along a major fracture in the centre of the vein.

Quartz is present as fine to medium sized anhedral crystals.

Topaz occurs as fine anhedral crystals containing fine inclusions of opaque minerals (S).

Opaque minerals occur as elongate crystals (wolframite?) and as aggregates of bent flakes (molybdenite?). Siderite and muscovite rims are prominent on many opaque grains.

Fluorite and cassiterite are minor phases present as very fine anhedral grains interstitial to quartz crystals.

Sample number: 1803, 89.6m

Sample name: veined arenite

Thin section description

Vein mineralogy quartz

fluorite

topaz

opaques (minor)

siderite (minor)

muscovite (minor)

Vein contains largely quartz with lesser topaz and fluorite and minor siderite, muscovite and opaque minerals.

Quartz occurs as fine to medium sized anhedral crystals.

Topaz has formed largely along fracture orientated through the centre of the vein in the vein direction. Topaz occurs as fine anhedral and occasional medium sized subhedral crystals.

Fluorite occurs as fine anhedral crystals interstitial to quartz.

Muscovite is present as scattered fine crystals interstitial to quartz.

Siderite forms rims around opaque minerals.

Wallrock

Fine angular to subangular quartz grains are present in a matrix of very fine-grained brown biotite, tourmaline, muscovite and minor opaques.

Sample number: 1741, 99.1m

Sample name: Hydrothermal breccia vein

A B C

A - muscovite greisen

B - breccia vein

C - seritized pelite

Thin section description

Breccia vein

tourmaline

quartz

muscovite

fluorite

siderite

opaques

Aggregates of coarse subhedral β-quartz crystals (up to 5mm across) and angular tourmalinized clasts (up to 8mm across) occur in a matrix of very fine quartz crystals, muscovite, tourmaline, fluorite, siderite and minor opaque minerals.

Muscovite occurs as fine skeletal crystals interstital to quartz and also as aggregates of medium sized crystals. Siderite partially replaces muscovite.

Tourmaline in the matrix is green in colour and occurs as fine anhedral crystals interstitial to quartz and containing fine inclusions of muscovite and quartz. Tourmaline in clasts is brown in colour and occurs as fine elongate crystals.

Fluorite is present as occastional poikilitic crystals enclosing muscovite. Siderite rims are observed on some fluorite crystals.

Opaques occur in aggregates with cubic crystal shapes prominent. Partial siderite rims are present, but are not common.

Remarks: Dark coloured clasts are comprised mainly of fine crystals of brown tourmaline with lesser quartz. The subangular grains of quartz which are prominent in one of the clasts, suggest an origin from a pelitic horizon, which frequently show tourmalinization peripheral to veins.

Muscovite greisen

The boundary between the breccia vein and the greisen zone is marked by aggregates of medium sized muscovite flakes.

The muscovite greisen is comprised largely of quartz, and muscovite with minor siderite, opaques, fluorite, tourmaline and trace cassiterite.

Sericitized pelite

Fine angular to sub-angular grains of quartz are present in a very fine grained matrix of sericite, with minor tourmaline, siderite and opaques.

Fluorite occurs as anhedral crystals in the matrix including muscovite and quartz.

Remarks

(i) The large pale brown patches seen in the core sample are siderite

(ii) The smaller darker brown patches are sphalerite.

Sample number: 1713, 227.5m

Rock name: Muscovite greisen

Mineralogy

muscovite/sericite	50%
quartz	37%
siderite	5%
fluorite	3%
sphalerite	2%
opaques	2%
fluoro apatite	1%

Thin section description

Fine grained rock consisting mainly of muscovite/sericite and quartz with lesser siderite, fluorite, sphalerite, opatite and opaques.

Muscovite occurs as aggregates of fine to medium sized crystals. Microcrystalline aggregates of sericite appear to represent relict feldspars.

Quartz occurs as fine to medium sized anhedral (β-quartz?) grains (up to 0.3mm across), in the matrix and in veinlets. Interstitial quartz crystals contain minute inclusions of muscovite and opaque minerals. Siderite is present in discontinuous veinlets crosscutting the matrix and as irregular patches including muscovite.

Sphalerite is pale-brown in colour (low Fe?) and is present as scattered fine to medium sized grains, sometimes poikilitically enclosing muscovite.

Sample number: 1713, 201.2m

Sample name: Argillically altered quartz porphyry

Mineralogy

quartz	45%
kaolinite	32%
sericite	18%
k-feldspar	3%
muscovite	2%
opaques	trace

Thin section description

Relict feldspar phenocrysts and occasional β-quartz phenocrysts occur in a very fine grained groundmass of quartz, muscovite, kaolinite and opaque minerals. The groundmass contains numerous fractures infilled largely by quartz with minor muscovite and opaques.

Relict feldspars show alteration of two different types. One type consists entirely of sericite, while the second type shows largely alteration to kaolinite and minor sericite. K-feldspar is observed in small patches in some relics.

Quartz occurs as very fine anhedral crysalts interstitial to relict feldspar and quartz phenocrysts, also as medium sized anhedral crystals in fractures.

Muscovite occurs as scattered fine flakes in the groundmass and occasionally in fractures.

Sample number: 1637, 94.0m

Sample name: quartz-muscovite vein with vermiculite alteration

Mineralogy

quartz	50%
muscovite	28%
vermiculite	20%
topaz	2%
cassiterite	trace
carbonate	trace

Thin section description

Fine to medium sized anhedral quartz crystals are present with interstitial aggregates of muscovite partially altered to brown vermiculite.

Topaz is a minor phase occurring as scattered fine anhedral crystals.

Occasional very fine grains of cassiterite are observed in vermiculite alteration and interstitial to quartz crystals.

Carbonate and opaques are present in trace amounts.

Remarks

Brown alteration patches are aggregates of vermiculite and occur as an alteration product of muscovite.

Sample number: 1637, 72.7m

Sample name: Potassic alteration in vein

Mineralogy

k-feldspar	45%
quartz	40%
muscovite	5%
vermiculite	3%
kaolinite	3%
opaques	2%
siderite	2%

Thin section description

Aggregates of medium sized "cloudy" k-feldspar crystals containing inclusions of muscovite, together with medium sized anhedral quartz crystals, comprise the bulk of the groundmass.

K-feldspar occurs as aggregates of anhedral to subhedral crystals (up to 3mm across) often containing inclusions of skeletal muscovite, vermiculite and very fine kaolinite grains.

Quartz is present as fine to medium sized anhedral crystals in the groundmass.

Muscovite occurs as fine skeletal crystals included in k-feldspar and also interstitial to quartz.

Opaques occur as elongate crystals (wolframite?) interstitial to quartz. Siderite occurs as irregular shaped patches partially replacing muscovite.

Remarks

The white mineral in the sample is k-feldspar, which appears to replace muscovite.

Brown patches are vermiculite.

Marcasite occurs as fine anhedral crystals included in siderite.

Tourmaline is blue-green in colour and occurs as zoned, euhedral, elongate crystals included in siderite, sulphides, quartz and topaz.

Cassiterite occurs along the periphery of the vein as fine to medium zoned, subhedral crystals.

Topaz occurs as fine subhedral crystals mainly along the periphery of the vein.

Quartz occurs as medium sized anhedral crystals, often fractured.

Siderite occurs interstitial to sulphides and encloses quartz, tourmaline, sulphides and fluorite.

Fluorite is a minor phase, present as medium sized poikilitic crystals enclosing tourmaline, quartz and minor sulphides.

Fine veinlet

A fine veinlet comprised of quartz and lesser brown biotite, is crosscut by the major vein.

Wallrock

Framework grains of sub-angular quartz are present in a fine grained matrix of quartz, brown biotite and sericite.

Sample number: 1637, 60.5m

Sample name: Sulphide-rich vein

Vein mineralogy

arsenopyrite

chalcopyrite

sphalerite

marcasite

tourmaline

siderite

quartz

topaz

cassiterite

fluorite

vermiculite

chlorite

Thin section description

The vein contains abundant, fine, crosscutting fractures and consists of arsenopyrite, chalcopyrite, sphalerite and marcasite with interstitial tourmaline, siderite, quartz and fluorite. Topaz and cassiterite are prominent along the periphery of the vein. Chlorite and vermiculite occur mainly along fractures.

Arsenopyrite occurs as medium to coarse subhedral crystals, often fractured, and showing partial replacement by chalcopyrite.

Chalcopyrite occurs as coarse anhedral crystals and as fine subrounded inclusions in sphalerite.

Sphalerite is present as occasional coarse anhedral crystals and partially replaces chalcopyrite.

Sample number: 1634, 160.6B

Sample name: Quartz rich veins

C

A B

Vein mineralogy and thin section description

Vein A quartz

chlorite

muscovite (minor)

siderite (minor)

fluorite (minor)

topaz (minor)

cassiterite (minor)

scheelite (minor)

wolframite (minor)

Quartz is the major mineral present in the vein and occurs as fine to medium anhedral crystals (up to 2mm across). Interstitial to quartz crystals are aggregates of chlorite and muscovite partially replaced by siderite.

Cassiterite is present as scattered fine anhedral crystals.

Wolframite occurs as isolated elongate crystals and in aggregates and is generally rimmed and partially replaced by scheelite.

Vein B quartz

muscovite

siderite

fluorite (minor)

Comprised mainly of medium sized anhedral quartz crystals. Muscovite occurs in aggregates and shows partial replacement by siderite. Fluorite is a minor phase occurring as fine anhedral crystals interstitial to quartz.

Vein C quartz

muscovite

siderite

opaques (minor)

The vein is comprised of medium anhedral quartz crystals with minor interstitial muscovite (partially replaced by siderite) and minor opaques. There are bands of very fine grained quartz which are enriched in muscovite and siderite enclosed in the vein.

Sample number: 1811, 100.8m

Sample name: Quartz-rich vein

Mineralogy

quartz

topaz

opaque minerals

fluorite (minor)

siderite (minor)

cassiterite (minor)

muscovite (minor)

Thin section description

The vein is comprised largely of quartz with lesser topaz and opaque minerals. Fluorite, siderite, muscovite and cassiterite are minor occurring mineral phases. A number of fractures occur within the vein orientated parallel to the vein. Most of the topaz and muscovite occur along a major fracture in the centre of the vein.

Quartz is present as fine to medium sized anhedral crystals.

Topaz occurs as fine anhedral crystals containing fine inclusions of opaque minerals (S).

Opaque minerals occur as elongate crystals (wolframite?) and as aggregates of bent flakes (molybdenite?). Siderite and muscovite rims are prominent on many opaque grains.

Fluorite and cassiterite are minor phases present as very fine anhedral grains interstitial to quartz crystals.

151

Cleveland Tin Limited

72 152

Luina, Tasmania, 7321
Telephone: (004) 46 2135 Telex: AA59051

5th November, 1982
EVD/lc

Dr. Teunis A. Kwak,
Geology Depatment,
LaTrobe University,
BUNDOORA. VIC. 3083

Dear Teunis,

Find attached a list of 18 samples requiring petrological description. Some specimens require a polished thin section to enable you to identify the opaques. These are noted in the attached list. One sample in particular has fine needles within a green mineral (1634/145.4).

I hope that Pete has little trouble in working through them. Feel free to 'phone me if necessary.

On completion, please return the description, thin sections and what is left of the specimen with the packets.

Bill the Company quoting the number of the order form which will come with the parcel.

Yours faithfully,

E.V. Dronseika,
Mine Geologist.

Att.

LIST OF SAMPLES

	SAMPLE NO.	ROCK TYPE	WORK REQUIRED
1.	1615/189.3	Relict felspar in q.p.	Thin Section (T.S.) and Description (Des.)
2.	1615/247.9	Pyrhot, around relict felspar in q.p.	T.S. and Des.
3.	1633/496.9	Carb.-Tourm. alter. in sst adjacent q.p.	" " "
4.	1633/615.3	'Necklace' textured, altered q.p.	" " "
5.	1634/105.3	Min q.v. (7) cutting sericitic (4) q.p.	" " "
6.	1634/108.9	Sericitized (4) sst.	" " "
7.	1634/138.8	Crosscutting veins (4-7)	" " "
8.	1634/145.4	Q.v. Identify opaques and fine needles in green mineral	Polished Thin Section & Des.
9.	1634/160.6	Crosscutting veins (3-4-5)	T.S. and Des.
10.	1637/60.5	Arspy - py.v. (10) Identify opaques	Polished T.S. and Des.
11.	1637/72.7	Sericitic alter. vein (4)	T.S. and Des.
12.	1637/94.0	Brown carb. alter. (8)	" " "
13.	1713/201.2	Argillic alter. (12)	" " "
14.	1713/227.5	Sericitic q.p. Indentify brown spots (sph) (4)	" " "
15.	1741/99.1	Hydrothermal breccia	" " "
16.	1803/89.6	Q.v. with moly rich margin (10) in sst.	" " "
17.	1811/100.8	Mineralized q.v. (11)	" " "
18.	1811/133.3	Mineralized lode	" " "

Sample number: 1615, 189.3m

Rock Name: muscovite greisen

Mineralogy:

quartz	50%
muscovite/ sericite	34%
siderite	5%
opaques	5%
tourmaline	3%
fluorite	2%
fluoroapatite	1%
zircon	trace

Thin section description

Phenocrysts of β-quartz (up to 7mm across) and a single, relict, zoned plagioclase phenocryst (15mm across), occur in a fine-grained groundmass consisting of fine to medium-sized crystals of muscovite, skeletal tourmaline, quartz, fluorite, siderite and opaque minerals.

Quartz occurs as medium to coarse anhedral to subhedral phenocrysts (β-quartz), often in aggregates and as microcrystalline to fine crystals in the groundmass. Inclusions of fine muscovite and tourmaline are often included in quartz.

Muscovite occurs as medium-sized crystals and scattered fine crystals often in aggregates associated with microcrystalline sericite and siderite, pseudomorphing feldspars. Zircon and fluorite occur as inclusions in coarser muscovite flakes. Muscovite shows partial replacement by siderite.

Siderite is present in irregular-shaped masses, partially replacing and intergrown with muscovite and sericite. Siderite also forms rims around opaques.

Tourmaline occurs as medium-sized poikilitic crystals, including fine crystals of quartz.

Opaques are anhedral, poikilitically enclose muscovite and quartz and shown minor partial replacement of muscovite.

Fluorite occurs as scattered, fine, anhedral crystals.

Remarks

The large euhedral, relict plagioclase phenocryst seen in the drill core has been replaced by quartz, siderite and muscovite.

Sample number: 1615, 247.9m

Rock name: Quartz-topaz greisen

Mineralogy

topaz	36%
quartz	30%
siderite	12%
tourmaline	10%
opaques	8%
fluorite	2%
cassiterite	2%
zircon	trace

Thin section description

Porphyritic rock containing phenocrysts of ß-quartz and relict feldspars in a fine grained groundmass consisting of topaz, quartz, tourmaline, siderite and opaque minerals with minor fluorite and cassiterite and trace zircon.

Topaz occurs in fine grained aggregates and as scattered medium-sized subhedral to euhedral crystals. Fine topaz crystals contain inclusions of very fine subhedral to euhedral quartz crystals.

Quartz is present as medium to coarse anhedral phenocrysts (up to 8mm across) and as fine grains in the groundmass.

Siderite forms rims around opaque minerals and includes tourmaline, fluorite, topaz and cassiterite crystals. Siderite also occurs in irregular shaped patches pseudomorphing phyllosilicates (biotite?) with zircon inclusions occasionally observed.

Tourmaline is emerald green in colour and occurs as scattered fine to medium skeletal crystals (generally associated with topaz aggregates) and as euhedral crystals included in siderite.

Opaques poikilitically enclose topaz, tourmaline, quartz and cassiterite.

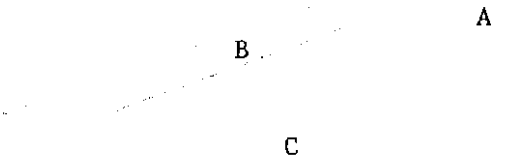
Cassiterite is present as scattered fine anhedral to euhedral crystals included in opaques and also in siderite.

Fluorite is present as scattered fine anhedral crystals.

Remarks

Relict euhedral feldspars have discontinuous pyrrhotite rims with a core comprised largely of topaz aggregates, quartz and siderite.

Sample number: 1633, 496.9m



A - tourmaline-topaz greisen

B - vein

C - tourmalinised arenite

Thin section description

Tourmaline-topaz greisen

quartz	50%
tourmaline	28%
topaz	15%
fluorite	5%
siderite	2%
opaques	trace

Quartz phenocrysts are present in a fine grained groundmass of tourmaline, quartz, fluorite, topaz and siderite.

Quartz occurs as anhedral phenocrysts (up to 3mm across) and as fine anhedral grains in the groundmass.

Tourmaline is green in colour and occurs as medium sized subhedral crystals (including topaz and quartz) and fine anhedral crystals interstitial to quartz and topaz in the groundmass.

Topaz occurs as fine to medium sized anhedral crystals and contains fine inclusions of quartz.

Siderite is a minor phase and is interstitial to quartz and topaz.

Fluorite is present as medium sized poikilitic crystals enclosing quartz, topaz and tourmaline.

Vein

quartz

muscovite

fluorite (minor)

topaz (minor)

cassiterite (trace)

The vein comprises largely quartz with lesser muscovite, minor fluorite and topaz and trace cassiterite. Muscovite shows partial replacement by siderite.

Tourmalinized wallrock

Fine angular to sub-angular grains of quartz are present in a very fine grained matrix which has been tourmalinised.

Sample number: 1633, 615.3m

Rock name: quartz-topaz greisen

Mineralogy

quartz	40%
topaz	30%
siderite	12%
opaques	9%
muscovite	2%
fluorite	2%

Thin section description

Porphyritic rock comprising aggregates of medium to coarse anhedral quartz crystals and lesser aggregates of medium sized topaz crystals in a fine grained groundmass comprised largely of quartz, topaz, siderite and opaque minerals.

Quartz occurs as aggregates of medium to coarse anhedral β-quartz crystals (up to 5mm across), and as fine anhedral to subhedral crystals in the groundmass. Minor muscovite inclusions are seen in some quartz crystals.

Topaz occurs as aggregates of medium sized subhedral crystals and also as fine anhedral crystals interstitial to quartz.

Siderite occurs as small irregular shaped patches in the matrix interstitial to quartz and including quartz, topaz, fluorite, muscovite and opaque minerals. Siderite rims are frequently observed around opaques with reaction textures prominent.

Siderite also occurs as pseudomorphs of feldspars (?).

Opaque minerals occur as aggregates of cubic crystals (pyrite?) and fine anhedral crystals. Siderite rims are prominent.

Fluorite occurs as fine anhedral crystals interstitial to quartz, and occasionally poikilitically enclosing topaz.

Muscovite occurs as scattered fine crystals interstitial to quartz.

Sample number: 1634, 108.9m

Rock name: muscovite greisen crosscut by quartz filled fractures

Mineralogy

quartz	50%
muscovite	40%
siderite	10%
opaques	trace
fluorite	trace

Thin section description

Microcrystalline muscovite and quartz with lesser siderite and trace fluorite and opaques, occur in a groundmass crosscut by fractures infilled with quartz.

Quartz occurs in the groundmass as very fine anhedral crystals with abundant interstitial muscovite and as medium anhedral crystals in fractures with minor interstitial muscovite.

Siderite occurs as fine irregular shaped patches in the groundmass.

Vein D quartz

scheelite

wolframite

muscovite

fluorite (minor)

vermiculite (minor)

This vein crosscuts all of the other veins in the sample.

Quartz occurs as fine to medium sized anhedral crystals with interstitial fine crystals of scheelite, wolframite, muscovite and minor fluorite.

Wolframite is present as aggregates of elongate crystals showing varying degrees of replacement by scheelite.

Scheelite forms rims around wolframite and in some cases forms wolframite pseudomorphs.

Muscovite occurs as scattered fine grains showing minor partial replacement by vermiculite.

Fluorite is a minor phase occurring as occasional fine anhedral crystals.

Wallrock

Angular framework grains of quartz and minor sericitized feldspar are present in a fine grained matrix of biotite, sericite, and quartz.

Sample number: 1634, 138.8m

Rock name: Veined arenite

Thin section description

Vein A quartz

muscovite

The vein is comprised largely of fine to medium sized anhedral quartz crystals with lesser interstitial muscovite.

Vein B quartz

muscovite

k-feldspar

fluorite (minor)

The vein is comprised of fine to medium sized anhedral quartz crystals and muscovite aggregates.

K-feldspar occurs as occasional medium sized anhedral crystals.

Fluorite is a minor phase occurring as isolated fine anhedral crystals.

Vein C quartz

muscovite

fluorite (minor)

The vein is comprised of medium sized anhedral crystals of quartz with interstitial muscovite and minor fluorite.

Sample number: 1634, 105.3m

Sample name: quartz vein crosscutting muscovite greisen

Thin section description

Vein

quartz

fluorite (minor)

siderite (minor)

cassiterite (minor)

opaques (minor)

Quartz comprises the bulk of the vein, occurring as fine to medium anhedral crystals.

Opaque minerals are fine elongate crystals often in aggregates (wolframite?).

Siderite forms rims around opaque aggregates.

Cassiterite is present as occasional very fine anhedral crystals.

Fluorite contains fine opaque inclusions.

Muscovite greisen

quartz	59%
muscovite	30%
siderite	5%
muscovite	3%
tourmaline	3%

Quartz occurs as microphenocrysts (up to 1.5mm across) and as fine anhedral crystals in the groundmass.

Aggregates of fine muscovite grains partially replaced by siderite, appear to be feldspar relics.

Tourmaline is green in colour, occurring as occasional

SAMPLE NUMBER: C1754 146.5m

SAMPLE NAME: Veined arenite

MINERALOGY:

Vein 1
quartz
fluorite
wolframite (minor)
vermiculite (minor)
topaz (minor)

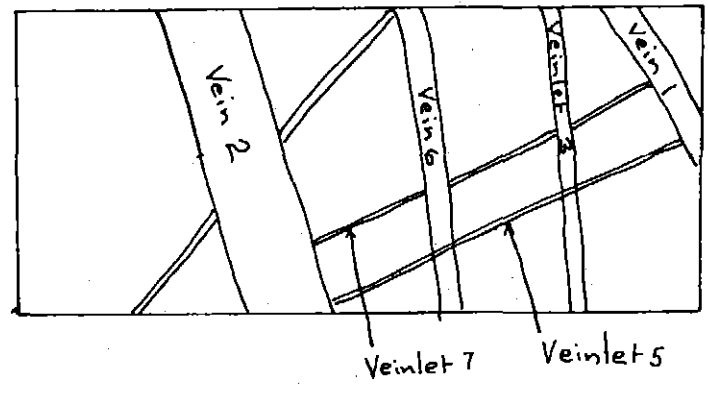
Vein 2
quartz
siderite
wolframite
topaz (minor)
muscovite (minor)

Veinlet 3
quartz
fluorite(minor)

Veinlet 4
quartz
fluorite
topaz (minor)

Veinlet 5
quartz
topaz

Veinlet 6
quartz
fluorite (minor)
vermiculite(minor)
wolframite



THIN-SECTION DESCRIPTION:

Vein 1

This vein is comprised largely of quartz with lesser fluorite and minor topaz, wolframite and vermiculite.

Quartz occurs as moderately fractured, medium-sized, anhedral crystals.

Fluorite occurs as fine, anhedral crystals including quartz and minor topaz.

Vermiculite and wolframite are minor phases with vermiculite

Vein 2

Quartz comprises the bulk of the vein mineralogy with lesser siderite and wolframite present and minor amounts of of topaz and muscovite.

Quartz is present as fine to medium anhedral crystals.

Siderite occurs as fine anhedral crystals interstitial to quartz and as partial rims around opaques.

Wolframite occurs as fine, generally elongate crystals often partially rimmed by siderite.

Topaz is present as very fine crystals (enclosed by siderite) surrounding some wolframite crystals.

Muscovite is enclosed in a single siderite crystal.

Veinlet 3

This veinlet is comprised almost entirely of quartz with minor fluorite along the periphery of the veinlet.

Veinlet 4

The veinlet is comprised of medium anhedral quartz and fluorite crystals with minor topaz present.

Veinlet 5

This veinlet is not very well-defined, where it can be distinguished from the country rock it is seen to consist of fine anhedral quartz and topaz crystals.

Veinlet 6

Comprised largely of quartz with minor vermiculite, wolframite and fluorite. Tourmaline selvages are observed along the periphery of the vein.

Veinlet 7

Comprised of fine anhedral quartz crystals.

Wallrock

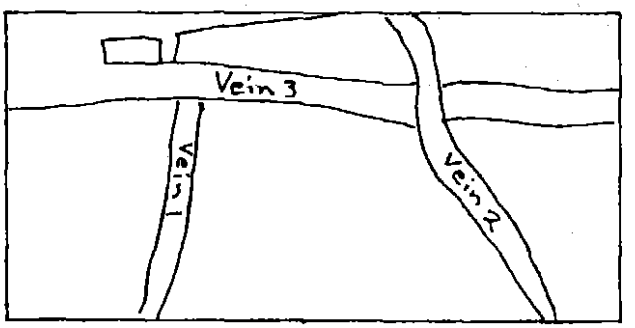
The wallrock alteration is extremely heterogeneous. Pale colour-regions are comprised largely of fine detrital and authigenic quartz in a very fine-grained matrix of carbonate, with patches of fluorite commonly observed. Opaques, sellaite and tourmaline are minor phases

present.

Darker coloured regions contain detrital quartz and authigenic quartz in a fine-grained matrix which is tourmaline-rich. Carbonate, sellaite, fluorite and opaques are minor phases present.

SAMPLE NUMBER: C1865 54.8m

SAMPLE NAME: Veined arenite



MINERALOGY:

Vein 1
quartz
fluorite
topaz (minor)
muscovite(minor)
opaques (minor)
vermiculite (minor)

Vein 2
quartz
fluorite
topaz (minor)
muscovite(minor)
opaques (minor)

Vein 3
tourmaline
siderite
quartz
muscovite
serpentine
arsenopyrite (minor)
fluorite (minor)

THIN-SECTION DESCRIPTION:

Vein 1

Comprised mainly of quartz with lesser fluorite and minor topaz, muscovite, opaques and vermiculite.

Quartz occurs as fine anhedral crystals in the vein.

Fluorite is present as fine, scattered, anhedral crystals interstitial to quartz.

Fine aggregates of muscovite also occur interstitially to quartz and have been partially altered to vermiculite.

Topaz occurs as isolated fine crystals interstitial to quartz and rimmed by muscovite.

Vein 2

Very similar to vein 1. Muscovite aggregates often have partial fluorite rims.

Vein 3

Tourmaline is the most abundant mineral present in the vein with lesser siderite, quartz, muscovite, serpentine and minor fluorite and arsenopyrite.

Tourmaline occurs as aggregates of fine to medium, elongate crystals enclosed in siderite.

Siderite occurs in coarse patches interstitial to and enclosing tourmaline and minor fluorite.

Quartz is present as medium-sized, elongate crystals growing inwards from vein walls and scattered medium, euhedral crystals within the vein.

Muscovite and serpentine occur in patches interstitial to tourmaline.

Arsenopyrite occurs as occasional euhedral crystals along the periphery of the vein.

Wallrock

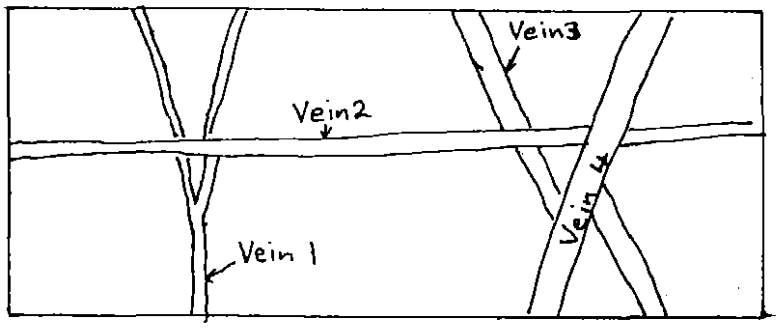
Wallrock adjacent to vein 1 shows largely sericite alteration with lesser siderite and tourmaline.

Wallrock adjacent to vein 2 shows strong sericite alteration with minor biotite and siderite present in the matrix and very minor tourmaline.

Wallrock adjacent to vein 3 has been moderately tourmalinized. Biotite, sericite and siderite are present in the matrix in lesser amounts.

SAMPLE NUMBER: C1852 94.7m

SAMPLE NAME: Veined arenite



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
muscovite (minor)	topaz
vermiculite (minor)	muscovite
fluorite (minor)	vermiculite (minor)
chlorite (trace)	opaques (trace)
	fluorite (trace)

Vein 3	Vein 4
quartz	topaz
muscovite	quartz
fluorite (minor)	muscovite
chlorite (minor)	wolframite
siderite (minor)	molybdenite
vermiculite (minor)	tourmaline (minor)
	siderite (minor)
	fluorite (minor)
	other opaques (minor)
	chlorite (minor)
	vermiculite (minor)

THIN-SECTION DESCRIPTION:

Vein 1

This vein is comprised largely of quartz with minor amounts of muscovite, fluorite, vermiculite and chlorite.

Quartz is present as fine anhedral crystals.

Muscovite occurs as fine-grained aggregates, interstitial to quartz and partially altered to chlorite and vermiculite.

Fluorite occurs as occasional, fine, anhedral crystals interstitial to quartz.

Vein 2

This vein is comprised of quartz with lesser topaz and muscovite occurring in the centre of the vein, minor vermiculite and trace amounts of fluorite and opaques are also present.

Quartz occurs as fine, anhedral crystals in the vein and as fine inclusions in topaz.

Topaz appears to be a late vein-filling stage, with fine anhedral crystals along the centre of the vein. Topaz is rimmed by and partially replaced by muscovite.

Muscovite occurs in fine-grained aggregates, rimming and partially replacing topaz, also as occasional aggregates of crystals interstitial to quartz.

Vermiculite infills fine fractures that crosscut the vein and as a minor alteration product of muscovite.

Fluorite and opaques are very minor phases.

Vein 3

Quartz comprises the bulk of the vein with lesser muscovite occurring along the periphery of the vein. Minor amounts of fluorite, siderite, chlorite and vermiculite are also present.

Quartz is present as fine anhedral crystals in the vein.

Muscovite occurs in fine-grained aggregates mainly along the periphery of the vein and is partially altered to chlorite and vermiculite.

Siderite and fluorite occur in very fine patches interstitial to quartz crystals.

Vein 4

This vein is quartz-topaz rich, with topaz occupying the central portion of the vein.

Muscovite, wolframite and molybdenite are present in lesser amounts, together with minor tourmaline, siderite, fluorite, chlorite, opaques (other than wolframite and molybdenite) and vermiculite.

Quartz occurs as fine, anhedral crystals throughout the vein and contains minor inclusions of opaques and muscovite.

Topaz occurs as fine to medium anhedral to subhedral crystals in the centre of the vein and is partially altered around rims and along fractures to muscovite.

Muscovite occurs through partial replacement of topaz and also as aggregates of fine crystals throughout the vein. Fine molybdenite crystals are often observed intergrown with muscovite. Muscovite is sometimes observed to be partially altered to chlorite and vermiculite.

Tourmaline occurs as fine anhedral crystals partially replaced by opaques and occasionally having partial fluorite rims.

Siderite forms rims around some opaque minerals.

Wolframite occurs as aggregates of fine (generally elongate) crystals.

Wallrock

The wallrock alteration is consistent throughout the sample. The wallrock consists of fine, subangular to subrounded quartz grains in a very fine-grained matrix of quartz and biotite with minor sericite.

The abundance of sericite increases slightly, adjacent to veins 1 and 3.

Minor acicular tourmaline occurs adjacent to vein 4.

SAMPLE NUMBER: C1800 240.0m
SAMPLE NAME: Veined siltstone

MINERALOGY:

Vein	Wallrock
quartz	tourmaline
illite	quartz
siderite	sericite
muscovite	opaques (minor)
opaques	carbonate (minor)
topaz (minor)	
fluorite (minor)	
cassiterite (minor)	
bismuth (minor)	

THIN-SECTION DESCRIPTION:

Vein

Fine to medium-grained vein, comprising largely quartz with interstitial illite, siderite, muscovite and opaque minerals and minor topaz, fluorite, cassiterite and bismuth. The major opaque mineral (arsenopyrite) is concentrated towards the edges of the vein.

Quartz is the major mineral phase present and occurs as fine to medium-sized anhedral crystals showing undulose extinction and also as medium-sized euhedra enclosed in illite.

Illite is a major occurring phase, interstitial to quartz and largely replacing muscovite, minor topaz and fluorite. Illite in turn is partially replaced by siderite.

Opaque mineral (arsenopyrite) is present as fine to medium anhedral to subhedral crystals, included in illite and having well-formed siderite rims.

Minor topaz occurs towards the periphery of the vein as corroded crystals partially replaced by illite.

Minor fluorite is observed interstitial to quartz and is partially replacedby illite.

Fine needles of native bismuth are included in a patch of illite.

A single cassiterite crystal is included in illite.

Wallrock

The wallrock is extensively tourmalinized and comprises fine-grained tourmaline and quartz, lesser sericite and minor carbonate and opaque minerals.

SAMPLE NUMBER: C1800 258.0m

SAMPLE NAME: Veined arenite

MINERALOGY:

Vein	Wallrock
quartz	quartz
topaz	tourmaline
sellaite	fluorite
fluorite (minor)	biotite (minor)
sericite (minor)	cassiterite (minor)
opaques (minor)	opaques (minor)

THIN-SECTION DESCRIPTION:

Vein

Coarse, elongate, quartz crystals have grown outwards from the vein walls into the centre of the vein. Later stage vein-filling has taken place producing aggregates of fine to medium, euhedral topaz crystals, coarse anhedral sellaite crystals with minor fluorite and opaque minerals also present.

Quartz is present as medium to coarse anhedral to subhedral crystals aligned perpendicular to the vein wall.

Topaz occurs as aggregates of fine, euhedral, strongly zoned crystals, interstitial to quartz and occasionally included in sellaite. Most of the topaz crystals show minor alteration to sericite.

Sellaite occurs as fine to coarse anhedral crystals (up to 16mm across) and poikilitically encloses aggregates of fine topaz euhedra.

Fluorite and opaque minerals are minor occuring phases intergrown with topaz and sellaite.

Wallrock

The wallrock has been extensively tourmalinized and comprises subangular quartz grains in a fine-grained matrix of tourmaline, lesser fluorite and minor brown biotite and opaque minerals. A euhedral cassiterite crystal was also observed in the matrix.

SAMPLE NUMBER : C1634 380.8m

SAMPLE NAME : Quartz - topaz - fluorite vein

MINERALOGY :

topaz
quartz
fluorite
illite
cassiterite
opaques (minor)
tourmaline (minor)
sericite (minor)

THIN-SECTION DESCRIPTION :

Coarse anhedral to euhedral crystals of quartz, topaz, fluorite and cassiterite comprise the bulk of the vein with interstitial aggregates of fine topaz, quartz, fluorite and minor opaques, tourmaline and cassiterite included in illite.

Topaz occurs as coarse, anhedral to subhedral crystals, frequently highly fractured with illite and minor sericite occurring along growth-zone boundaries.

Quartz is present as coarse anhedral to euhedral crystals intergrown with topaz and as fine anhedral crystals enclosed in illite, interstitial to coarse quartz crystals in the vein.

Fluorite occurs as medium to coarse anhedral to subhedral crystals throughout the vein and contains fine inclusions of quartz and opaque minerals.

Illite and minor sericite occur in patches interstitial to topaz, quartz and fluorite and include fine-grained aggregates of topaz, quartz, fluorite, opaques, tourmaline and cassiterite. Illite and sericite also infill fractures in topaz.

Cassiterite is present as a coarse, zoned, subhedral crystal (10mm across) and as minor anhedral crystals included by illite and sericite.

Minor opaques occur as inclusions in quartz, fluorite and illite.

SAMPLE NUMBER: C1869 7.4m

SAMPLE NAME: Wolframite-rich vein

MINERALOGY:

Vein	Wallrock
tourmaline	quartz
topaz	tourmaline
fluorite	opaques
wolframite	fluorite (minor)
quartz	
muscovite (minor)	
chlorite (minor)	
molybdenite (minor)	
cassiterite (minor)	

THIN-SECTION DESCRIPTION

Vein

The vein comprises coarse crystals of fluorite, wolframite and lesser quartz, together with aggregates of topaz and tourmaline and minor amounts of muscovite, chlorite, molybdenite and cassiterite.

Fluorite occurs as coarse anhedral crystals poikilitically enclosing tourmaline euhedra and wolframite.

Tourmaline is abundant in the vein and occurs as aggregates of medium-sized subhedral to euhedral, zoned crystals and aggregates of fine needles. Tourmaline has greenish coloured rims with brownish coloured cores. Tourmaline is frequently included in fluorite and topaz crystals.

Topaz is present as medium-sized, zoned, subhedral to euhedral crystals, often showing some degree of partial alteration to muscovite.

Quartz occurs as an aggregate of medium-sized, anhedral crystals.

Wolframite occurs as coarse skeletal crystals partially enclosed by fluorite.

Chlorite occurs along fractures in topaz (partially replacing muscovite?), interstitial to tourmaline and intergrown with minor molybdenite.

Cassiterite was observed as a single anhedral crystal enclosed by wolframite.

Wallrock

The wallrock is extensively tourmalinized and comprises micro-crystalline tourmaline and quartz with minor fluorite and opaques.

SAMPLE NUMBER : C1754 126.1m

SAMPLE NAME : Veined arenite

MINERALOGY:

Vein	Wallrock
quartz	quartz
topaz	biotite
fluorite	sericite
wolframite	opaques (minor)
muscovite	apatite (minor)
chlorite	cassiterite (minor)
cassiterite (minor)	tourmaline (minor)

THIN-SECTION DESCRIPTION :

Vein

Fine to medium-sized anhedral quartz crystals (up to 2mm across) comprise the major phase present in the vein.

Fine anhedral topaz crystals occur in the centre of the vein and are rimmed by and partially altered to muscovite.

Wolframite occurs as aggregates of elongate crystals aligned parallel to the edge of the vein. Wolframite is intergrown with chlorite which it appears to replace.

Chlorite occurs intergrown with wolframite and in small patches interstitial to quartz.

Minor fine, anhedral fluorite crystals are present interstitial to quartz.

Cassiterite is present as isolated very fine anhedral grains.

Wallrock

The wallrock comprises primary (detrital) and secondary quartz grains, in a matrix consisting of biotite, lesser sericite and minor opaques, apatite and cassiterite.

SAMPLE NUMBER: C1869 30.4m

SAMPLE NAME: Veined arenite

MINERALOGY:

Vein	Wallrock
quartz	quartz
topaz	tourmaline
wolframite	fluorite (minor)
molybdenite	opaques (minor)
sericite (minor)	zircon (minor)
chlorite (minor)	biotite (minor)
cassiterite (minor)	
fluorite (minor)	
tourmaline (minor)	

THIN-SECTION DESCRIPTION:

Vein

The vein comprises largely quartz, topaz, wolframite and molybdenite with minor amounts of sericite, chlorite, cassiterite, fluorite and tourmaline.

Quartz is present as fine to medium anhedral crystals (up to 5mm across).

Topaz is present as fine to medium anhedral crystals (often highly fractured) showing partial replacement by sericite. Topaz partially encloses wolframite and molybdenite.

Molybdenite occurs as aggregates of bent flakes along the periphery of the vein and is occasionally intergrown with chlorite.

Wolframite occurs as aggregates of elongate crystals concentrated mainly towards the edge of the vein.

Sericite occurs in small masses interstitial to quartz and partially replacing topaz. Molybdenite is sometimes included in sericite aggregates.

Cassiterite is present as medium, subhedral crystals along the centre of the vein and show partial replacement by an opaque mineral. Cassiterite crystals show strong concentric and hourglass zoning.

Fluorite is present as occasional medium-sized anhedral crystals partially enclosing wolframite.

Tourmaline is a minor phase as vein selvages.

Wallrock

The wallrock is tourmalinized with sub-angular framework grains of quartz in a fine-grained matrix of tourmaline, quartz, minor

fluorite, opaques, biotite and zircon.

SAMPLE NUMBER: 1741 187.2m

SAMPLE NAME: Veined pelite

MINERALOGY:

Vein	Wallrock
phengite	quartz
fluorite	biotite
quartz	fluorite
wolframite (minor)	opaques
muscovite (minor)	
scheelite (minor)	
tourmaline (minor)	

THIN-SECTION DESCRIPTION:

Vein

Quartz, fluorite and phengite-rich vein with minor wolframite and muscovite and trace scheelite and tourmaline.

Fluorite occurs as coarse anhedral crystals poikilitically enclosing fine to medium-grained aggregates of phengite.

Phengite occurs as aggregates of fine to coarse crystals often enclosed by fluorite or interstitial to quartz. Fine aggregates of phengite infill fractures in quartz. Some coarse phengite crystals show partial alteration to quartz and muscovite and minor replacement by opaque minerals.

Wolframite occurs as an aggregate of skeletal crystals enclosing fluorite and minor scheelite.

Very fine crystals of scheelite are present in embayments in wolframite crystals.

Wallrock

The wallrock is composed of fine grains of subangular quartz and biotite with minor fluorite and opaque minerals.

SAMPLE NUMBER: C1865 35.4m

SAMPLE NAME: Wolframite-rich vein

MINERALOGY:

wolframite
quartz
tourmaline
chlorite
cassiterite
sericite/muscovite
siderite (minor)
vermiculite (minor)
topaz (trace)

THIN-SECTION DESCRIPTION:

The vein is comprised largely of quartz and wolframite with lesser tourmaline, fluorite, chlorite, cassiterite and sericite/muscovite and minor siderite and vermiculite.

Wolframite is the major occurring mineral phase present as scattered aggregates of skeletal, elongate crystals, sometimes included in fluorite, quartz and cassiterite and often intergrown with cassiterite, tourmaline and chlorite.

Quartz is present as fine to medium, anhedral to subhedral crystals containing inclusions of wolframite, sericite and rare topaz.

Tourmaline occurs as medium subhedral to euhedral crystals, interstitial to quartz and occasionally included in fluorite. Tourmaline is also present as acicular inclusions in fluorite.

Fluorite is present as medium-sized anhedral crystals, including wolframite, tourmaline, chlorite and sericite.

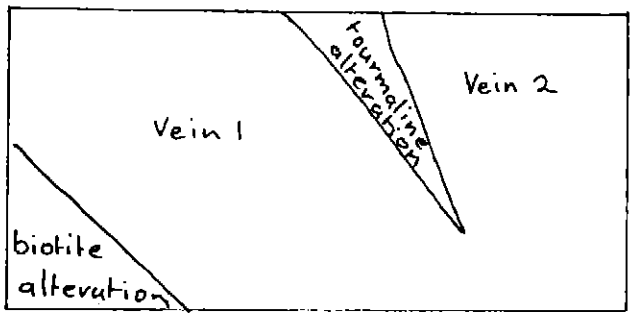
Muscovite and sericite occur in scattered aggregates and is artially altered to chlorite with minor alteration to vermiculite and minor partial replacement by siderite.

Chlorite occurs as radial aggregates of medium-sized crystals formrd mainly through alteration of muscovite and is itself partially altered to vermiculite.

Cassiterite is present as occasional medium-sized, anhedral to euhedral crystals which show well-defined concentric zoning.

SAMPLE NUMBER: C1754 109.5m

SAMPLE NAME: Veins cross-cutting arenite



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
chlorite (minor)	wolframite
siderite (minor)	siderite (minor)
fluorite (minor)	chlorite (minor)
opaques (minor)	fluorite (minor)
cassiterite (trace)	muscovite (minor)
tourmaline (trace)	sellaite (trace)
	cassiterite (trace)

THIN-SECTION DESCRIPTION:

Vein 1

Comprised largely of medium-sized anhedral quartz crystals (up to 2mm across) with minor interstitial chlorite, fluorite, siderite and opaques and trace cassiterite and tourmaline.

Opaque minerals are present as fine inclusions in fluorite and siderite and intergrown with chlorite.

Siderite partially replaces chlorite.

Cassiterite is present as isolated very fine grains.

Vein 2

Quartz and lesser wolframite comprise the bulk of the vein. Quartz is present as fine to medium anhedral crystals (up to 5mm across).

Wolframite occurs as aggregates of fine to medium crystals (often bladed) and sometimes enclosed by minor siderite or fluorite.

Chlorite is a minor occurring phase interstitial to quartz and intergrown with muscovite which it appears to alter.

Siderite is a minor phase which partially replaces chlorite and muscovite.

Cassiterite and sellaite are present in trace amounts.

Wallrock

Two types of wallrock alteration are observed in the sample.

(a) Tourmaline alteration

Subangular to subrounded framework grains of quartz are present in a fine-grained matrix of tourmaline and quartz with minor sellaite, chlorite, biotite and opaques.

(b) Biotite alteration

Subangular to subrounded framework grains of quartz are present in a fine-grained matrix consisting mainly of biotite and quartz with minor occurring muscovite, sphalerite, apatite and tourmaline and trace cassiterite.

SAMPLE NUMBER: C1713 101.6m

SAMPLE NAME: Quartz - fluorite - biotite vein

MINERALOGY:

quartz
fluorite
biotite
chlorite
vermiculite
opaques (minor)
muscovite (minor)
carbonate (minor)
apatite (minor)
brucite (minor)

THIN-SECTION DESCRIPTION:

The vein is comprised largely of coarse anhedral crystals of fluorite, medium anhedral to subhedral crystals of quartz and aggregates of biotite partially altered to chlorite and vermiculite. Opaques, muscovite, carbonate, apatite and brucite are minor phases.

Fluorite occurs as coarse anhedral crystals (up to 15mm across) poikilitically enclosing biotite and minor muscovite.

Carbonate is occasionally observed infilling fractures in fluorite crystals.

Biotite (pleochroism colourless to reddish-brown) occurs as medium-sized crystals, frequently showing marked alteration to chlorite and vermiculite.

Quartz is present as fine to medium anhedral crystals containing fine inclusions of biotite. Fractures in quartz crystals are occasionally observed and are infilled with minor brucite.

Minor opaques occur as fine elongate crystals intergrown with biotite and as inclusions in fluorite.

SAMPLE NUMBER: C1800 251.3m

SAMPLE NAME: Veined pelite

MINERALOGY:

Vein	Wallrock
quartz	tourmaline
wolframite	quartz
fluorite	opaques
siderite	
molybdenite (minor)	
tourmaline (minor)	
cassiterite (minor)	

THIN-SECTION DESCRIPTION:

Vein

Quartz and wolframite are the major occurring mineral phases present in the vein, with lesser fluorite and siderite and minor molybdenite, tourmaline and cassiterite.

Quartz occurs as fine to medium anhedral to subhedral crystals and is the dominant mineral phase. Quartz contains minor inclusions of wolframite and tourmaline.

Wolframite occurs as aggregates of medium anhedral crystals and fine elongate crystals. Partial siderite rims are sometimes seen on wolframite crystals. Wolframite appears to partially replace tourmaline.

Fluorite occurs interstitial to quartz and occasionally partially encloses wolframite and quartz.

Siderite also occurs interstitially to quartz and poikilitically encloses molybdenite and fine tourmaline euhedra.

Tourmaline occurs as inclusions in siderite and as fine anhedral and acicular selvages along the periphery of the vein.

Wallrock

The wallrock is strongly tourmalinized and consists of fine grains of quartz in a very fine-grained matrix of tourmaline, quartz and opaque minerals.

SAMPLE NUMBER: C1842 42.9m

SAMPLE NAME: Mini lode

MINERALOGY:

quartz 60%	wolframite 1%
topaz 12%	biotite (trace)
bismuthinite 10%	sericite (trace)
cassiterite 5%	chalcopyrite (trace)
bismuth 3%	sphalerite (trace)
tourmaline 3%	molybdenite (trace)
fluorite 3%	ilmenorutile (trace)
sellaite 1%	stannite (trace)
siderite 1%	

THIN-SECTION DESCRIPTION:

Quartz is the major occurring phase with lesser topaz, tourmaline, and fluorite. These major occurring non-opaque minerals are highly fractured with fractures infilled by bismuthinite and bismuth. Bismuthinite and bismuth also occur interstitially to quartz.

Quartz occurs as medium to coarse anhedral crystals containing isolated very fine inclusions of biotite and muscovite.

Topaz occurs as a large aggregate of fine to medium anhedral to subhedral crystals which are extensively fractured. Bismuthinite bismuth and sericite infill fractures. Topaz is also present as fine inclusions in fluorite.

Bismuth occurs as fine to medium-sized anhedral crystals which are often completely replaced by bismuthinite or have complete bismuthinite rims around bismuth cores. Bismuthinite also partially replaces tourmaline and cassiterite.

Cassiterite occurs as scattered fine anhedral to euhedral crystals included by and partially replaced by bismuthinite and minor stannite. Cassiterite is also present as fine euhedra included in topaz.

Aggregates of fine to medium, subhedral to euhedral crystals of tourmaline occur interstitially to quartz and are partially enclosed by topaz and bismuthinite.

Fluorite occurs as occasional medium-sized anhedral crystals enclosing quartz, sellaite and topaz.

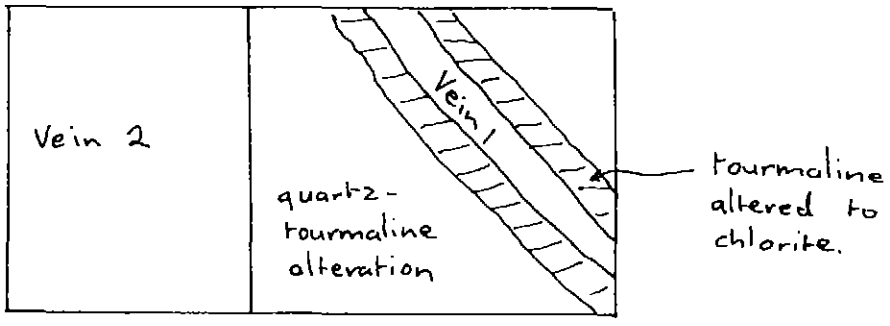
Siderite forms along some fractures and rarely as rims on bismuthinite.

Wolframite occurs as an aggregate of medium-sized elongate crystals showing minor partial replacement by bismuthinite.

Molybdenite, chalcopyrite, ilmenorutile, sphalerite and stannite are present in trace amounts.

SAMPLE NUMBER: C1865 70.6m

SAMPLE NAME: Veined arenite



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
muscovite (minor)	wolframite
siderite (minor)	chlorite
tourmaline (minor)	vermiculite
fluorite (minor)	fluorite (minor)
vermiculite (minor)	tourmaline (minor)
opaques (minor)	cassiterite (minor)

THIN-SECTION DESCRIPTION:

Vein 1

Quartz is the major mineral phase present as medium-sized anhedral crystals.

Siderite (in association with fluorite) occurs along fractures that are orientated approximately parallel to the vein walls. Minor tourmaline is included in siderite.

Muscovite is a minor phase, interstitial to quartz and partially altered to vermiculite.

Fluorite occurs in fractures and as isolated interstitial crystals and includes minor opaques.

Vein 2

Quartz-rich vein containing longitudinal fractures.

Quartz occurs as fine to coarse anhedral crystals (up to 20mm across) often crosscut by very fine fractures containing chlorite and vermiculite.

Chlorite is present interstitial to quartz and is partially altered to brown vermiculite.

Wolframite occurs as an aggregate of medium to coarse anhedral crystals including minor quartz and tourmaline and is crosscut by a fluorite filled fracture.

Fluorite occurs in fractures and as isolated medium-sized anhedral crystals enclosing chlorite.

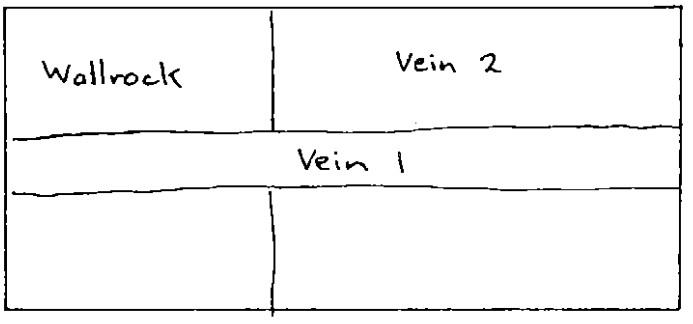
Tourmaline is a minor phase present as fine anhedral crystals enclosed by quartz.

Wallrock

Immediately bordering the vein and extending out to a distance of 6mm, the wallrock consists of subangular framework grains of quartz in a fine-grained matrix of quartz, altered tourmaline and minor opaques. The tourmaline in the matrix has been largely altered to chlorite and vermiculite. Outside the altered tourmaline zone the tourmaline shows no evidence of alteration in the matrix.

SAMPLE NUMBER: C1811 110.9m

SAMPLE NAME : Veined arenite



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
topaz	opaques (minor)
chlorite	chlorite (minor)
siderite	siderite (minor)
molybdenite	
wolframite	Wallrock
muscovite (minor)	quartz
tourmaline (minor)	tourmaline (minor)
fluorite (minor)	biotite (minor)
cassiterite (minor)	fluorite (minor)
sellaite (minor)	chlorite (minor)

THIN-SECTION DESCRIPTION:

Vein 1

Quartz is the major mineral phase present and occurs as fine to medium anhedral crystals.

Topaz is a late vein-filling mineral, present as fine subhedral to euhedral crystals along the centre of the vein. Some topaz crystals are partially rimmed by muscovite.

Chlorite occurs as fine aggregates along the periphery of the vein intergrown with m-lybdenite and appearing to largely replace muscovite.

Siderite occurs as fine anhedral crystals in the centre of the vein and as well-developed rims around opaque minerals towards the edges of the vein.

Opaque minerals (wolframite and molybdenite) are mainly aggregated towards the the vein edges.

Wolframite is present as fine to medium elongate crystals often

Wolframite is present as fine to medium elongate crystals often in aggregates and are occasionally partially rimmed by fluorite.

Molybdenite is present as aggregates of bent flakes intergrown with chlorite and minor muscovite and largely included in siderite with minor inclusions in fluorite.

Fluorite is a minor phase in the vein and includes molybdenite and minor cassiterite.

Tourmaline and sellaite are minor phases occurring towards the periphery of the vein.

Vein 2

Quartz is the dominant mineral phase present and comprises the bulk of the vein. Quartz is present as fine to coarse, anhedral crystals often crosscut by fine fractures infilled by siderite.

Chlorite, muscovite and fluorite are minor phases present as occasional fine anhedral crystals interstitial to quartz.

Vein 2 is crosscut by vein 1.

Wallrock

Fine subangular to subrounded framework grains of quartz are present in a strongly tourmalinized fine-gained matrix containing minor muscovite, biotite, fluorite, chlorite and opaque minerals.

SAMPLE NUMBER: C1869 72.1m

SAMPLE NAME: Veined pelite

MINERALOGY:

Vein	Wallrock
quartz	tourmaline
topaz	quartz
muscovite	sericite
fluorite (minor)	biotite
wolframite	opaques
scheelite minor)	
sellaite (minor)	
vermiculite (minor)	

THIN-SECTION DESCRIPTION:

Vein

Quartz-topaz-wolframite rich vein with lesser muscovite and minor vermiculite, fluorite, scheelite and sellaite. Topaz and muscovite form adjacent to fractures orientated parallel to the vein walls.

Quartz occurs as fine to medium anhedral crystals throughout the vein and contains minor inclusions of wolframite. Quartz crystals are sometimes crosscut by fractures containing vermiculite and muscovite.

Topaz is present as fine to medium anhedral crystals (often fractured) showing partial replacement by muscovite and including wolframite. Topaz forms interstitial to quartz and generally adjacent to fractures in the vein.

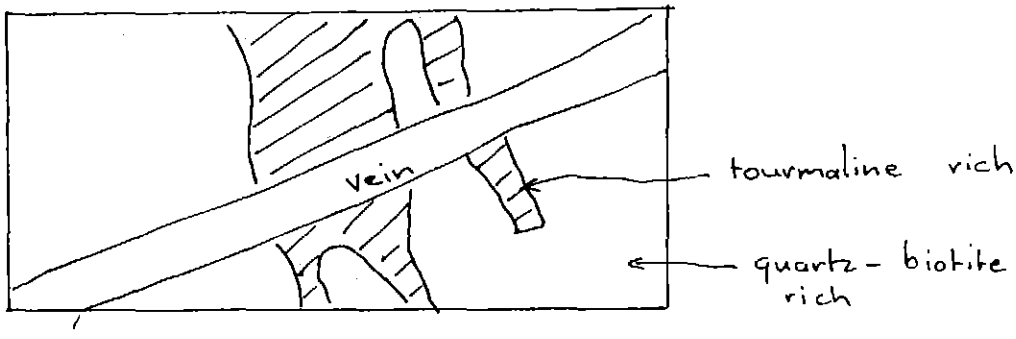
Muscovite forms along fractures, interstitial to quartz and topaz and through partial replacement of topaz.

Wolframite forms as aggregates of elongate crystals towards the edges of the vein. Wolframite is often included by quartz, topaz and fluorite.

Scheelite forms partial rims on may wolframite crystals.

Fluorite is present as occasional fine to medium anhedral crystals containing inclusions of wolframite.

Wallrock



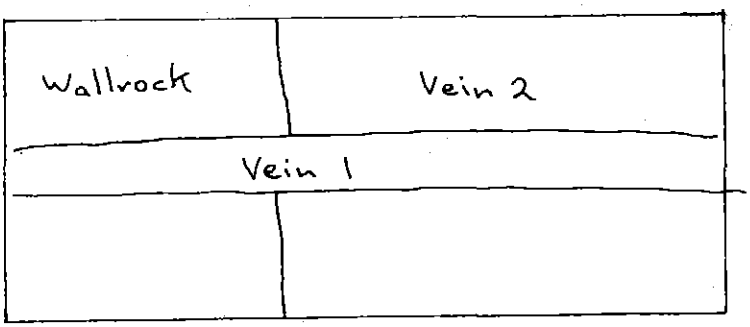
The wallrock alteration in the sample is quite complex.

Darker coloured regions comprise largely microcrystalline tourmaline with minor quartz and sericite also present.

Lighter coloured regions contain fine subangular to subrounded framework grains of quartz in a microcrystalline matrix comprising biotite and sericite with tourmaline a minor phase.

SAMPLE NUMBER: C1852 80.5m

SAMPLE NAME: Veined chert



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
arsenopyrite	wolframite (minor)
fluorite	fluorite (minor)
tourmaline	muscovite (minor)
siderite	topaz (trace)
sericite	cassiterite (trace)

THIN-SECTION DESCRIPTION:

Vein 1

Where the vein crosscuts the country rock, it consists of medium subhedral crystals of arsenopyrite rimmed and showing partial replacement by siderite. Medium-sized, corroded, euhedral crystals are also present enclosed in a sericite matrix. Tourmaline occurs as euhedral prisms often poikilitically enclosed by fluorite. Medium to coarse fluorite crystals poikilitically enclose acicular tourmaline, euhedral prismatic tourmaline and infrequent euhedral quartz and arsenopyrite crystals. Interstitial to the coarser crystals of arsenopyrite, fluorite and quartz is a microcrystalline matrix consisting mainly of sericite with lesser siderite, acicular tourmaline and quartz. Siderite occurs in ractures and in patches in the matrix and includes numerous fine needles of tourmaline. The crosscutting vein boundary is defined by cryptocrystalline aggregates of sericite, tourmaline, siderite and fluorite.

Vein 2

Largely comprised of fine anhedral quartz crystals with minor fluorite, muscovite and wolframite and trace cassiterite and topaz.

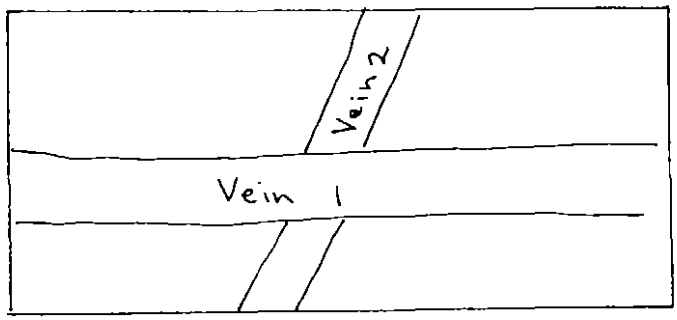
195

Wallrock

Cryptocrystalline fabric consisting of quartz, tourmaline, sericite and minor opaques.

SAMPLE NUMBER: C1633 591.2m

SAMPLE NAME: Veins crosscutting greisenized quartz porphyry



MINERALOGY:

Vein 1	Vein 2
quartz	quartz
topaz	muscovite
tourmaline	tourmaline
muscovite	topaz (minor)
wolframite	fluorite (minor)
other opaques	opaques (minor)
vermiculite (minor)	vermiculite (minor)
fluorite (minor)	

Dyke wallrock

quartz	topaz (minor)
muscovite	opaques (minor)
vermiculite (minor)	carbonate (minor)
fluorite (minor)	

THIN-SECTION DESCRIPTION:

Vein 1

This vein comprises medium to coarse crystals of quartz and topaz with lesser medium-sized crystals of quartz and topaz with lesser medium-sized crystals of tourmaline and wolframite and aggregates of muscovite. Vermiculite, opaques (other than wolframite) are minor phases.

Quartz is present as medium to coarse anhedral crystals containing minor inclusions of wolframite and muscovite.

Topaz occurs as medium to coarse anhedral crystals which are generally highly fractured. Muscovite, vermiculite and opaque minerals infill fractures, with muscovite partially replacing topaz.

Tourmaline occurs as zoned, skeletal crystals with bluish cores and greenish rims. Tourmaline is often partially enclosed by topaz.

Muscovite occurs in patches interstitial to quartz; as partial rims and in fractures associated with topaz and as minor inclusions in quartz and tourmaline. Muscovite is partially altered to vermiculite and partially replaced by opaque minerals.

Wolframite is present as aggregates of fine to medium elongate crystals.

Fluorite is purplish in colour including minor opaques and is also found interstitial to wolframite.

Vein 2

This vein is comprised largely of quartz, tourmaline and aggregates of muscovite, with lesser topaz, fluorite and opaque minerals. Vermiculite is a very minor phase.

Quartz is present as fine to medium anhedral crystals containing minor inclusions of topaz and muscovite.

Tourmaline is present as medium-sized, zoned, skeletal crystals concentrated towards the periphery of the vein. Tourmaline contains fine inclusions of quartz and muscovite.

Muscovite is present as aggregates throughout the vein and shows minor partial alteration to vermiculite.

Topaz occurs as occasional fine anhedral crystals with minor partial replacement by muscovite.

Fluorite and opaque minerals are very minor phases.

Greisen wallrock

The greisen wallrock is comprised largely of quartz and partially vermiculitized muscovite, with minor fluorite, topaz, carbonate and opaques.

Quartz occurs as fine anhedral crystals containing minor very fine inclusions of muscovite and fluorite.

Muscovite occurs as fine skeletal crystals, often in aggregates and showing partial (sometimes extreme) alteration to vermiculite.

Topaz is present as occasional fine, anhedral crystals crosscut by fractures infilled by vermiculite.

Fluorite is present as occasional fine anhedral crystals and lso as laminae intergrown with vermiculite where extreme vermiculitization of muscovite has occurred.

Carbonate is a minor phase present in fine patches replacing vermiculite.

Opaques are minor, occurring as very fine grains, often partially enclosed in fluorite.

Appendix B.

APPENDIX B.

MAJOR AND MINOR METAL ASSAYS

200

LIST D.D.H. INTERSECTIONS (0.2% WO_3 CUT-OFF)

72 202

D.D.H. No.	Intersection (metres)	Length (metres	% SnT	% Cu	% Wo_3	% $Mo5_2$	% Bi
C1633	555.0-657.8	102.8	.054	.036	.310	.021	.069
C1637	162.5-202.5	40.0	.016	.013	.236	.056	.040
C1642	650-77.5	12.5	.032	.016	.296	.053	.015
C1713	152.5-290.0	137.5	.057	.033	.318	.018	.029
C1730	57.5-135.0	87.5	.037	.038	.382	.032	.030
C1741	75.0-167.5	92.5	.030	.029	.276	.016	.013
C1754	130.0-185.0	55.0	.044	.044	.528	.036	.045
C1803	80.0-105.0	25.0	.028	.018	.252	.041	.036
C1811	85.0-122.5	37.5	.048	.024	.310	.059	.024
C1826	70.0-120.0	50.0	.026	.014	.241	.032	.025
C1832	85.0-110.0	25.0	.094	.024	.270	.093	.035
C1833	77.5-122.5	45.0	.030	.013	.230	.042	.031
C1840	57.5-62.5	5.0	.005	.010	.378	.025	.013
C1840	80.0-85.0	5.0	.085	.020	.265	.033	.040
C1842	95.0-100.0	5.0	.240	.050	.305	.043	.060
C1852	45.0-100.0	55.0	.020	.018	.294	.027	.020
C1860	60.0-95.0	35.0	.021	.013	.268	.049	.029
C1865	57.5-72.5	15.0	.032	.018	.294	.033	.024
C1869	105.0-110.0	5.0	.045	.010	.335	.045	.028

201

CLEVELAND TIN LIMITED

72 203 MEMORANDUM

Date	16th July, 1981	Ref	EVD:MM
To	G.J. McArthur	From	E. Dronseika
At	Cleveland	At	Cleveland
Copies to	B.W. Hampel & M.T. Waters.	Keep	

Subject ACCURACY OF FOLEY'S MINE ASSAYS IN COMPARISON TO OUTSIDE ASSAY SERVICES.

The routine assaying of core and rock samples for Foley's Zone elements, ie. molybdenum, wolfram and bismuth, is a recent development within the mine.

Although previous mine assay laboratory determinations for tin and copper have been generally accepted as being accurate it was thought to confirm this accuracy for the newer routine Foley's elements.

Reject samples obtained from Cleveland Assay lab. representing 2.5m lengths of core from diamond drill hole C1608 were despatched to Amdel laboratories in Adelaide. A copy of their results is attached with this memorandum.

The comparitive results are shown graphically for the three elements. Excellent correlation exists between assays. Some very slight increase in assay value is shown for low level wolfram and bismuth determinations. Differences of mean values are 0.4% for wolfram, 1.3% for bismuth and 3.1% for molybdenum.

Conclusion:

For all practical purposes on the mine routine assay results relevant to Foley's Zone are considered as accurate.

E.V. Dronseika.

attach.

202

GOLDSACK GRAPH PAPERS · CHRISTCHURCH N.Z. E221Y Log-log 2 cycles x 2 cycles

72 204

C 1608 25m Samples

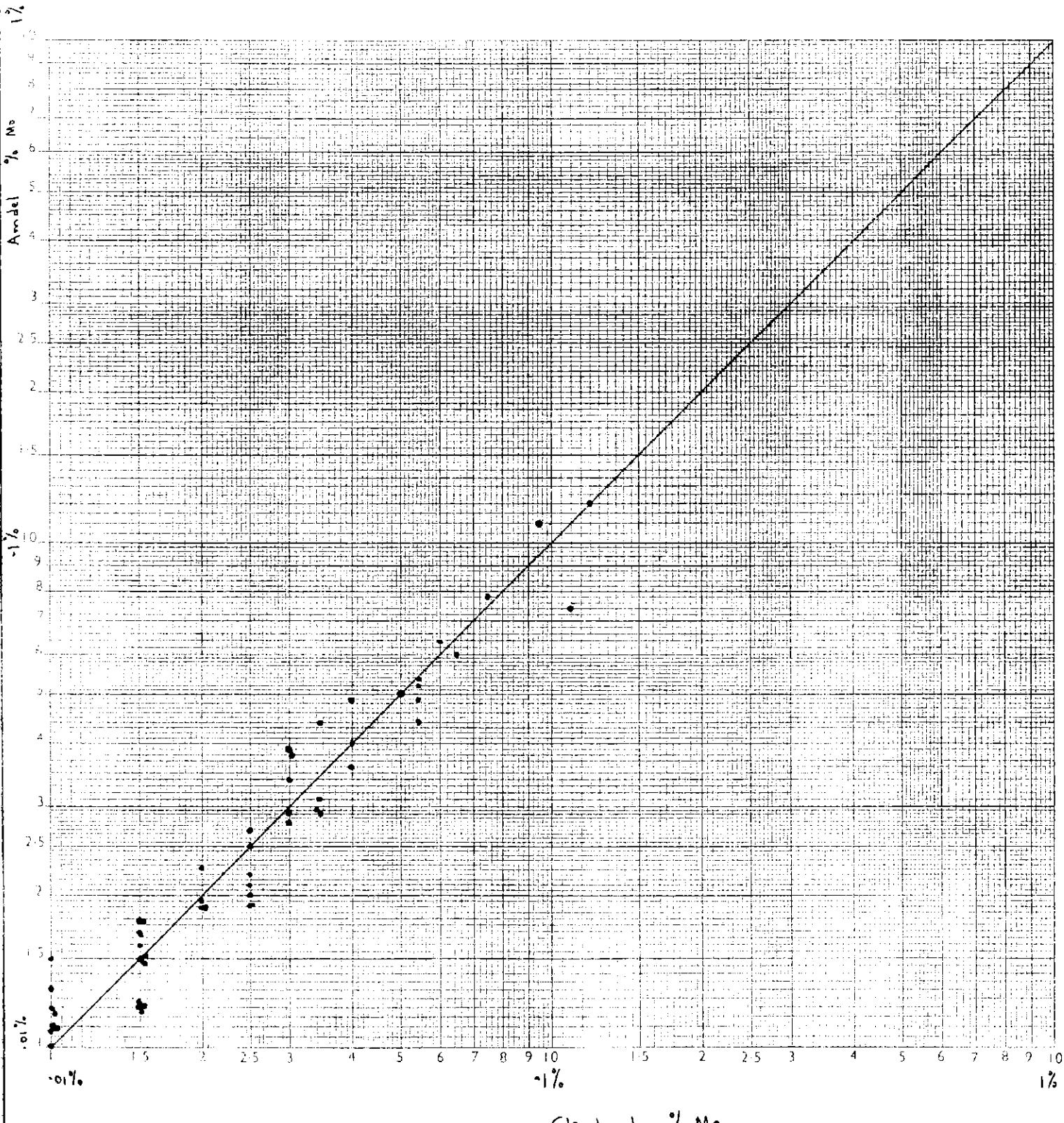
Mo

$\bar{x}_{Amdel}$ = 0.0250

$\bar{x}_{Cleveland}$ = 0.0258

} 3.1% d.f

r = 0.9831



203

GOPSON-CK GRAPH PAPERS : CHRISTCHURCH N.Z. E221Y Log-log 2 cycles x 2 cycles

72 205

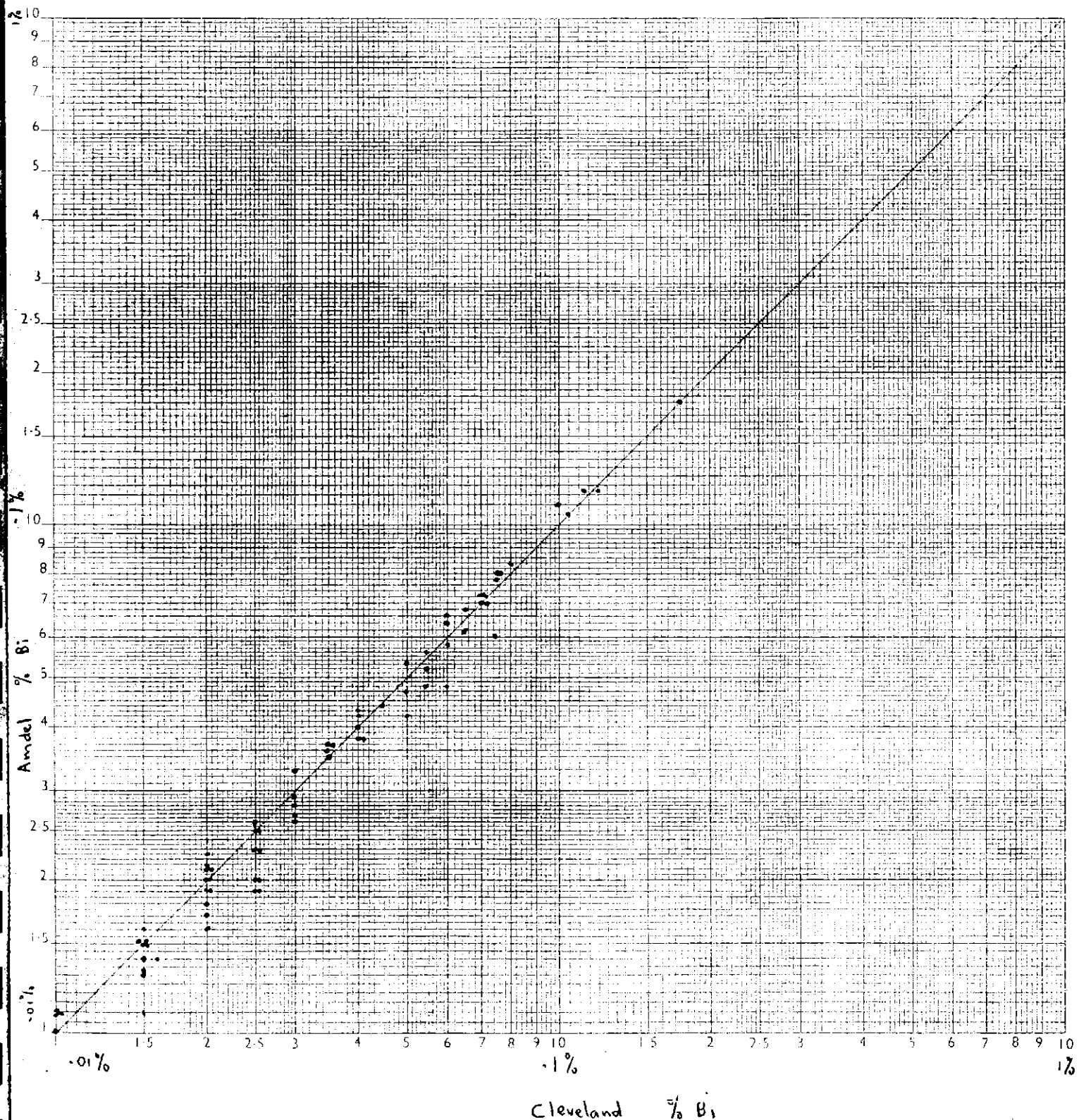
C1608 2-5m samples Bi

$\bar{x}_{AMDEL}$ = 0·03717

$\bar{x}_{CLEVELAND}$ = 0·03765

} 1·3% difference

r = 0·9943



GORMACK GRAPH PAPERS : CHRISTCHURCH N.Z. E221Y Log-log 2 cycles x 2 cycles

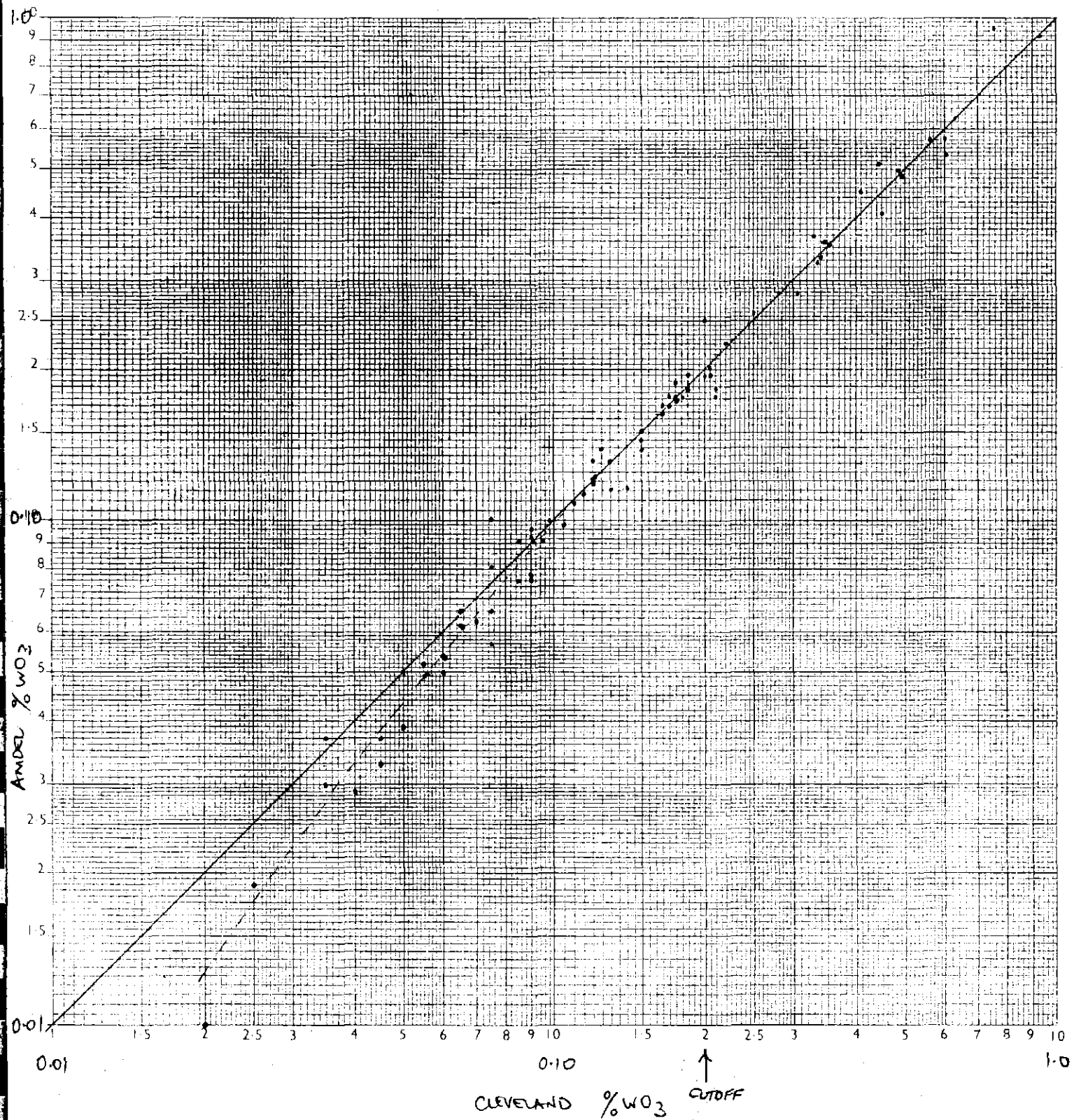
72 206

204

$\bar{x}_{AMDEL} = 0.1957$

$\bar{x}_{CLEVELAND} = 0.1964$ } 0.4% difference

C1608 2.5m samples. WO_3



Job No 4972/81. Semi-Quantitative Spectrographic Analysis Schemes A1, A2, A3, A4, A5, A7, A8 & A9

* A1 → A8

Results in ppm unless otherwise stated. Detection limits in brackets

	SAMPLE NO.	248911 Ankerite veins	248912 veins
A1	Ba (200)	x	x
	Be (1)	x	1
	Ce (300)	x	x
	Co (5)	5	x
	Cr (20)	20	40
	La (50)	x	x
	Mn (10)	1000	2500
	Mo (3)	100	250
	Nb (20)	x	x
	Ni (5)	60	20
	Sc (3)	x	6
	Sr (50)	50	x
	Ta (100)	x	x
	Th (100)	x	x
	Ti (100)	500	1500
	V (10)	10	30
	W (50)	1000	3000
	Y (10)	30	10
	Yb (1)	4	2
	Zr (10)	50	60
A2	Ag (0.1)	0.8	2.
	As (50)	400	1000
	Bi (1)	150	300
	Cd (3)	x	x
	Cu (1)	250	300
	Ga (1)	10	25
	Ge (1)	20	3
A2	In (10)	x	x
	Pb (1)	20	20
	Sb (30)	x	x
	Sn (1)	1500	600
	Zn (20)	60	200
A3	Au (3)	x	x
	P (100)	100	100
	Te (20)	x	x
	Tl (1)	1	6
A4	Li (1)	10	60
	Na (50)	x	250
A5	Cs (30)	x	x
	K (5)	400	3000
	Rb (10)	10	100
A8	B (3)	150	700
A9	Al (100)		
	Ca (100)		
	Fe (100)		
	Mg (100)		
	Si (100)		

— Rutile —

[redacted] Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined [redacted] appropriate quantitative analytical technique. X = not detected at limit [redacted]

JOB NO 4972/81. Semi-Quantitative Spectrographic Analysis Schemes A1,A2,A3,A4,A5,A7,A8 & A9 BATCH 111

* A1→A8 Results in ppm unless otherwise stated. Detection limits in brackets

	SAMPLE NO.	248911 FORMBY	248912 VEINS
A1	Ba (200)	x	x
	Be (1)	x	1
	Ce (300)	x	x
	Co (5)	5	x
	Cr (20)	20	40
	La (50)	x	x
	Mn (10)	1000	2500
	Mo (3)	100	250
	Nb (20)	x	x
	Ni (5)	60	20
	Sc (3)	x	6
	Sr (50)	50	x
	Ta (100)	x	x
	Th (100)	x	x
	Ti (100)	500	1500
	V (10)	10	30
	W (50)	1000	3000
	Y (10)	30	10
	Yb (1)	4	2
	Zr (10)	50	60
A2	Ag (0.1)	0.8	2.
	As (50)	400	1000
	Bi (1)	150	300
	Cd (3)	x	x
	Cu (1)	250	300
	Ga (1)	10	25
	Ge (1)	20	3

	SAMPLE NO.	248911 FORMBY	248912 VEINS
A2	In (10)	x	x
	Pb (1)	20	20
	Sb (30)	x	x
	Sn (1)	1500	600
	Zn (20)	60	200
A3	Au (3)	x	x
	P (100)	100	100
	Te (20)	x	x
	Tl (1)	1	6
A4	Li (1)	10	60
	Na (50)	x	250
A5	Cs (30)	x	x
	K (5)	400	3000
	Rb (10)	10	100
A8	B (3)	150	700
A9	Al (100)		
	Ca (100)		
	Fe (100)		
	Mg (100)		
	Si (100)		

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by appropriate analytical techniques. x = Not detected at limit quoted

72 208

209

Job No. 4412/81. Semi-quantitative spectrographic analysis [illegible]

* A1 → A8 Results in ppm unless otherwise stated. Detection limits in brackets

	SAMPLE NO.	248911 (Country rock)	248912 (Veins)
A1	Ba (200)	x	x
	Be (1)	x	1
	Ce (300)	x	x
	Co (5)	5	x
	Cr (20)	20	40
	La (50)	x	x
	Mn (10)	1000	2500
	Mo (3)	100	250
	Nb (20)	x	x
	Ni (5)	60	20
	Sc (3)	x	6
	Sr (50)	50	x
	Ta (100)	x	x
	Th (100)	x	x
	Ti (100)	500	1500 — Rutile —
	V (10)	10	30
	W (50)	1000	3000
	Y (10)	30	10
	Yb (1)	4	2
	Zr (10)	50	60
A2	Ag (0.1)	0.8	2.
	As (50)	400	1000
	Bi (1)	150	300
	Cd (3)	x	x
	Cu (1)	250	300
	Ga (1)	10	25
	Ge (1)	20	3
A2	In (10)	x	x
	Pb (1)	20	20
	Sb (30)	x	x
	Sn (1)	1500	600
	Zn (20)	60	200
A3	Au (3)	x	x
	P (100)	100	100
	Te (20)	x	x
	Tl (1)	1	6
A4	Li (1)	10	60
	Na (50)	x	250
A5	Cs (30)	x	x
	K (5)	400	3000
	Rb (10)	10	100
A8	B (3)	150	700
A9	Al (100)		
	Ca (100)		
	Fe (100)		
	Mg (100)		
	Si (100)		

Results are semi-quantitative. Elements apparently present in concentrations of economic interest should be redetermined by [redacted] appropriate [redacted] quantitative technique. X = Not detected at limit quoted

72 209

201

208

72 210 G McA

The Australian
Mineral Development
Laboratories

Flemington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

amdel

3/43/6/0 - AC 1251/83

22 September 1982

NATA CERTIFICATE

The Manager,
Cleveland Tin Limited,
LUNIA, Tasmania 7321

REPORT AC 1251/83

YOUR REFERENCE:	*Order No. 21837*
IDENTIFICATION:	*As listed*
DATE RECEIVED:	*19 August 1982*
NOTE:	*No sample list supplied. All samples received have been analysed.*

D. K. Rowley
Manager
Analytical Chemistry Division

D. K. Rowley

for Norton Jackson
Managing Director

cjw

Head Office:
Flemington Street, Frewville
South Australia 5063,
Telephone (08) 79 1662
Telex: Amdel AA82520
Pilot Plant:
Osman Place
Thebarton, S.A.
Telephone (08) 43 8053
Branch Laboratories:
Melbourne, Vic.
Telephone (03) 645 3093
Perth, W.A.
Telephone (09) 325 7311
Townsville
Queensland 4814
Telephone (077) 75 1377

This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

ANALYSIS
ppm

SAMPLE MARK	302-637	302-639	302-641	302-643	302-645	302-647	302-649	302-651
Ag Silver	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
As Arsenic	5	6	5	40	6	< 1	5	7
Cd Cadmium	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Ce Cerium	90	100	70	60	70	60	80	80
K Potassium	2.68%	2.60%	2.74%	2.18%	2.71%	2.20%	2.38%	2.22%
La Lanthanum	40	50	45	55	40	40	40	45
Mn Manganese	1000	1100	1300	1250	1200	1150	1200	1500
Nb Niobium	10	10	10	30	15	15	10	25
P Phosphorus	660	680	670	620	620	640	660	820
Pb Lead	7	< 5	< 5	10	< 5	5	5	30
Sb Antimony	< 15	< 15	< 15	15	< 15	< 15	< 15	< 15
Ta Tantalum	5	< 5	< 5	10	< 5	< 5	< 5	< 5
Ti Titanium	4100	4100	4000	3800	3800	4100	4200	4100
Zn Zinc	75	150	120	115	80	100	100	180
Zr Zirconium	190	230	180	160	160	140	190	200

Method: I3

ANALYSIS
ppm

SAMPLE MARK	302-653	302-655	302-657	302-659	302-661	302-663	302-665	302-667
Ag Silver	<1	<1	<1	<1	<1	<1	<1	<1
As Arsenic	4	8	15	80	60	5	4	<1
Cd Cadmium	<1	<1	<1	<1	<1	<1	<1	<1
Ce Cerium	70	90	90	80	80	60	70	90
K Potassium	1.42%	1.86%	2.02%	2.20%	1.16%	2.44%	1.87%	3.25%
La Lanthanum	40	45	50	40	50	45	35	40
Mn Manganese	1600	1000	1250	1450	1700	1450	1300	1200
Nb Niobium	25	20	20	15	25	25	25	15
P Phosphorus	800	620	640	640	510	500	510	610
Pb Lead	5	5	25	5	25	22	15	5
Sb Antimony	<15	<15	<15	<15	<15	<15	<15	<15
Ta Tantalum	<5	<5	<5	<5	<5	<5	<5	<5
Ti Titanium	3500	3600	3500	3800	3000	2900	2800	3800
Zn Zinc	140	110	140	110	150	120	140	120
Zr Zirconium	150	200	160	210	170	150	160	160

Method: I3

ANALYSIS
ppm

SAMPLE MARK	302-669	302-671	302-673	302-675	302-677	302-679	302-681	302-683
Ag Silver	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
As Arsenic	10	6	11	8	7	8	6	6
Cd Cadmium	< 1	< 1	< 1	< 1	< 1	1	< 1	< 1
Ce Cerium	80	70	90	60	100	80	90	70
K Potassium	3.19%	2.54%	2.95%	2.13%	2.71%	1.47%	2.01%	3.30%
La Lanthanum	45	45	40	35	50	45	55	45
Mn Manganese	1200	1300	1600	1150	1400	820	1000	1250
Nb Niobium	20	20	10	20	25	25	20	20
P Phosphorus	600	590	640	540	490	610	620	620
Pb Lead	10	10	5	15	5	5	5	7
Sb Antimony	< 15	< 15	< 15	< 15	< 15	< 15	< 15	< 15
Ta Tantalum	< 5	< 5	< 5	< 5	5	< 5	< 5	< 5
Ti Titanium	4200	3500	3700	2800	4200	3800	4000	4000
Zn Zinc	85	110	100	90	75	90	90	90
Zr Zirconium	130	170	190	140	110	220	160	180

Method: I3

ANALYSIS
ppm

SAMPLE MARK	302-685	302-687	302-689	302-691	302-693	302-695
Ag Silver	1	<1	2	<1	<1	1
As Arsenic	20	<1	35	6	6	<1
Cd Cadmium	<1	<1	1	<1	<1	<1
Ce Cerium	90	100	40	110	70	90
K Potassium	2.20%	1.34%	2.15%	3.85%	1.62%	1.83%
La Lanthanum	50	50	40	55	45	45
Mn Manganese	1350	1200	4400	2700	990	1200
Nb Niobium	25	20	10	20	15	15
P Phosphorus	610	530	550	430	740	610
Pb Lead	5	8	67	23	<5	23
Sb Antimony	<15	<15	<15	<15	<15	<15
Ta Tantalum	5	<5	<5	<5	<5	<5
Ti Titanium	3800	4000	1900	4400	3300	3800
Zn Zinc	120	85	290	170	75	100
Zr Zirconium	180	120	50	130	100	100

Method: I3

213

lemington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

NATA CERTIFICATE

30 April 1981

72 215

Mr G J McArthur
Cleveland Tin Limited
LUINA, TAS., 7321

REPORT AC 4972/81

YOUR REFERENCE: Order No 14668, Hammond/JW, Req. No. 08807 McArthur

IDENTIFICATION: As listed

DATE RECEIVED: 10 April 1981

ANALYSIS %

SAMPLE MARK	CALCIUM FLUORIDE CaF_2
248911	2.90
248912	4.65

METHOD: E3

D.K. Rowley
Manager
Analytical Chemistry Division

for Norton Jackson
Managing Director

dam

Pilot Plant: Osman Place
Thebarton S.A.
Telephone 43 8053
Branch Laboratory: Perth

This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

Appendix C.

APPENDIX C.

GEOSTATISTICS

FOLEY ZONE ORE RESOURCE.

32 - 31 Level — RL 845 to RL 865

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1805230	.070	.036	.210	.022	.024
.025	1805230	.070	.036	.210	.022	.024
.050	1805230	.070	.036	.210	.022	.024
.075	1802360	.070	.036	.210	.022	.024
.101	1785140	.071	.037	.211	.022	.024
.125	1699040	.072	.037	.216	.022	.023
.150	1523970	.072	.037	.224	.022	.023
.175	1139390	.074	.038	.245	.022	.021
.200	815080	.069	.039	.269	.022	.020
.225	617050	.064	.039	.287	.022	.020
.250	462070	.062	.039	.304	.022	.019
.275	318570	.052	.037	.323	.022	.018
.300	235340	.046	.036	.335	.022	.018
.325	134890	.039	.035	.354	.021	.016
.350	74620	.032	.032	.368	.020	.014
.375	20090	.024	.027	.389	.020	.011
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

31 - 30 Level RL 865 to RL 885

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.054	.037	.213	.022	.022
.025	1808100	.054	.037	.213	.022	.022
.050	1808100	.054	.037	.213	.022	.022
.075	1805230	.054	.037	.214	.022	.022
.101	1765050	.055	.037	.216	.022	.022
.125	1644510	.056	.037	.224	.022	.022
.150	1357510	.060	.039	.242	.022	.020
.175	1056160	.068	.041	.265	.021	.019
.200	832300	.068	.042	.285	.020	.018
.225	645750	.066	.043	.306	.020	.019
.250	536690	.063	.043	.320	.021	.019
.275	419020	.059	.043	.336	.021	.019
.300	318570	.058	.043	.351	.021	.018
.325	220990	.053	.042	.368	.021	.018
.350	149240	.047	.039	.381	.023	.018
.375	80360	.045	.039	.399	.023	.017
.400	31570	.038	.031	.422	.025	.015
.425	11480	.045	.036	.438	.025	.018
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

30 - 29 Level RL 885 to RL 905

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.037	.030	.200	.024	.022
.025	1808100	.037	.030	.200	.024	.022
.050	1808100	.037	.030	.200	.024	.022
.075	1782270	.037	.031	.202	.024	.022
.101	1670340	.038	.032	.209	.024	.022
.125	1389080	.040	.034	.228	.023	.021
.150	1104950	.043	.034	.252	.022	.020
.175	872480	.046	.034	.275	.022	.018
.200	726110	.049	.035	.293	.021	.018
.225	596960	.051	.035	.311	.021	.018
.250	487900	.052	.036	.328	.021	.018
.275	387450	.053	.037	.345	.021	.019
.300	298480	.053	.036	.363	.021	.018
.325	218120	.051	.034	.381	.022	.017
.350	166460	.049	.034	.395	.022	.017
.375	111930	.047	.031	.410	.022	.017
.400	60270	.049	.031	.431	.022	.014
.425	25830	.045	.029	.453	.022	.012
.450	14350	.043	.026	.462	.021	.006
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

29 - 28 Level RL 905 to RL 925

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.026	.021	.174	.027	.021
.025	1808100	.026	.021	.174	.027	.021
.050	1808100	.026	.021	.174	.027	.021
.075	1747830	.027	.021	.177	.027	.021
.101	1426390	.029	.023	.197	.026	.022
.125	1110690	.032	.025	.221	.026	.021
.150	872480	.035	.025	.244	.025	.020
.175	694540	.037	.026	.265	.024	.019
.200	565390	.040	.027	.283	.023	.018
.225	430500	.043	.029	.305	.022	.017
.250	341530	.045	.029	.323	.022	.017
.275	255430	.047	.030	.343	.021	.017
.300	177940	.049	.030	.368	.021	.016
.325	137760	.051	.031	.383	.021	.017
.350	111930	.053	.032	.394	.020	.016
.375	66010	.056	.031	.415	.020	.016
.400	40180	.053	.029	.433	.020	.014
.425	25830	.056	.030	.443	.018	.013
.450	8610	.059	.029	.462	.019	.011
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

28 - 27 Level RL 925 to RL 945

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.021	.016	.148	.027	.022
.025	1808100	.021	.016	.148	.027	.022
.050	1802360	.021	.016	.148	.027	.022
.075	1589980	.022	.017	.159	.027	.022
.101	1170960	.025	.018	.185	.028	.023
.125	869610	.026	.020	.210	.028	.022
.150	674450	.027	.022	.231	.027	.021
.175	490770	.031	.024	.257	.026	.021
.200	384580	.033	.026	.277	.026	.020
.225	289870	.034	.029	.297	.025	.020
.250	232470	.035	.030	.313	.024	.020
.275	163590	.035	.031	.334	.024	.020
.300	117670	.038	.033	.353	.024	.021
.325	86100	.040	.033	.368	.025	.022
.350	51660	.044	.034	.389	.024	.022
.375	37310	.044	.036	.400	.025	.024
.400	11480	.055	.036	.425	.025	.024
.425	5740	.070	.033	.449	.023	.021
.450	2870	.089	.037	.470	.024	.022
.500	0	0	0	0	0	0

220

FOLEY ZONE ORE RESOURCE.

27 - 26 Level RL 945 to RL 965

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.020	.014	.132	.028	.023
.025	1808100	.020	.014	.132	.028	.023
.050	1793750	.020	.014	.132	.028	.023
.075	1432130	.022	.015	.149	.028	.024
.101	1007370	.022	.016	.175	.030	.024
.125	746200	.023	.017	.198	.030	.024
.150	542430	.024	.018	.221	.030	.024
.175	396060	.026	.020	.243	.029	.024
.200	295610	.027	.021	.261	.029	.024
.225	212380	.027	.023	.280	.029	.024
.250	149240	.027	.024	.298	.029	.024
.275	97580	.028	.026	.319	.030	.025
.300	71750	.029	.027	.330	.031	.026
.325	34440	.035	.030	.354	.033	.030
.350	17220	.032	.030	.373	.033	.033
.375	8610	.032	.032	.387	.030	.032
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

221

FOLEY ZONE ORE RESOURCE.

26 - 25 Level RL 965 to RL 985

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.024	.015	.117	.029	.024
.025	1808100	.024	.015	.117	.029	.024
.050	1776530	.024	.015	.119	.029	.024
.075	1357510	.025	.016	.136	.032	.025
.101	961450	.028	.017	.156	.033	.027
.125	677320	.029	.017	.174	.035	.026
.150	433370	.034	.018	.195	.036	.027
.175	243950	.039	.020	.221	.039	.026
.200	137760	.040	.021	.246	.043	.023
.225	80360	.040	.022	.271	.047	.023
.250	57400	.042	.022	.283	.049	.023
.275	34440	.040	.022	.296	.048	.023
.300	11480	.038	.023	.308	.047	.026
.325	0	0	0	0	0	0
.350	0	0	0	0	0	0
.375	0	0	0	0	0	0
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

25 - 24 Level RL 985 to RL 1005

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.026	.016	.109	.029	.025
.025	1808100	.026	.016	.109	.029	.025
.050	1753570	.026	.016	.111	.030	.025
.075	1383340	.028	.017	.125	.032	.027
.101	947100	.031	.018	.142	.034	.029
.125	599830	.034	.017	.159	.036	.029
.150	335790	.039	.019	.177	.039	.030
.175	126280	.046	.022	.200	.045	.032
.200	45920	.050	.021	.223	.049	.032
.225	20090	.059	.024	.237	.058	.023
.250	2870	.050	.019	.252	.063	.019
.275	0	0	0	0	0	0
.300	0	0	0	0	0	0
.325	0	0	0	0	0	0
.350	0	0	0	0	0	0
.375	0	0	0	0	0	0
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

223

72 226

FOLEY ZONE ORE RESOURCE.

24 - 23 Level RL 1005 to RL 1025

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.025	.016	.105	.027	.024
.025	1808100	.025	.016	.105	.027	.024
.050	1776530	.025	.016	.106	.027	.024
.075	1412040	.026	.016	.117	.029	.025
.101	898310	.027	.016	.135	.031	.026
.125	562520	.027	.015	.148	.032	.026
.150	238210	.027	.014	.165	.033	.023
.175	31570	.024	.014	.184	.037	.018
.200	0	0	0	0	0	0
.225	0	0	0	0	0	0
.250	0	0	0	0	0	0
.275	0	0	0	0	0	0
.300	0	0	0	0	0	0
.325	0	0	0	0	0	0
.350	0	0	0	0	0	0
.375	0	0	0	0	0	0
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

FOLEY ZONE ORE RESOURCE.

23 - 22 Level RL 1025 to RL 1045

CUTOFF	TONNEAGE	% SnT	% Cu	% Wo3	% MoS2	% Bi
0.000	1808100	.024	.016	.101	.024	.022
.025	1808100	.024	.016	.101	.024	.022
.050	1805230	.024	.016	.101	.024	.022
.075	1437870	.024	.015	.111	.025	.022
.101	809340	.023	.014	.129	.025	.023
.125	453460	.022	.013	.143	.027	.022
.150	126280	.021	.012	.159	.028	.019
.175	0	0	0	0	0	0
.200	0	0	0	0	0	0
.225	0	0	0	0	0	0
.250	0	0	0	0	0	0
.275	0	0	0	0	0	0
.300	0	0	0	0	0	0
.325	0	0	0	0	0	0
.350	0	0	0	0	0	0
.375	0	0	0	0	0	0
.400	0	0	0	0	0	0
.425	0	0	0	0	0	0
.450	0	0	0	0	0	0
.500	0	0	0	0	0	0

```
**********************************************************************
 SEARCH DIRECTION No.   1
      Azimuth =    0.0
 Inclination =    0.0                          Mine = FD      Element = WO
      Window = 180.0
**********************************************************************


==========================================================================
 BLOCK    4725. -    5125.N    4760. -    5160.E     700. -    1100.RL
==========================================================================

   SAMPLES WITHIN BLOCK              |    SAMPLES WITHIN BLOCK & SEARCH CONE
     No.of Samples =        544     |          No.of Samples =       572.
  Arithmetic Mean =        .1619    |       Arithmetic Mean =        .1602
  Actual Variance =        .0156    |       Actual Variance =        .0152  Sill
Relative Variance =        .5952    |     Relative Variance =        .5923  Sill

        DISTANCE          NO.     AVER.          VARIOGRAM
   FROM     TO     AVER.  PAIRS   GRADE       ACTUAL     RELATIVE

    0.0    10.0     9.1   308.     .1529        .0042      .1797
   10.0    20.0    15.1  1068.     .1762        .0081      .2609
   20.0    30.0    25.2  1810.     .1915        .0103      .2809
   30.0    40.0    35.4  3137.     .1977        .0130      .3326
   40.0    50.0    45.3  5030.     .1950        .0147      .3866
   50.0    60.0    55.1  6689.     .1912        .0162      .4431
   60.0    70.0    65.0  7275.     .1884        .0170      .4789
   70.0    80.0    75.2  8236.     .1865        .0168      .4830
   80.0    90.0    85.0  9645.     .1779        .0177      .5593
   90.0   100.0    95.0  9743.     .1718        .0167      .5658
  100.0   110.0   105.0  9239.     .1701        .0172      .5945
  110.0   120.0   115.1  9079.     .1682        .0176      .6221
  120.0   130.0   125.0  9532.     .1634        .0172      .6442
  130.0   140.0   134.9  8729.     .1610        .0176      .6790
  140.0   150.0   145.0  8147.     .1556        .0170      .7021
  150.0   160.0   154.9  7481.     .1546        .0168      .7029
  160.0   170.0   164.9  6801.     .1507        .0170      .7486
  170.0   180.0   175.0  6323.     .1445        .0157      .7019
  180.0   190.0   185.0  5661.     .1413        .0148      .7413
  190.0   200.0   195.0  4969.     .1375        .0142      .7511

 REGRESSION LINE FIT FOR [ ACTUAL ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS    1 TO    5
 NUGGET (C0) =      .0036     SLOPE/100 =      .0253     C0/SLOPE =      .1445
 Predicted GAMMA at    25.0 Distance is      .0100

 REGRESSION LINE FIT FOR [ RELATIVE ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS    1 TO    5
 NUGGET (C0) =      .1648     SLOPE/100 =      .4858     C0/SLOPE =      .3392
 Predicted GAMMA at    25.0 Distance is      .2862
```

VARIOGRAM MODEL - MINE - FO ELEMENT - RL BLOCK 4725.N 4760.E 700.RL 2:05 PM WED
SEARCH DIRECTION No. 1 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 0.0 C0 = .1594
INCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 180.0 X is < 30 PAIRS RELATIVE VARIOGRAM

ISOTROPIC

80

Sill

Distance

SEARCH DIRECTION No. 1
Azimuth = 0.0
Inclination = 0.0 Mine - FD Element - Bi
Window = 180.0

BLOCK 4725. - 5125.N 4760. - 5160.E 700. - 1100.RL

SAMPLES WITHIN BLOCK		SAMPLES WITHIN BLOCK & SEARCH CONE	
No.of Samples =	544	No.of Samples =	572.
Arithmetic Mean =	.0252	Arithmetic Mean =	.0251
Actual Variance =	.0004	Actual Variance =	.0004 Sill
Relative Variance =	.6299	Relative Variance =	.6349 Sill

DISTANCE FROM	DISTANCE TO	AVER.	NO. PAIRS	AVER. GRADE	VARIOGRAM ACTUAL	VARIOGRAM RELATIVE
0.0	10.0	9.1	308.	.0234	.0001	.1826
10.0	20.0	15.1	1068.	.0248	.0002	.3252
20.0	30.0	25.2	1810.	.0239	.0002	.3501
30.0	40.0	35.4	3137.	.0241	.0003	.5165
40.0	50.0	45.3	5080.	.0237	.0003	.5341
50.0	60.0	55.1	6689.	.0241	.0003	.5165
60.0	70.0	65.0	7275.	.0240	.0003	.5208
70.0	80.0	75.2	8236.	.0244	.0003	.5039
80.0	90.0	85.0	9645.	.0242	.0004	.6830
90.0	100.0	95.0	9743.	.0246	.0004	.6610
100.0	110.0	105.0	9239.	.0245	.0004	.6664
110.0	120.0	115.1	9079.	.0249	.0004	.6452
120.0	130.0	125.0	9532.	.0253	.0004	.6249
130.0	140.0	134.9	8729.	.0258	.0004	.6009
140.0	150.0	145.0	8147.	.0259	.0004	.5963
150.0	160.0	154.9	7481.	.0265	.0004	.5696
160.0	170.0	164.9	6801.	.0266	.0004	.5653
170.0	180.0	175.0	6373.	.0268	.0004	.5569
180.0	190.0	185.0	5661.	.0271	.0004	.5447
190.0	200.0	195.0	4969.	.0268	.0004	.5569

REGRESSION LINE FIT FOR [ACTUAL] VARIOGRAM
LEAST SQUARES REGRESSION ON POINTS 1 TO 5
NUGGET (C0) = .0001 SLOPE/100 = .0005 C0/SLOPE = .2173
Predicted GAMMA at 25.0 Distance is .0002

REGRESSION LINE FIT FOR [RELATIVE] VARIOGRAM
LEAST SQUARES REGRESSION ON POINTS 1 TO 5
NUGGET (C0) = .1594 SLOPE/100 = .8758 C0/SLOPE = .1820
Predicted GAMMA at 25.0 Distance is .3784

```
**********************************************************************
 SEARCH DIRECTION No.  1
     Azimuth =   0.0
 Inclination =   0.0                          Mine - FO     Element - Mo
      Window = 180.0
**********************************************************************


======================================================================
 BLOCK   4725. -   5125.N   4760. -   5160.E    700. -   1100.RL
======================================================================

   SAMPLES WITHIN BLOCK              |    SAMPLES WITHIN BLOCK & SEARCH CONE
     No.of Samples =        544      |          No.of Samples =       572.
  Arithmetic Mean =        .0251     |       Arithmetic Mean =        .0252
   Actual Variance =       .0005     |        Actual Variance =       .0005  Sill
Relative Variance =        .7936     |     Relative Variance =        .7874  Sill

      DISTANCE          NO.    AVER.          VARIOGRAM
   FROM     TO    AVER.  PAIRS  GRADE      ACTUAL     RELATIVE

    0.0   10.0    9.1    308.   .0273        .0005      .6709
   10.0   20.0   15.1   1068.   .0283        .0004      .4994
   20.0   30.0   25.2   1810.   .0291        .0005      .5905
   30.0   40.0   35.4   3137.   .0283        .0005      .6243
   40.0   50.0   45.3   5080.   .0286        .0005      .6113
   50.0   60.0   55.1   6689.   .0284        .0005      .6199
   60.0   70.0   65.0   7275.   .0277        .0005      .6516
   70.0   80.0   75.2   8236.   .0272        .0005      .6758
   80.0   90.0   85.0   9645.   .0263        .0005      .7229
   90.0  100.0   95.0   9743.   .0260        .0005      .7396
  100.0  110.0  105.0   9239.   .0254        .0005      .7750
  110.0  120.0  115.1   9079.   .0252        .0005      .7874
  120.0  130.0  125.0   9532.   .0249        .0005      .8064
  130.0  140.0  134.9   8729.   .0249        .0005      .8064
  140.0  150.0  145.0   8147.   .0247        .0005      .8196
  150.0  160.0  154.9   7481.   .0243        .0005      .8468
  160.0  170.0  164.9   6801.   .0245        .0005      .8330
  170.0  180.0  175.0   6373.   .0242        .0005      .8539
  180.0  190.0  185.0   5661.   .0241        .0005      .8609
  190.0  200.0  195.0   4969.   .0232        .0005      .9290

 REGRESSION LINE FIT FOR [ ACTUAL ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =      .0004    SLOPE/100 =      .0002     C0/SLOPE =     2.4406
 Predicted GAMMA at   25.0 Distance is      .0005

 REGRESSION LINE FIT FOR [ RELATIVE ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =      .5499    SLOPE/100 =      .1483     C0/SLOPE =     3.7077
 Predicted GAMMA at   25.0 Distance is      .5870
```

VARIOGRAM MODEL - MINE - FO ELEMENT - MG BLOCK 4725.N 4760.E 700.RL 1:59 PM WED., 27
SEARCH DIRECTION No. 1 -- -- LIMIT 5135.N 5160.E 1100.RL
AZIMUTH = 0.0 CO = .5499
INCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 180.0 X is < 30 PAIRS R E L A T I V E V A R I O G R A M

ISOTROPIC

GAMMA

.157E+01 :
.154E+01 :
.151E+01 :
.148E+01 :
.145E+01 :
.142E+01 :
.139E+01 :
.135E+01 :
.132E+01 :
.129E+01 :
.126E+01 :
.123E+01 :
.120E+01 :
.117E+01 :
.113E+01 :
.110E+01 :
.107E+01 :
.104E+01 :
.101E+01 :
.976E+00 :
.945E+00 :
.913E+00 :
.882E+00 :
.850E+00 :
.819E+00 :
Sill .787E+00 :
.756E+00 :
.724E+00 :
.693E+00 :
.661E+00 :
.630E+00 :
.598E+00 :
.567E+00 :
.535E+00 :
.504E+00 :
.472E+00 :
.441E+00 :
.409E+00 :
.378E+00 :
.346E+00 :
.315E+00 :
.283E+00 :
.252E+00 :
.220E+00 :
.189E+00 :
.157E+00 :
.126E+00 :
.945E-01 :
.630E-01 :
.315E-01 :
.000E+00 :

0 20 40 60 80 100 120 140 160 180 200
Distance

****

SEARCH DIRECTION No. 1
Azimuth = 0.0
Inclination = 0.0 Mine - FO Element - Mo
Window = 180.0

****

BLOCK 4725. - 5125.N 4760. - 5160.E 700. - 1100.RL

SAMPLES WITHIN BLOCK		SAMPLES WITHIN BLOCK & SEARCH CONE		
No.of Samples =	544	No.of Samples =	572.	
Arithmetic Mean =	.0251	Arithmetic Mean =	.0252	
Actual Variance =	.0005	Actual Variance =	.0005	Sill
Relative Variance =	.7936	Relative Variance =	.7874	Sill

DISTANCE FROM	DISTANCE TO	DISTANCE AVER.	NO. PAIRS	AVER. GRADE	VARIOGRAM ACTUAL	VARIOGRAM RELATIVE
0.0	10.0	9.1	308.	.0273	.0005	.6709
10.0	20.0	15.1	1068.	.0283	.0004	.4994
20.0	30.0	25.2	1810.	.0291	.0005	.5905
30.0	40.0	35.4	3137.	.0283	.0005	.6243
40.0	50.0	45.3	5080.	.0286	.0005	.6113
50.0	60.0	55.1	6689.	.0284	.0005	.6199
60.0	70.0	65.0	7275.	.0277	.0005	.6516
70.0	80.0	75.2	8236.	.0272	.0005	.6758
80.0	90.0	85.0	9645.	.0263	.0005	.7229
90.0	100.0	95.0	9743.	.0260	.0005	.7396
100.0	110.0	105.0	9239.	.0254	.0005	.7750
110.0	120.0	115.1	9079.	.0252	.0005	.7874
120.0	130.0	125.0	9532.	.0249	.0005	.8064
130.0	140.0	134.9	8729.	.0249	.0005	.8064
140.0	150.0	145.0	8147.	.0247	.0005	.8196
150.0	160.0	154.9	7481.	.0243	.0005	.8468
160.0	170.0	164.9	6801.	.0245	.0005	.8330
170.0	180.0	175.0	6373.	.0242	.0005	.8538
180.0	190.0	185.0	5661.	.0241	.0005	.8609
190.0	200.0	195.0	4969.	.0232	.0005	.9290

REGRESSION LINE FIT FOR [ACTUAL] VARIOGRAM
LEAST SQUARES REGRESSION ON POINTS 1 TO 5
NUGGET (C0) = .0004 SLOPE/100 = .0002 C0/SLOPE = 2.4406
Predicted GAMMA at 25.0 Distance is .0005

REGRESSION LINE FIT FOR [RELATIVE] VARIOGRAM
LEAST SQUARES REGRESSION ON POINTS 1 TO 5
NUGGET (C0) = .5499 SLOPE/100 = .1483 C0/SLOPE = 3.7077
Predicted GAMMA at 25.0 Distance is .5870

VARIOGRAM MODEL - MINE - FD ELEMENT - Cu BLOCK 4725.N 4760.E 700.RL 1:50 PM WED..
SEARCH DIRECTION No. 1 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 0.0 C0 = 1.6553
INCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 180.0 X is < 30 PAIRS R E L A T I V E V A R I O G R A M

Isotropic

.530E+01
.519E+01
.508E+01
.498E+01
.487E+01
.477E+01
.466E+01
.455E+01
.445E+01
.434E+01
.424E+01
.413E+01
.403E+01
.392E+01
.381E+01
.371E+01
.360E+01
.350E+01
.339E+01
.328E+01
.318E+01
.307E+01
.297E+01
.286E+01
.275E+01
Sill .265E+01
.254E+01
.244E+01
.233E+01
.222E+01
.212E+01
.201E+01
.191E+01
.180E+01
.169E+01
.159E+01
.148E+01
.138E+01
.127E+01
.117E+01
.106E+01
.953E+00
.847E+00
.741E+00
.636E+00
.530E+00
.424E+00
.318E+00
.212E+00
.106E+00
.000E+00

100

Range

0 20 40 60 80 100 120 140 160 180
Distance

72 234

131

```
**********************************************************************
 SEARCH DIRECTION No.  1
     Azimuth =    0.0
 Inclination =    0.0                        Mine - FO     Element - Cu
      Window = 180.0
**********************************************************************


 BLOCK    4725. -    5125.N    4760. -    5160.E     700. -    1100.RL
```

SAMPLES WITHIN BLOCK		SAMPLES WITHIN BLOCK & SEARCH CONE	
No.of Samples =	544	No.of Samples =	572.
Arithmetic Mean =	.0243	Arithmetic Mean =	.0238
Actual Variance =	.0016	Actual Variance =	.0015 Sill
Relative Variance =	2.7096	Relative Variance =	2.6481 Sill

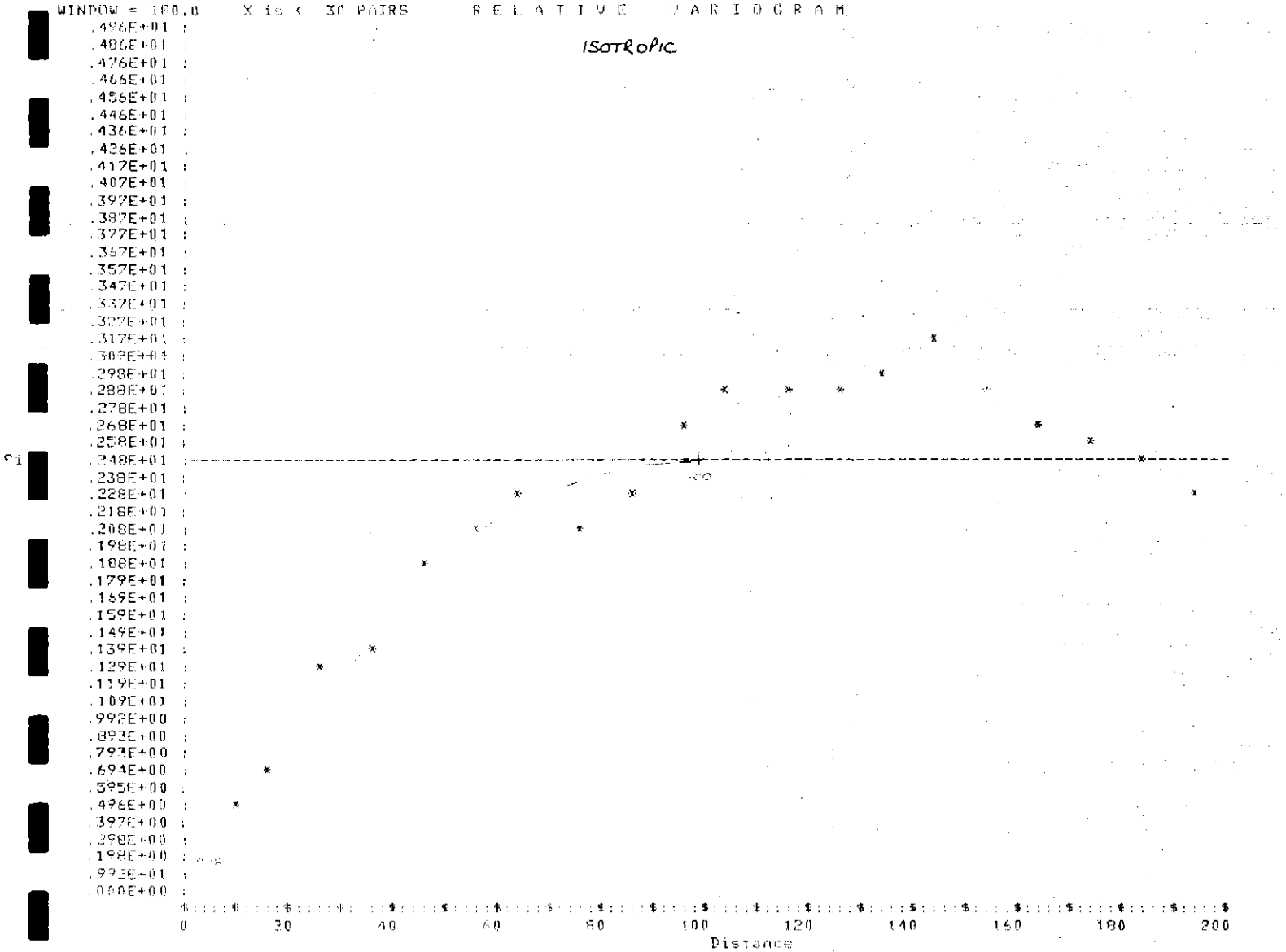
DISTANCE FROM	DISTANCE TO	AVER.	NO. PAIRS	AVER. GRADE	VARIOGRAM ACTUAL	VARIOGRAM RELATIVE
0.0	10.0	9.1	308.	.0215	.0011	2.1633
10.0	20.0	15.1	1068.	.0222	.0008	1.6232
20.0	30.0	25.2	1810.	.0226	.0011	1.9579
30.0	40.0	35.4	3137.	.0238	.0014	2.4716
40.0	50.0	45.3	5080.	.0231	.0012	2.2488
50.0	60.0	55.1	6689.	.0238	.0013	2.2950
60.0	70.0	65.0	7275.	.0243	.0014	2.3709
70.0	80.0	75.2	8236.	.0240	.0013	2.2569
80.0	90.0	85.0	9645.	.0229	.0011	2.0976
90.0	100.0	95.0	9743.	.0244	.0016	2.6875
100.0	110.0	105.0	9239.	.0253	.0017	2.6559
110.0	120.0	115.1	9079.	.0256	.0018	2.7466
120.0	130.0	125.0	9532.	.0250	.0016	2.5600
130.0	140.0	134.9	8729.	.0251	.0018	2.8571
140.0	150.0	145.0	8147.	.0254	.0019	2.9450
150.0	160.0	154.9	7481.	.0254	.0020	3.1000
160.0	170.0	164.9	6801.	.0255	.0022	3.3833
170.0	180.0	175.0	6373.	.0249	.0022	3.5483
180.0	190.0	185.0	5661.	.0244	.0019	3.1913
190.0	200.0	195.0	4969.	.0239	.0016	2.8011

```
 REGRESSION LINE FIT FOR [ ACTUAL ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =      .0008    SLOPE/100 =      .0012     C0/SLOPE =      .6220
 Predicted GAMMA at   25.0 Distance is      .0011

 REGRESSION LINE FIT FOR [ RELATIVE ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =    1.6553    SLOPE/100 =    1.5395     C0/SLOPE =    1.0752
 Predicted GAMMA at   25.0 Distance is    2.0402
```

AR GRAM MODEL - MINE - FO ELEMENT - SN BLOCK 4725.N 4760.E 700.RL 1:20 PM WED., 27 APR
EA H DIRECTION No. 1 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 0.0 C0 = .1772
NCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 100.0 X is < 30 PAIRS RELATIVE VARIOGRAM

ISOTROPIC



```
**********************************************************************
 SEARCH DIRECTION No.  1
     Azimuth =   0.0
 Inclination =   0.0                        Mine - FD     Element - SN
      Window = 180.0
**********************************************************************


======================================================================
 BLOCK   4725. -   5125.N   4760. -   5160.E    700. -   1100.RL
======================================================================

   SAMPLES WITHIN BLOCK          |    SAMPLES WITHIN BLOCK & SEARCH CONE
     No.of Samples =      544    |      No.of Samples =      572.
  Arithmetic Mean =      .0335    |   Arithmetic Mean =      .0330
  Actual Variance =      .0028    |   Actual Variance =      .0027  Sill
Relative Variance =     2.4950    | Relative Variance =     2.4793  Sill

        DISTANCE          NO.    AVER.          VARIOGRAM
   FROM     TO    AVER.  PAIRS   GRADE      ACTUAL    RELATIVE

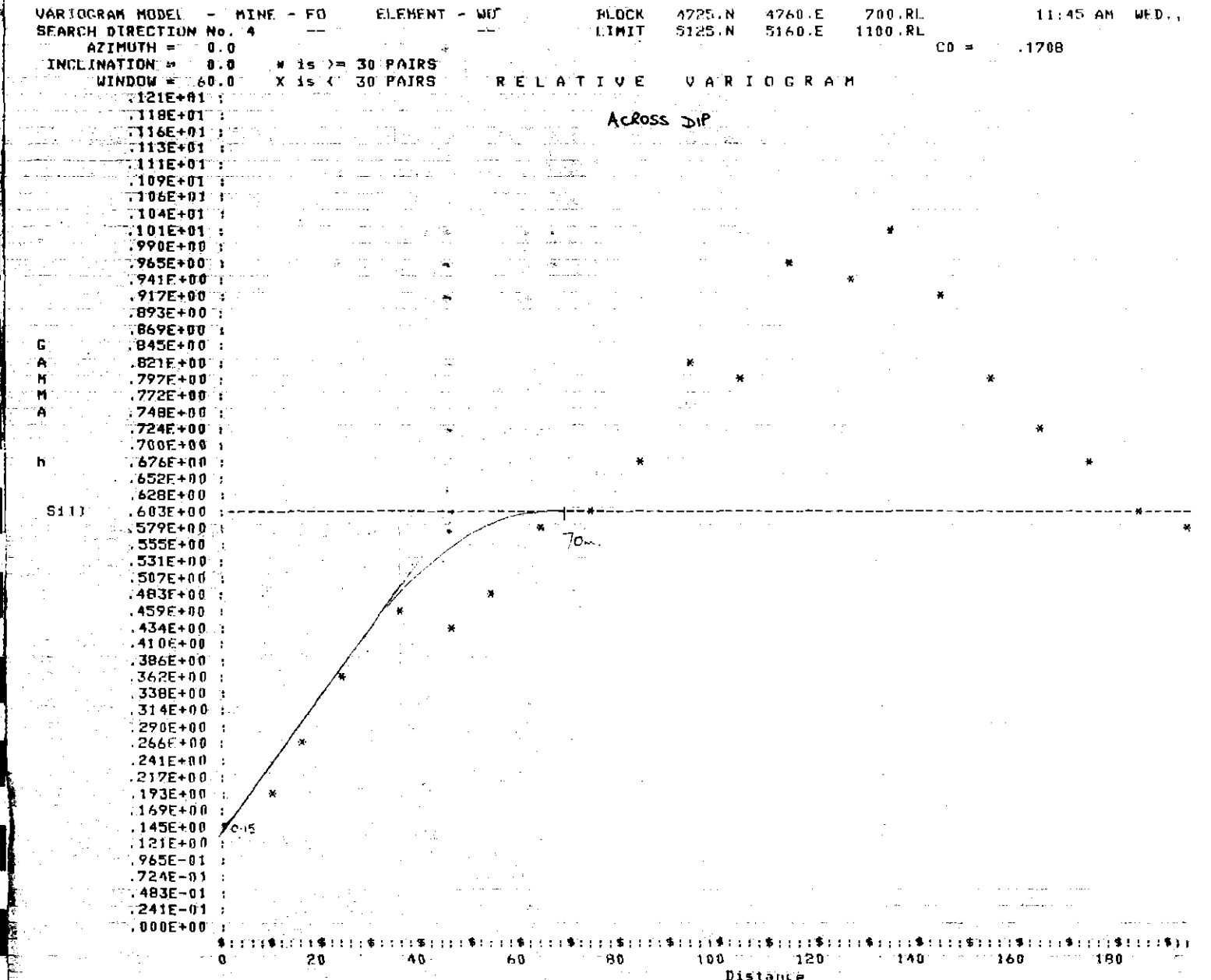
    0.0    10.0     9.1    308.    .0259       .0003      .4472
   10.0    20.0    15.1   1068.    .0296       .0006      .6848
   20.0    30.0    25.2   1810.    .0313       .0013     1.3270
   30.0    40.0    35.4   3137.    .0315       .0014     1.4109
   40.0    50.0    45.3   5080.    .0318       .0019     1.8789
   50.0    60.0    55.1   6689.    .0329       .0023     2.1249
   60.0    70.0    65.0   7275.    .0333       .0025     2.2545
   70.0    80.0    75.2   8236.    .0335       .0023     2.0495
   80.0    90.0    85.0   9645.    .0332       .0025     2.2681
   90.0   100.0    95.0   9743.    .0350       .0033     2.6939
  100.0   110.0   105.0   9239.    .0374       .0040     2.8597
  110.0   120.0   115.1   9079.    .0376       .0041     2.9001
  120.0   130.0   125.0   9532.    .0371       .0040     2.9061
  130.0   140.0   134.9   8729.    .0361       .0039     2.9926
  140.0   150.0   145.0   8147.    .0357       .0040     3.1385
  150.0   160.0   154.9   7481.    .0345       .0034     2.8565
  160.0   170.0   164.9   6801.    .0333       .0030     2.7054
  170.0   180.0   175.0   6373.    .0323       .0027     2.5880
  180.0   190.0   185.0   5661.    .0319       .0025     2.4567
  190.0   200.0   195.0   4969.    .0315       .0023     2.3180

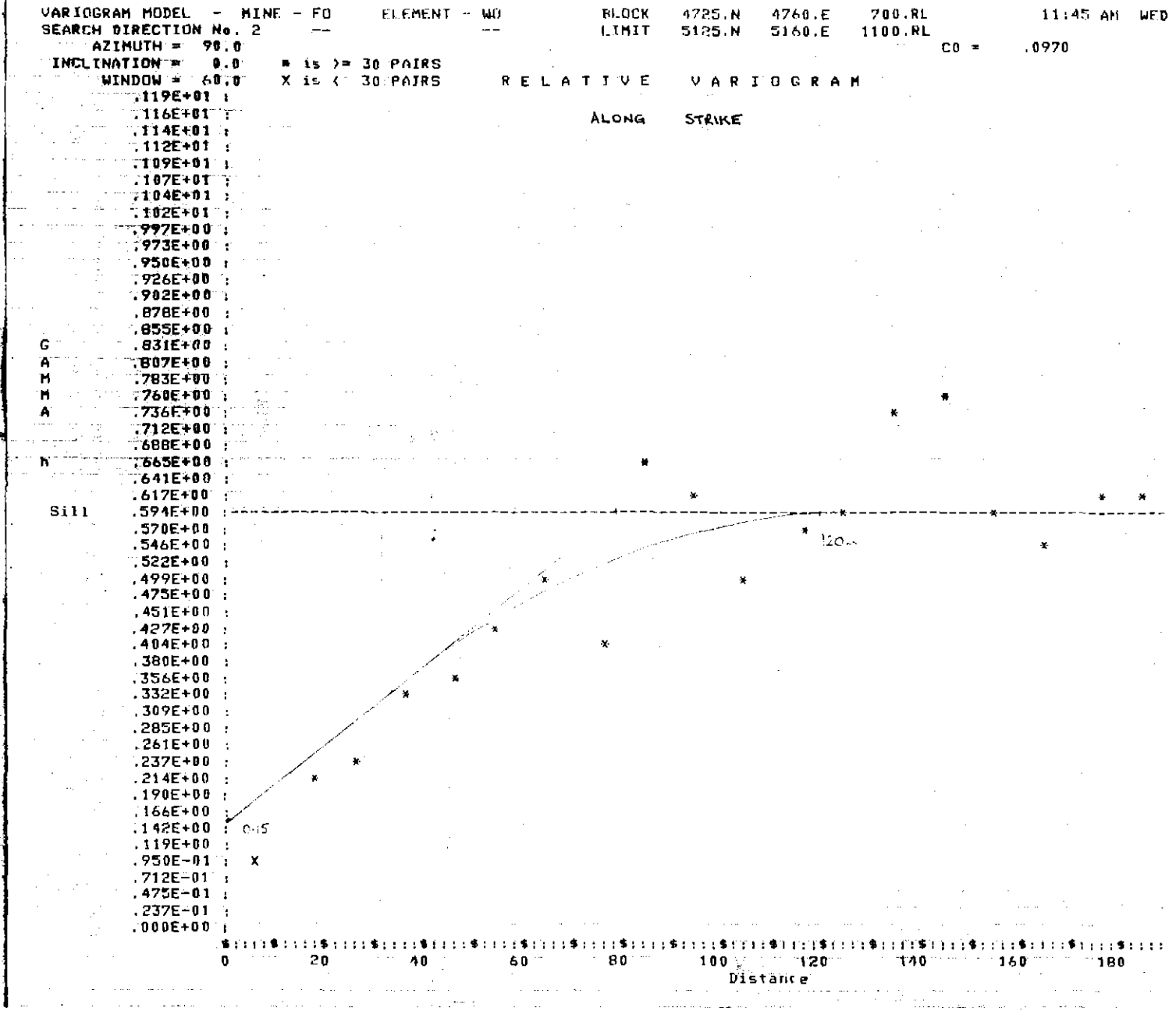
 REGRESSION LINE FIT FOR [ ACTUAL ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =      .0000    SLOPE/100 =      .0041     C0/SLOPE =      .0071
 Predicted GAMMA at   25.0 Distance is      .0011

 REGRESSION LINE FIT FOR [ RELATIVE ] VARIOGRAM
 LEAST SQUARES REGRESSION ON POINTS   1 TO   5
 NUGGET (C0) =      .1772    SLOPE/100 =     3.7520     C0/SLOPE =      .0472
 Predicted GAMMA at   25.0 Distance is     1.1152
```

235

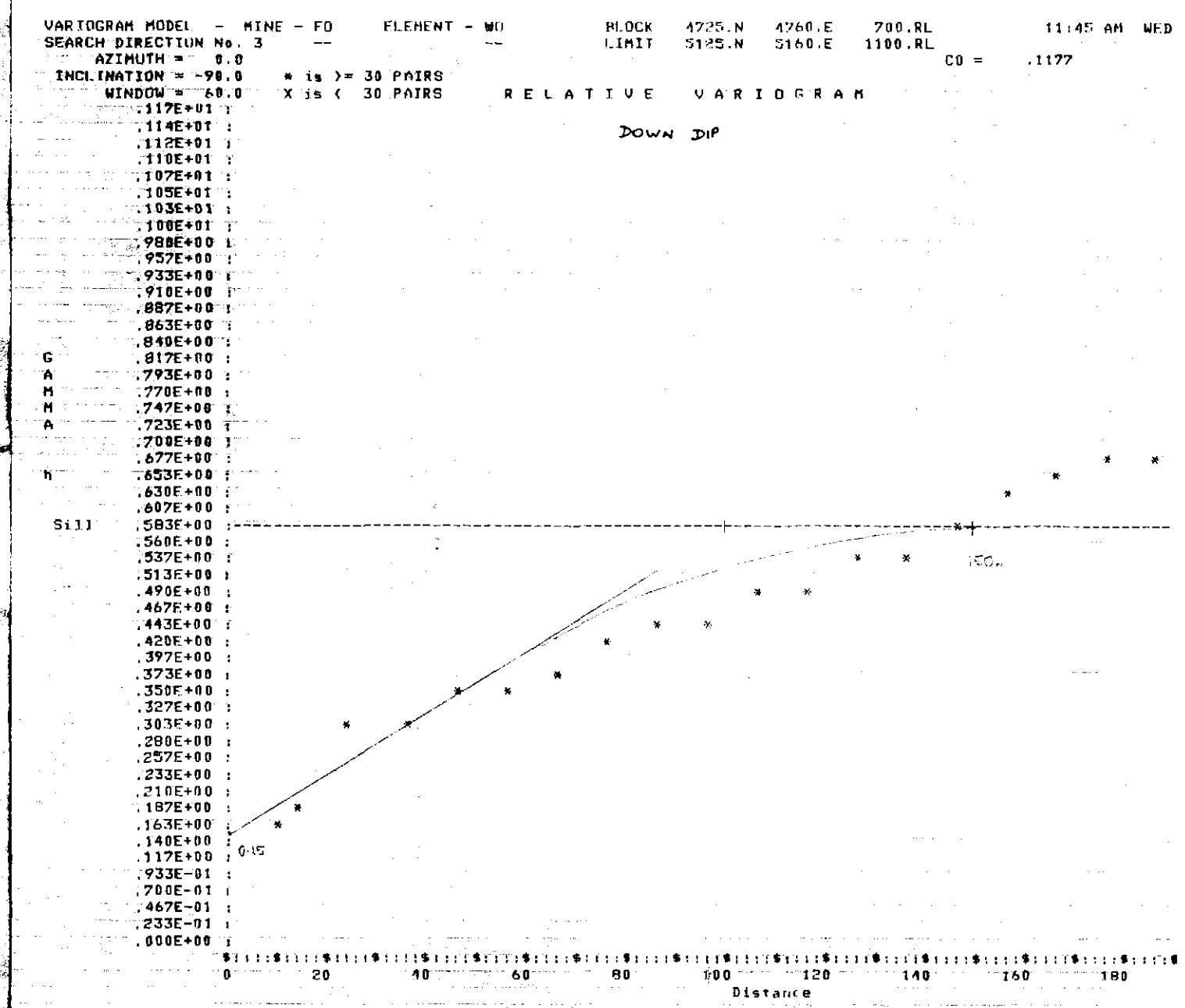
VARIOGRAM MODEL - MINE - FO ELEMENT - WO BLOCK 4725.N 4760.E 700.RL 11:45 AM WED.,
SEARCH DIRECTION No. 4 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 0.0 CO = .1708
INCLINATION = 0.0 # is >= 30 PAIRS
WINDOW = 60.0 X is < 30 PAIRS




VARIOGRAM MODEL - MINE - FO ELEMENT - WD BLOCK 4725.N 4760.E 700.RL 11:45 AM WED
SEARCH DIRECTION No. 2 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 90.0 C0 = .0970
INCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 60.0 X is < 30 PAIRS
RELATIVE VARIOGRAM
ALONG STRIKE
.119E+01
.116E+01
.114E+01
.112E+01
.109E+01
.107E+01
.104E+01
.102E+01
.997E+00
.973E+00
.950E+00
.926E+00
.902E+00
.878E+00
.855E+00
.831E+00
.807E+00
.783E+00
.760E+00
.736E+00
.712E+00
.688E+00
.665E+00
.641E+00
.617E+00
.594E+00
.570E+00
.546E+00
.522E+00
.499E+00
.475E+00
.451E+00
.427E+00
.404E+00
.380E+00
.356E+00
.332E+00
.309E+00
.285E+00
.261E+00
.237E+00
.214E+00
.190E+00
.166E+00
.142E+00
.119E+00
.950E-01
.712E-01
.475E-01
.237E-01
.000E+00
GAMMA
h
Sill
0-15
X
120
0
20
40
60
80
100
120
140
160
180
Distance

237

72 240

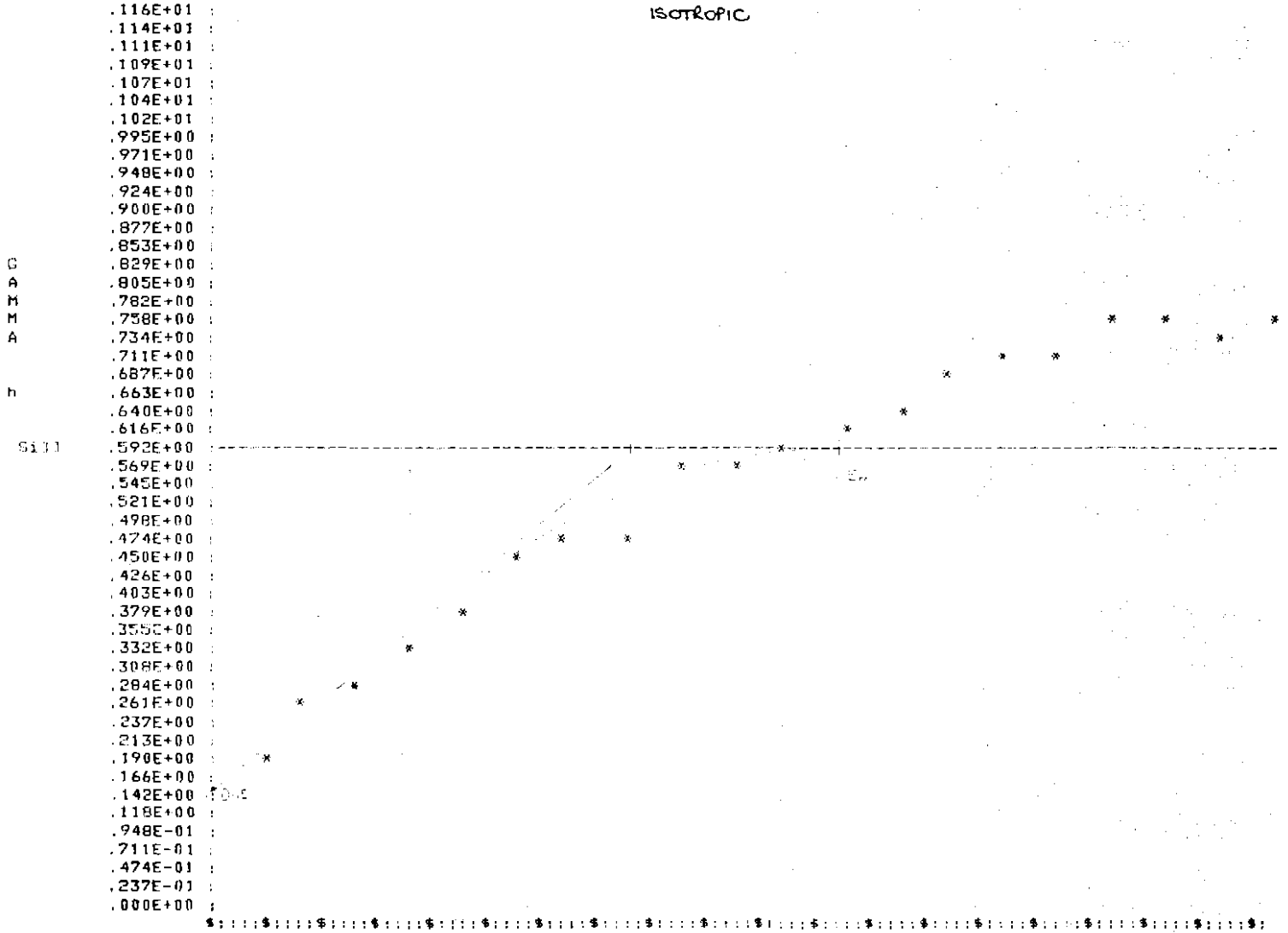

VARIOGRAM MODEL - MINE - FO ELEMENT - WO BLOCK 4725.N 4760.E 700.RL 11:45 AM WED
SEARCH DIRECTION No. 3 -- -- LIMIT 5125.N 5160.E 1100.RL
AZIMUTH = 0.0 C0 = .1177
INCLINATION = -90.0 * is >= 30 PAIRS
WINDOW = 60.0 X is < 30 PAIRS
RELATIVE VARIOGRAM
DOWN DIP
GAMMAh
Sill
0.15
150.
Distance

238

72 241

VARIOGRAM MODEL - MINE - FO ELEMENT - WO BLOCK 4725.N 4760.E 700.RL 11:45 AM WED.,
SEARCH DIRECTION No. 1 -- -- LIMIT 5185.N 5160.E 1100.RL
AZIMUTH = 0.0 C0 = .1648
INCLINATION = 0.0 * is >= 30 PAIRS
WINDOW = 180.0 X is < 30 PAIRS R E L A T I V E V A R I O G R A M

ISOTROPIC

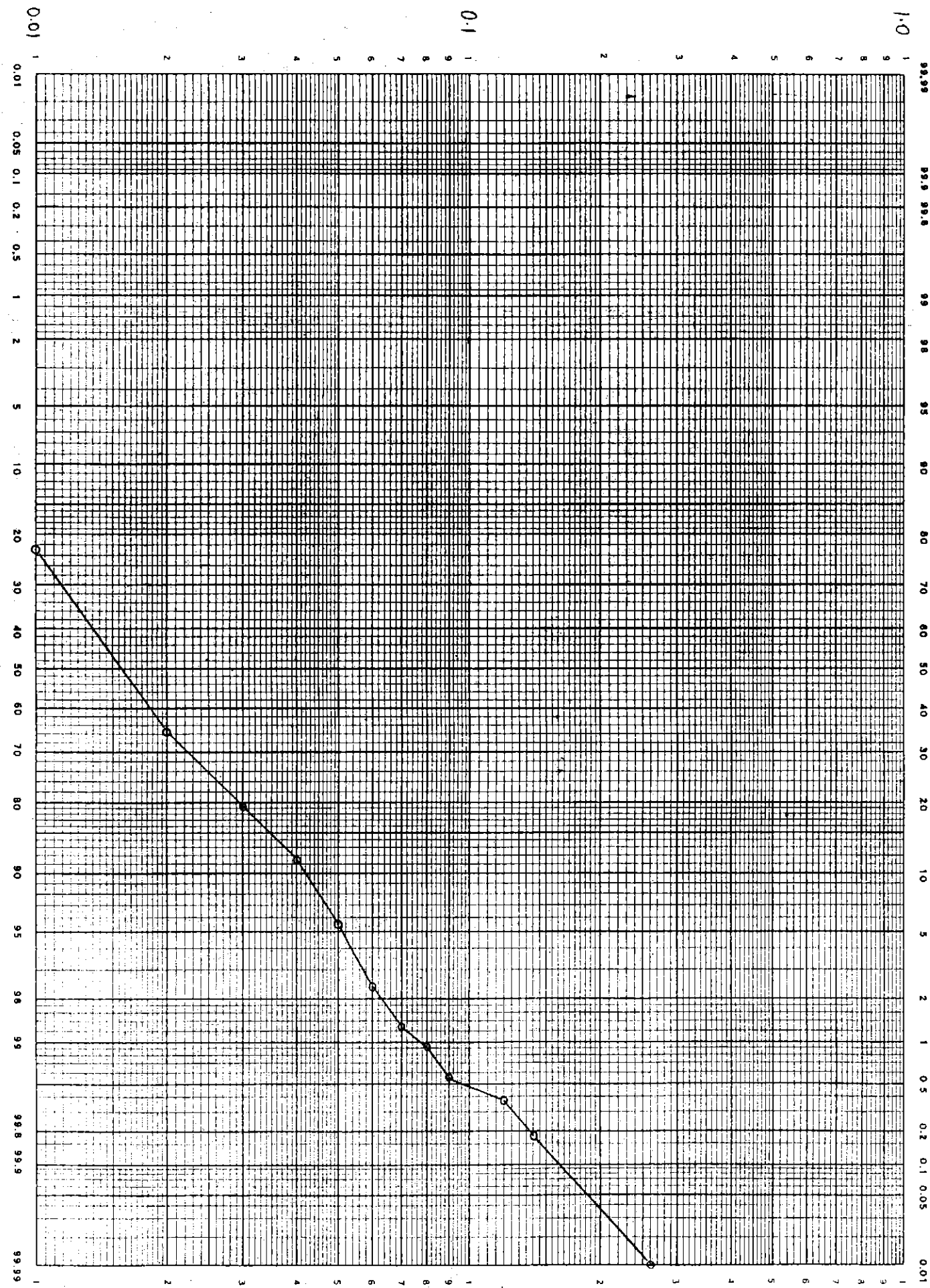


239

GORMACK GRAPH PAPERS . CHRISTCHURCH N.Z. P222Y Probability x 2 cycle log

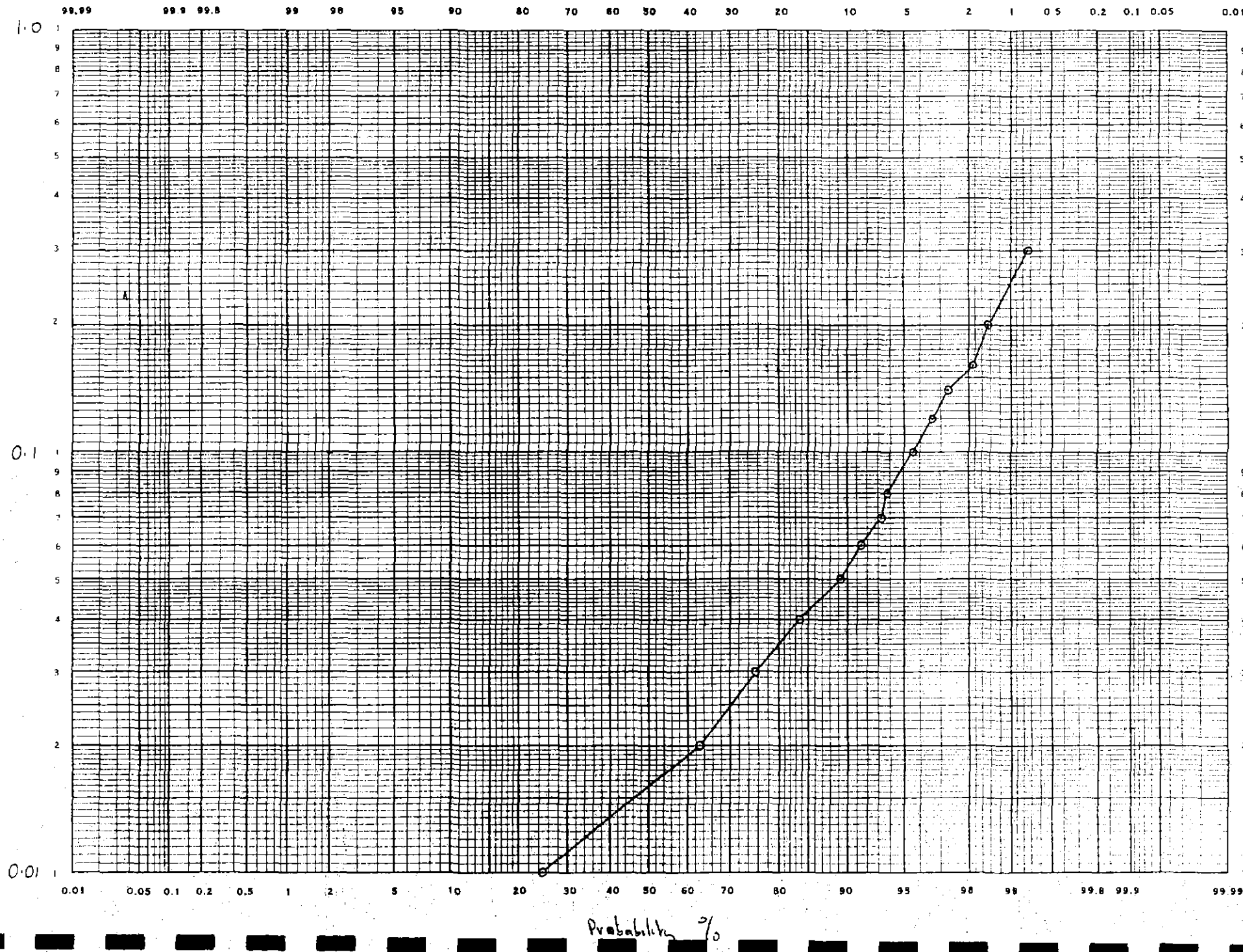
72 242

PERCENT Bi



FOLEY ZONE 10m COMPOSITES Bi

FOLEY ZONE 10m COMPOSITES SnT

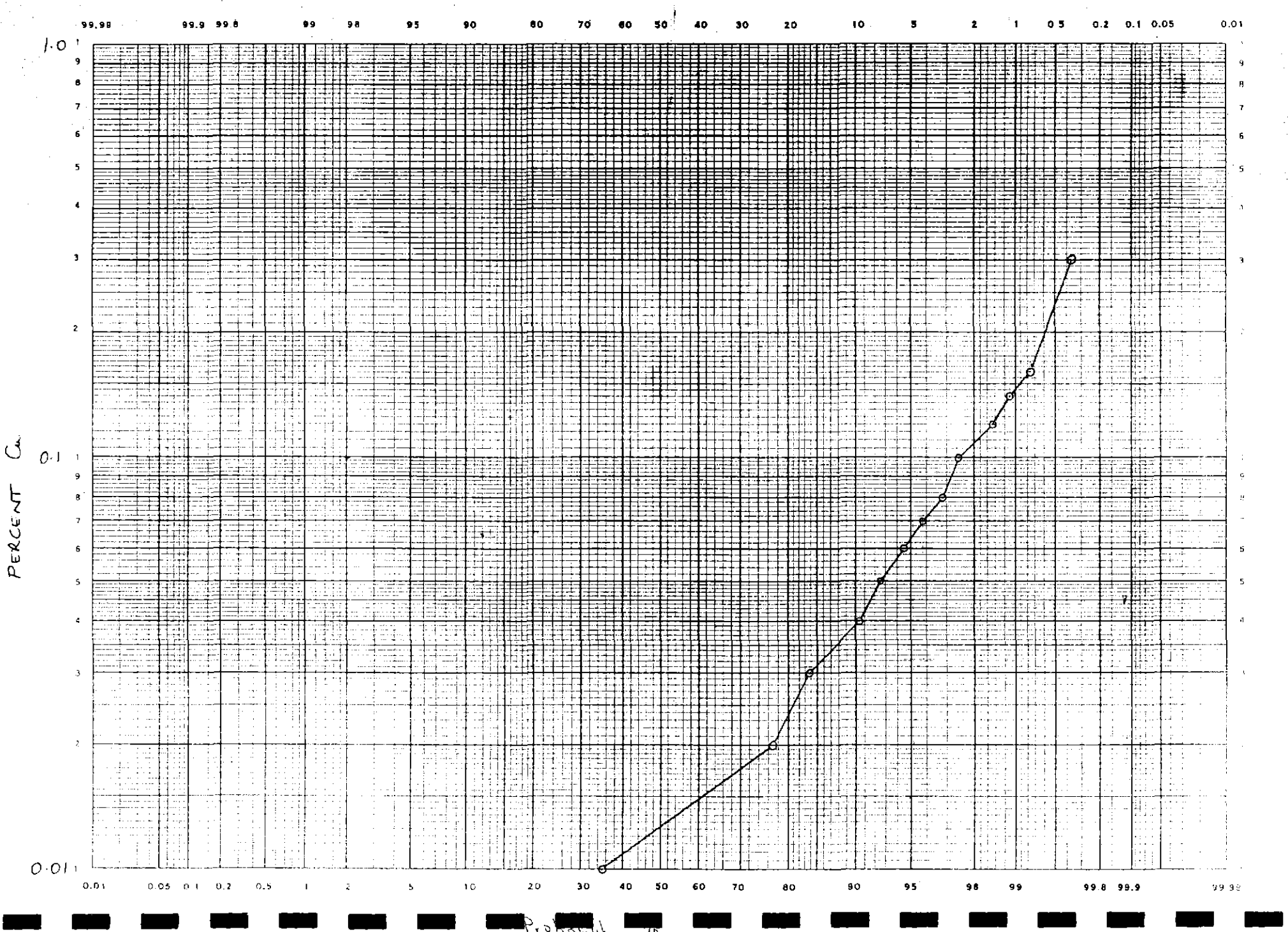


72 243

012

72 244

FOLEY ZONE 10m COMPOSITES Cu

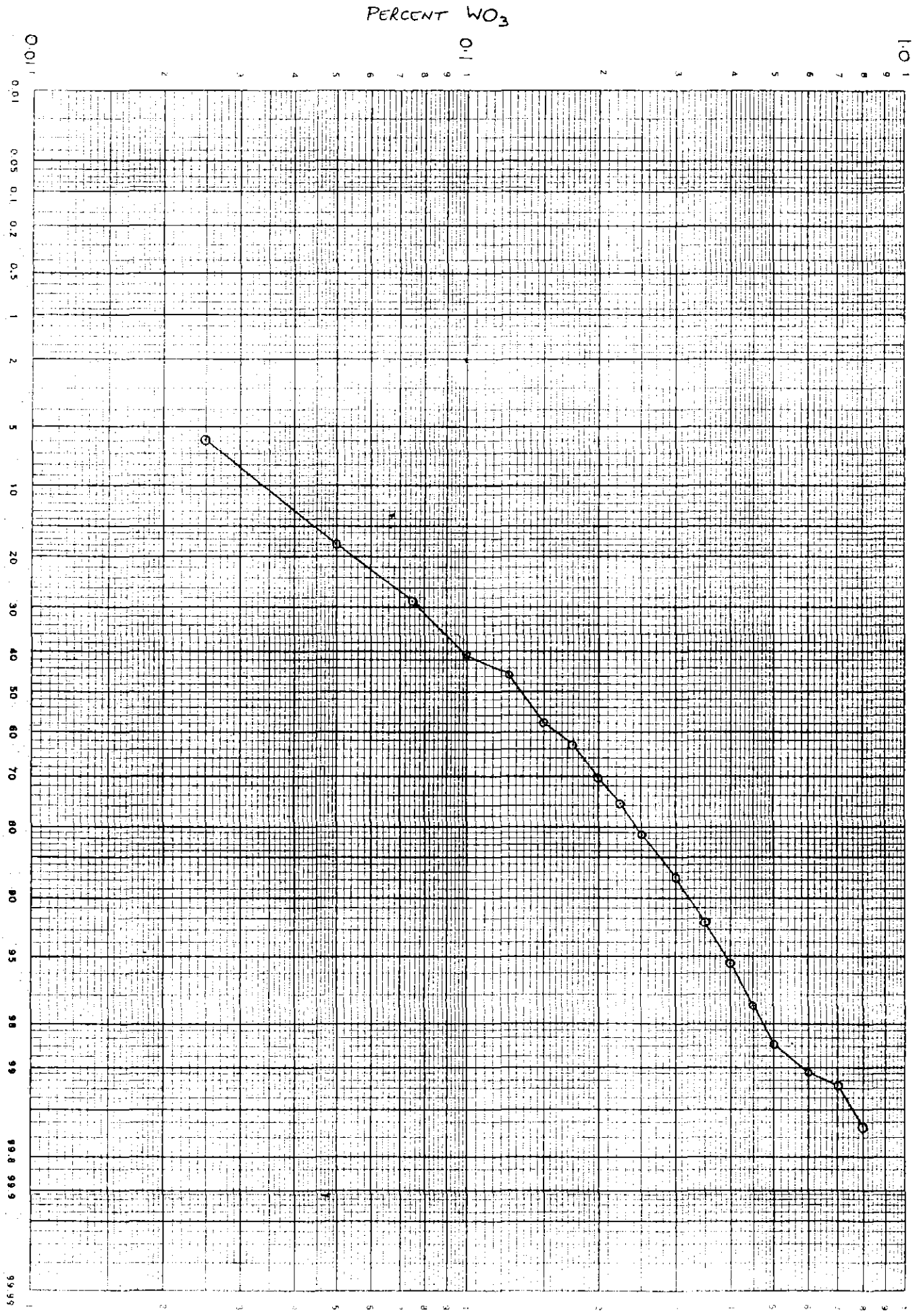


192

242

72 245

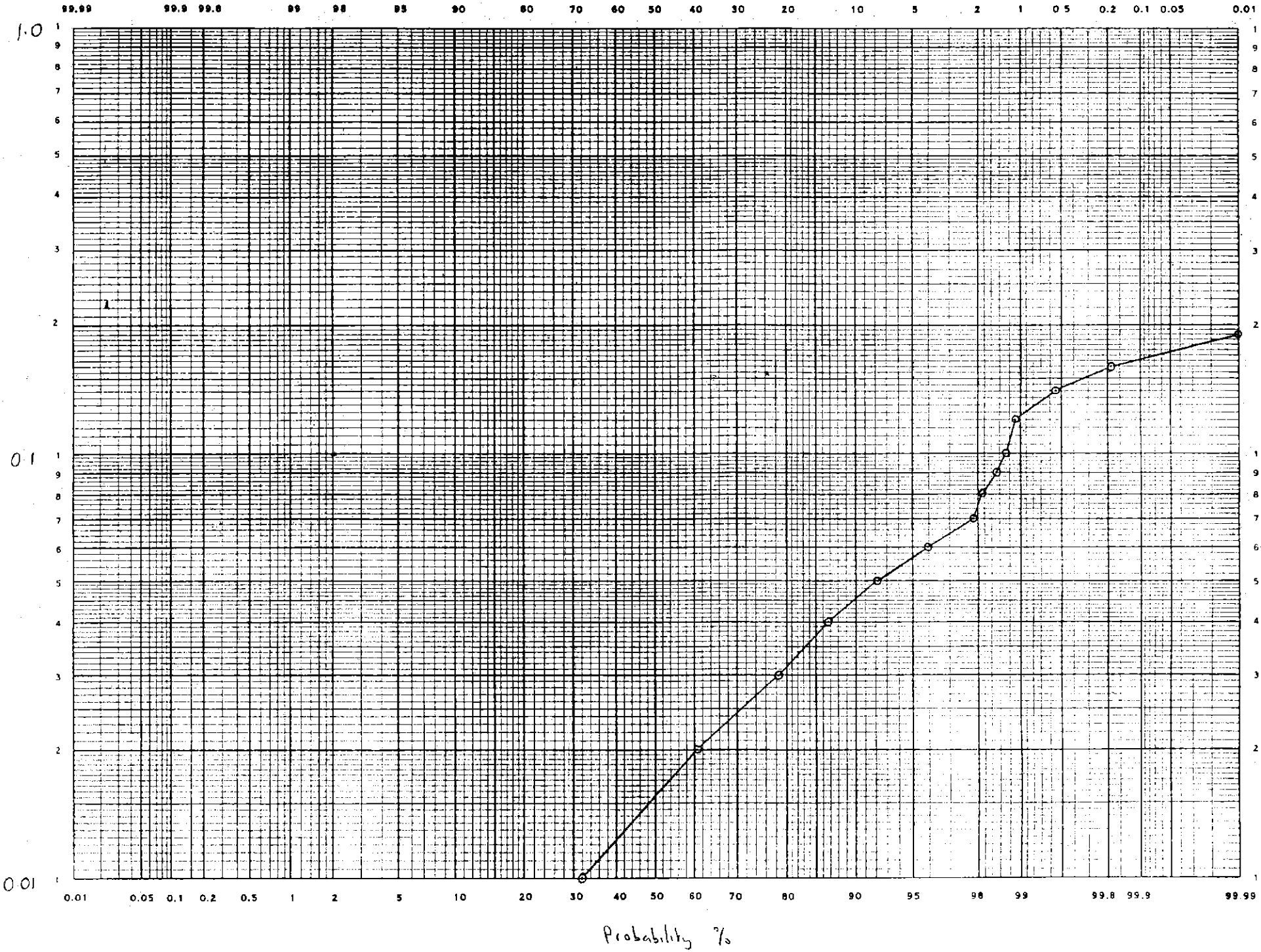
GORMACK GRAPH PAPERS - CHRISTCHURCH N.Z. P222Y Probability x 2 cycle log



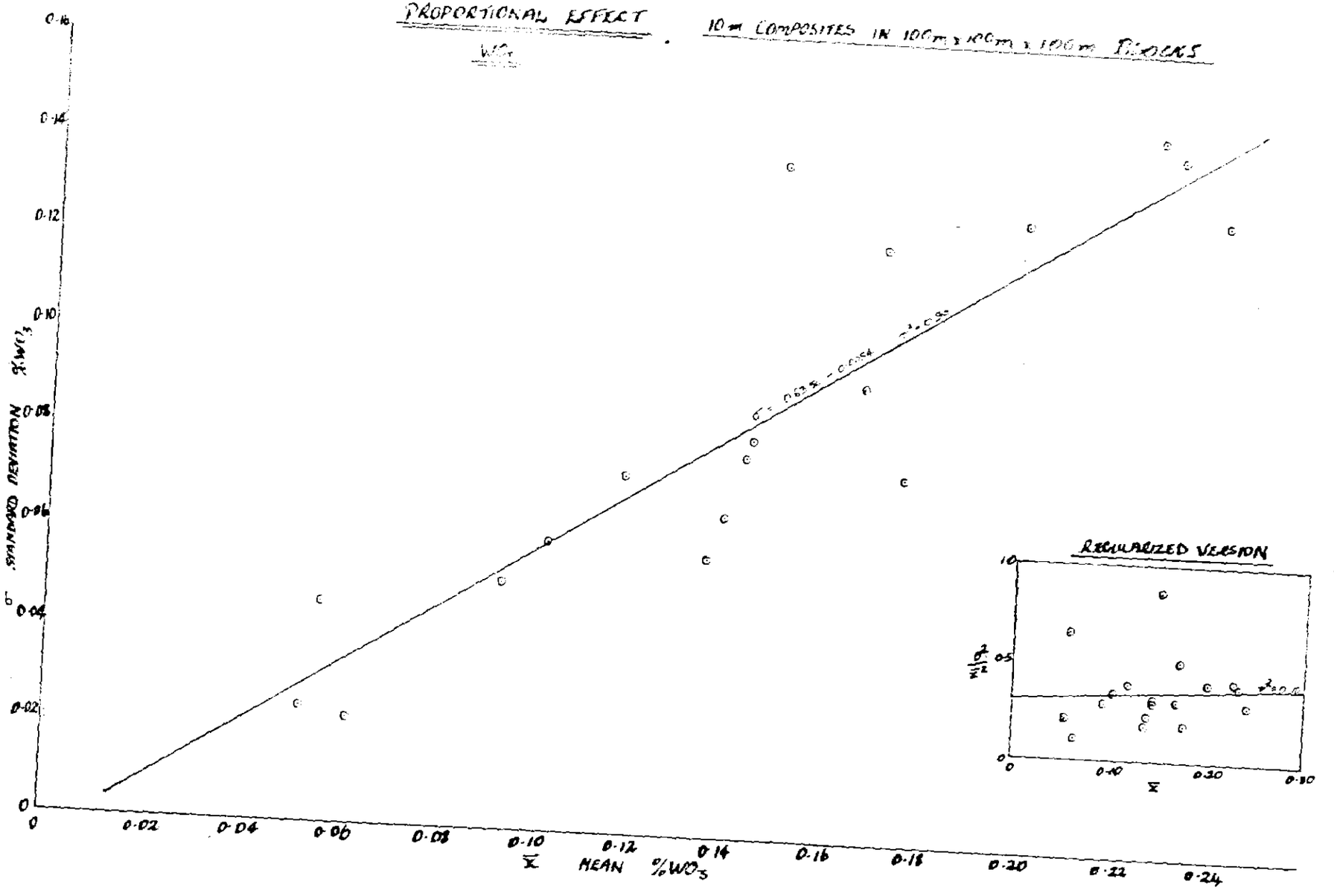
FOLEY ZONE 10m COMPOSITES WO_3

FOLEY ZONE 10m COMPOSITES MoS_2

72 246



72 247


PROPORTIONAL EFFECT
10m COMPOSITES IN 100m x 100m x 100m BLOCKS
STANDARD DEVIATION %WO3
MEAN %WO3
REGULARIZED VERSION

B43

Append D.

APPENDIX D.

METALLURGY

246

72 250

CLEVELAND TIN LIMITED MEMORANDUM

Date 27th October, 1981. Ref PGH/TRK

To J. P. Hamill From P. G. Hayward

At Cleveland At Cleveland

Copies to:- MJH, GJMcA, NE-M, KAF, JS. Keep

Subject:- ORE SORTING OF FOLEY'S ZONE

During July 1981 RTZ Ore Sorters of Thomastown, Victoria conducted a series of photometric ore sorting tests on two samples of Foley's Zone material. The samples tested were of the stockwork and of the porphyry ores. The as recieved ore samples were initial screened into the following fractions:- +110mm, -110 + 65mm, -65 + 15mm and -15mms. The +110 mm and the -15mm fractions were not subjected to any testwork. The remaining fractions were then sorted into accept and reject fractions with some further sorting of some of the products. The resorting carried out was as follows:-

1) -110 + 65mm stockwork reject resorted to remove higher grade material present.

2) -65 + 15mm stockwork accept resorted to remove lower grade material.

3) -65 + 15mm porphyry reject resorted to remove higher grade material.

The products were returned to Cleveland for sampling and analysis and the results are given in Table 1 & 2. Figures 1 & 2 show the breakdown of the samples into the various products. Table 3 gives an overall summary of the performance with the oversize material removed while Table 4 summarises the results into the different size ranges actually tested. In Tables 1 & 2 the assay values for the feed, oversize and fines were assumed to be the same as the weighted average values of all the products.

From the tables it can be concluded that the process of photometric ore sorting was successful in upgrading both types of Foley's Zone material.

FIGURE 1

STOCKWORK ORE

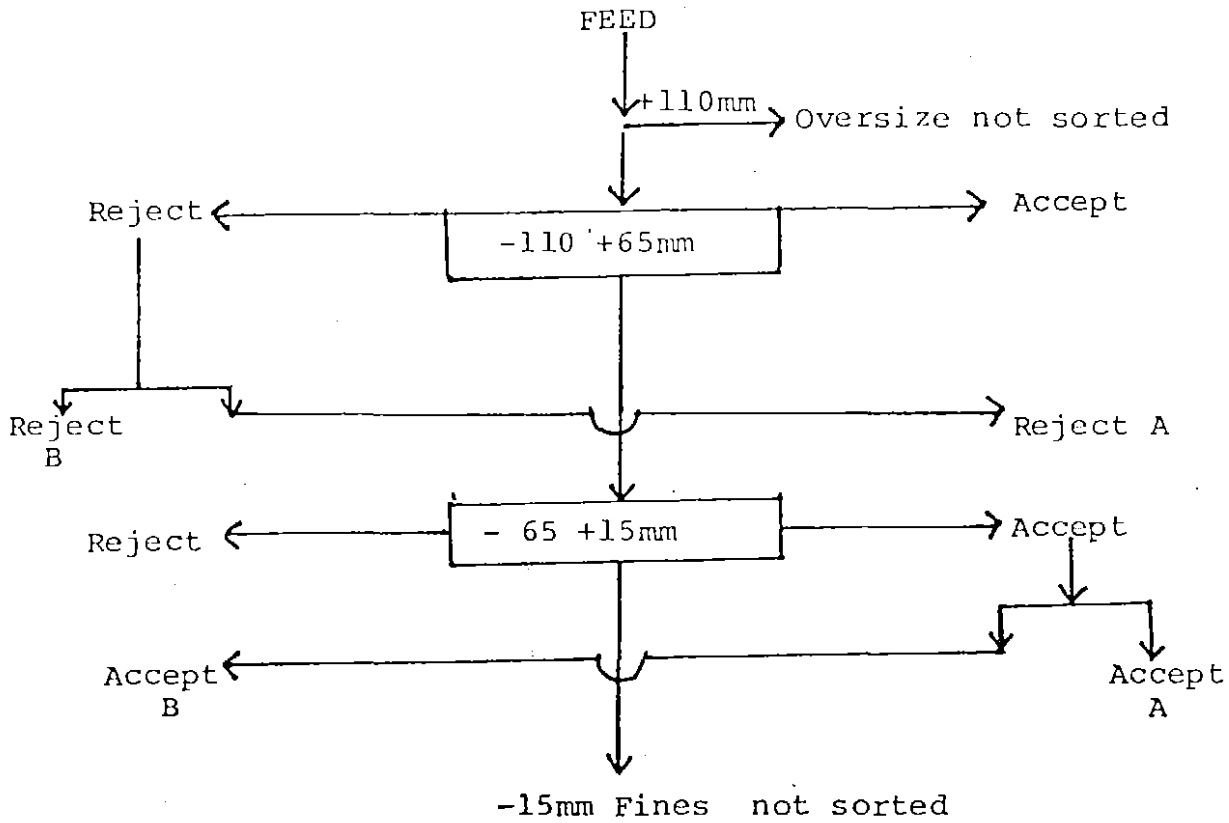


FIGURE 2

PORPHYRY ORE

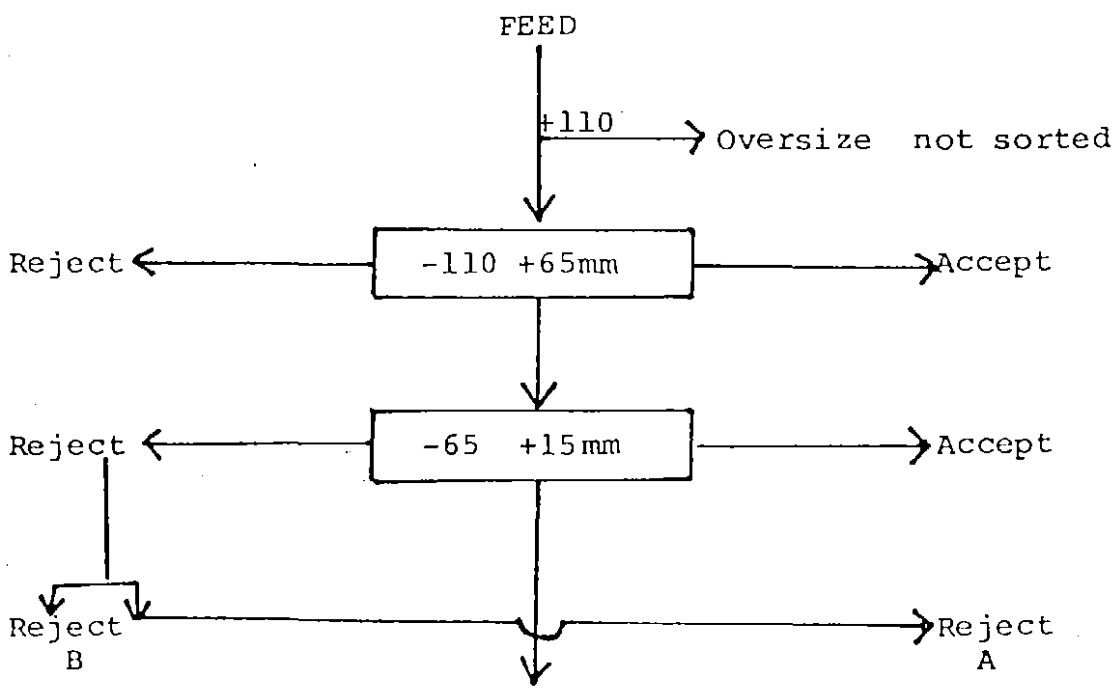


TABLE 1

RESULTS OF STOCKWORK TESTS

SIZE		+110	-110 +65			-65 +15			-15
FRACTION	FEED	OVERSIZE	ACCEPT	REJECT A	REJECT B	ACCEPT A	ACCEPT B	REJECT	FINES
Wt	1661.2	451	248	164.5	104	304	34.2	207	148.5
% Sn	0.04	0.04	0.04	0.02	0.01	0.05	0.03	0.04	0.04
% WO_3	0.230	0.230	0.280	0.175	0.095	0.355	0.175	0.105	0.230
% Bi	0.029	0.029	0.030	0.030	0.025	0.035	0.025	0.020	0.029
% MoS_2	0.034	0.034	0.025	0.030	0.025	0.055	0.030	0.020	0.034
% Wt	100.0	27.1	14.9	9.9	6.3	18.3	2.1	12.5	8.9
Sn Dist.	100.0	28.8	15.8	5.2	1.7	24.2	1.6	13.2	9.5
WO_3 Dist	100.0	27.2	18.2	7.5	2.6	28.3	1.6	5.7	8.9
Bi Dist.	100.0	27.2	15.5	10.3	5.4	22.2	1.8	8.6	9.0
MoS_2 Dist.	100.0	27.2	11.1	8.9	4.7	30.0	1.8	7.4	8.9

TABLE 2

RESULTS OF PORPHYRY TESTS

SIZE		+110	- 110 +65		-65 +15			-15
FRACTION	FEED	OVERSIZE	ACCEPT	REJECT	ACCEPT	REJECT A	REJECT B	FINES
WT	1845.7	289	485	59	628	55.9	53.2	275.6
% Sn	0.17	0.17	0.21	0.02	0.17	0.09	0.05	0.17
% WO_3	0.254	0.254	0.250	0.085	0.295	0.185	0.060	0.254
% Bi	0.026	0.026	0.025	0.015	0.030	0.020	0.010	0.026
% MoS_2	0.064	0.064	0.075	0.015	0.065	0.065	0.015	0.064
% Wt	100.0	15.7	26.3	3.2	34.0	3.0	2.9	14.9
Sn Dist	100.0	15.7	32.5	0.4	34.1	1.6	0.8	14.9
WO_3 Dist	100.0	15.7	25.9	1.1	39.5	2.2	0.7	14.9
Bi Dist	100.0	15.7	25.1	1.8	39.1	2.3	1.1	14.9
MoS_2 Dist	100.0	15.7	30.6	0.7	34.3	3.1	0.7	14.9

72 253

TABLE 3

SUMMARY OF TESTWORK WITH OVERSIZE REMOVED.

FRACTION	STOCKWORK						PORPHYRY					
	FEED		ACCEPT + FINE		REJECT		FEED		ACCEPT + FINE		REJECT	
	ASSAY	DIST	ASSAY	DIST	ASSAY	DIST	ASSAY	DIST	ASSAY	DIST	ASSAY	DIST
WT	1210.2	100.0	865.0	71.5	345.2	28.5	1556.7	100.0	1445.5	92.8	112.2	7.2
Sn	0.04	100.0	0.04	76.8	0.03	23.2	0.17	100.0	0.18	98.6	0.03	1.4
WO_3	0.230	100.0	0.278	86.4	0.109	13.6	0.254	100.0	0.269	97.9	0.075	2.1
Bi	0.029	100.0	0.032	78.3	0.022	21.7	0.026	100.0	0.027	96.6	0.013	3.4
MoS_2	0.034	100.0	0.038	80.8	0.023	19.2	0.064	100.0	0.068	98.4	0.015	1.6

249

TABLE 4

SIZE PERFORMANCE

SAMPLE	STOCKWORK									
SIZE	-110 +65					-65 +15				
FRACTION	FEED	ACCEPT		REJECT		FEED	ACCEPT		REJECT	
	ASSAY	ASSAY	DIST	ASSAY	DIST	ASSAY	ASSAY	DIST	ASSAY	DIST
WT			79.8		20.2			55.7		44.3
Sn	0.03	0.03	92.5	0.01	7.5	0.04	0.05	62.2	0.04	37.8
WO_3	0.209	0.238	90.8	0.095	9.2	0.249	0.355	79.6	0.115	20.4
Bi	0.029	0.030	82.7	0.025	17.3	0.029	0.035	68.1	0.021	31.9
MoS_2	0.027	0.027	80.8	0.025	19.2	0.040	0.055	76.4	0.021	23.6
SAMPLE	PORPHYRY									
WT			89.1		10.9			92.8		7.2
Sn	0.19	0.21	98.7	0.02	1.3	0.16	0.16	97.9	0.05	2.1
WO_3	0.232	0.250	95.9	0.085	4.1	0.270	0.286	98.4	0.060	1.6
Bi	0.024	0.025	93.4	0.015	6.6	0.028	0.029	97.4	0.010	2.6
MoS_2	0.069	0.075	97.8	0.015	2.2	0.061	0.065	98.2	0.015	1.8

The amount of upgrading that was achieved was not very high with a maximum for WO_3 of 0.355% from a feed 0.249 in the stockwork -65 +15mm test. This would indicate that without further testwork and refinements the application of photometric ore sorting would have limited application when treating Foley's Zone material.

It must, however, be remembered that the samples tested were not representative of the entire Foley's Zone. The samples treated were obtained from material brought to the surface during the excavation of drives. The stockwork material was considered to have very narrow veins in comparison to the majority of the material in this zone. If further testwork is to be carried out then a more representative sample will be required.

P. Hayward,
Plant Metallurgist.

252

72 256

CLEVELAND TIN LIMITED

MEMORANDUM

Date	15th July, 1982	Ref	EVD/lc
To	S.S. Meik	From	E.V. Dronseika
At	C.M.S., Burnie	At	Cleveland
Copies to	G.J. McArthur, N. E-Mooney	Keep	

Subject FOLEY ZONE ORE CHARACTERIZATION - REJECT SAMPLES

By now you would have received 159 samples separated into 6 classes or lots. We were unable to locate 23 samples which probably still exist in our core shed/store but in boxes with incorrect numbers.

The 6 lots cover zones which to a Geologist may have different metallurgical properties or may be mined preferentially. This does not actually mean that varying metallurgical properties do exist between them.

Lot 1: The lower grade stockwork. The vein densities and wolfram grades are less here than elsewhere in the heart of the system. This style may not be mined if only the higher grade areas are considered.

Lot 2: The higher grade stockwork. The vein densities and wolfram grades are highest here.

Lot 3: The alteration stockwork. This would be similar to the higher grade stockwork except that additional quartz veins containing carbonates, seriate (muscovite), topaz and sulphides have been superimposed upon the original mineralized veins. The large amount of quartz here has obvious metallurgical implications.

Lot 4: Mineralized quartz porphyry. The porphyry contains large amounts of seriate, quartz, topaz, sulphides and clays, and obviously differs substantially from the stockwork zone.

Lot 5: Tin quartz porphyry. A narrow central zone within the porphyry contains tin up to 0.2% in a quartz-topaz-pyrite matrix. It would rank second to wolfram in importance if it was to be recovered as a by-product.

Lot 6: Lode stockwork. Henry's lode strikes across the width of Foley Zone in one place. Quartz veins containing wolframite have been seen in the lode but often wolframite has been observed as fine specks and clots within the tin lode matrix itself. Some reaction between the tin lode and quartz veins is implied. Although this zone is not large in relation to the bulk of Foley Zone the style of mineralization is different and this would warrant further investigation in the future should more detailed work be required.

In essence there are two major groups, porphyry and stockwork. If the bulk of the deposit was to be mined then all 6 lots are representative. If a smaller but higher grade body was to be considered then only Lots 2, 3 and in some cases, 6 would be representative.

.../2

253

MEMO TO: S.S. Meik

I have enclosed relevant drill core logs, assay sheets and ore grade intersection sheets at different cut off grades, to enable you to contruct composites from ore grade intersections only, irrespective of rock type should this be necessary. It should be stressed that the separation into 6 lots for metallurgical testing was done by a Geologist. After looking at the information at hand be free to modify or ignore at your own discretion. None of the individual rejects have been tampered with.

I am always available for your assistance.

E.V. Dronseika,
Geologist.

Enclosure

FOLEY CORE - REJECT SAMPLES

C.1730

57.5	- 77.5m	1	303423	-	303430
77.5	- 82.5m	6	303431	-	303432
82.5	- 92.5m	4	303433	-	303436
92.5	- 100.0m	6	303437	-	303439
100.0	- 112.5m	2	303440	-	303444
112.5	- 135.0m	6	303445	-	303453

C.1741

75.0	- 120.0m	1	303479	-	303496
120.0	- 155.0m	3	303497	-	303508
"	"	3	303580	-	303581
155.0	- 167.5m	1	303582	-	303586

C.1637

42.5	- 60.0m	2	302173	-	302179
60.0	- 87.5m	1	302180	-	302190
87.5	- 127.5m	3	302191	-	302206
127.5	- 152.5m	2	302307	-	302316
152.5	- 202.5m	1	302317	-	302336

C.1713

152.5	- 172.5m	1	303083	-	303090
172.5	- 192.5m	3	303091	-	303098
192.5	- 205.0m	4	303099	-	303103
205.0	- 227.5m	5	303104	-	303112
227.5	- 250.0m	6	303113	-	303121
250.0	- 262.5m	3	303122	-	303124
"	"	3	303151	-	303152
262.5	- 290.0m	2	303153	-	303163

FOLEY DRILL CORE - REJECT SAMPLES

LOT 1: LOW STOCKWORK

C.1730	303423	- 303430	8	
C.1741	303479	- 303496	18-10 = 8	303479-303488 Missing
	303582	- 303586	5	
C.1637	302180	- 302190	11	
	302317	- 302336	20-4 = 16	302317, 302321, 302326, 302328 Missing
C.1713	303083	- 303090	8	

LOT 2: HIGH STOCKWORK

C.1730	303440	- 393444	5	
C.1637	302173	- 302179	7	
	302307	- 302316	10-4 = 6	302308, 302311, 302314, 302315 Missing
C.1713	303153	- 303163	11	

LOT 3: ALTERATION STOCKWORK

C.1741	303497	- 303508	12	
	303580	- 303581	2	
C.1637	302191	- 302206	16-5 = 11	302202 - 302206 Missing
C.1713	303091	- 303098	8	
	303122	- 303124	3	
	303151	- 303152	2	

LOT 4: POYPHYRY MIN.

C.1730	303433	- 303436	4	
C.1713	303099	- 303103	5	

LOT 5: TIN RICH PORPHYRY

C.1713	303104	- 303112	9	

LOT 6: LODE STOCKWORK

C.1713	303113	- 303121	7	
C.1730	303431	- 303432	2	
	303437	- 303439	3	
	303445	- 303453	9	

256

ABERFOYLE
CENTRAL METALLURGICAL SERVICES

72 260
MEMORANDUM

Date 22nd March, 1983 Ref

To G. J. McArthur From I. Thomas

At Cleveland At Burnie

Copies to N. E-Moony, Ed Dronseika Keep

Subject Analysis of Metallurgical Products from Foley Zone Upper Stockwork

The following are analyses of sulphide and oxide flotation concentrate products. These were produced from a composite of core 1637 (70-145m) assaying approx. 0.45% WO_3, 0.05%Sn, and 0.2%S.

	Sulphide Flotation Bulk Cleaner Concentrate	Oxide Flotation Cleaner Concentrate
S	30.6%	
WO_3	0.41%	20.0%
Sn	0.15%	3.97%
Ta	30 ppm	110 ppm
Se	<2 ppm	
Au	1.2 ppm	
Ag	131 ppm	
Pt	<50 ppb	
Pd	<50 ppb	
Fe	33.8%	
Bi	1.55%	
MoS_2	2.60%	
As	3.30%	
Pb	2.15%	
Zn	4.5%	
Cu	3.2%	

Note:- Sulphide flotation not selective for WO_3 not selective for WO_3 & Sn.

I. THOMAS

Appendix E.

APPENDIX E.

GROUNDWATER

258

72 263

FOLEY ZONE DRILL HOLES - GROUNDWATER CONTROL

Hole No.	Collar Location	Collar Azimuth (degrees)	Collar Dip (Degrees)	Wooden Plug (Seeled)	Aluminium Plug (Seeled)	No. Problems	Remarks
C1485	17 B Sth.Drive Cd Section	132°	-75°			X	
C1501	17 B Sth.Drive Cj Section	312°	-75°			X	
C1570	20/22L/Bay J Section	312°	-80°			X	
C1608	25 L/Bay	132°	-47°			X	
C1611	25 L/Bay	132°	-69°			X	
C1615	25 L/Bay		-90°		X		
C1627	25 L/Bay Ca Section	133°	-42°		X		
C1633	20/22 L/Bay J Section	132°	-80°		X		Plug temporary with Bullhose and Clamps. Dangerous - High Pressure.
C1634	25 L/Bay Ga Section	132°	-64°		X		
C1637	25 L/Bay Ga Section	200°	-50°		X		
C1642	25 L/Bay Ga Section	200°	+15°		X		
C1713	20/22 L/Bay 4960 E	200°	-58°			X	
C1730	25/26 D/D Plat. 5000 E	207°	-13°		X		
C1741	25/26 D/D Plat. 5000 E	207°	-39°		X		
C1754	25/26 D/D Plat. 5040 E	200°	-39°	X			
C1786	22 L/Bay 5080 E	207°	-54°			X	
C1800	22 L/Bay 5080 E	207°	-39°			X	
C1803	25 L/Bay 5040 E	199°	-48°		X		
C1809	25 L/Bay 5040 E	199°	-21°		X		
C1811	25/26 D/D Plat. 5000 E	207°	-5°		X		
C1822	25 L/Bay 5040 E	199°	-9°		X		
C1824	25 L/Bay 5040 E	199°	-36°	X			
C1826	25 L/Bay 4920 E	200°	-32°	X			
C1832	25/26 D/D Plat. 5000 E	209°	- 5°30"			X	
C1833	25 L/Bay 4920 E	200°	-22°	X			
C1840	25 L/Bay 4920 E	200°	-9°	X			
C1842	25/26 D/D Plat. 5000 E	200°	-16°			X	
C1852	25 L/Bay 4960 E	193°	-38°	X			
C1860	25 L/Bay 4960 E	193°	-27°	X			
C1865	25 L/Bay 4960 E	193°	-14°	X			
C1869	25 L/Bay 4880 E	220°	-38°	X			

/259

72 264

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

GEOHYDROLOGISTS & ENGINEERS

J. S. HANCOCK, B.Sc., M.Aus.I.M.M.
C. F. FORBES, B.E., A.M.Aus.I.M.M., M.I.E.
W. H. MORTON, Ph.D., A.M.Aus.I.M.M., M.I.E.

582 ST. KILDA ROAD, MELBOURNE, VICTORIA 3004 TELEPHONE: (03) 51 1547

ALSO AT SYDNEY AND PERTH CABLES: "SUBAQUA"

JSH:DK:721 29th October 1981

Cleveland Tin Limited,
LUINA. TAS 7321

ATTN: Mr. G. McArthur
Senior Mine Geologist

Dear Gary,

Cleveland Mines
Water and Gas Problems

Further to our letter of 24th August and your letters dated 21st August and 23rd September, we wish to advise that we have plotted up all the data sent to us. No conclusive evidence is available from this but when we have the water analyses back we may be able to get a better idea of the problems you have.

In our earlier letter and on-site, we undertook to give you a forward programme and cost estimate, and we set this out herewith.

It appears that your requirements are three-fold :-

(i) to determine the nature of the problem and to evaluate the problem so that its magnitude in respect of mining and development operations can be assessed.

(ii) to determine the best approach to drilling the new ore body without being curtailed by the water pressures, and

(iii) to determine the actions which can be taken to minimize or ameliorate the problem prior to development or mining.

Nature and Evaluation of the Problem

The extent of drilling which has intersected water bearing structures is limited by the effects of the water.

Plots of depth against temperature and conductivity tend to show C1615 and C1633 as being anomalous. These two intersect the footwall aureole of the Quartz Porphyry towards the central area of the deposit.

The water analyses will undoubtedly assist in clarifying the situation further and in identifying both the extent and consistency of the gas problem.

...2

These are expected very soon and work on these is estimated as follows :-

Professional Fees in evaluations, plotting and reporting		
Principal Consultant	$318	
Hydrogeologist	672	
Drafting	190	$1,180

In addition, once the various holes have been plugged pressure recovery and flow tests should be performed to assess the inflow capacity and inter-relationships between the holes indicated as being grouped by the chemical, geological and hydrological parameters.

It is anticipated that five such tests might be undertaken by one of our staff with assistance from one of your staff. The tests would have the form of :-

(i) shut-down of the well with recovery of pressure measured by a pressure meter.

(ii) flow recession test achieved by enclosed discharge to a drum with measurement of inflow rate at various times and gas flow.

Each testing procedure is expected to take about one day by the time preparation is taken into account.

Our costs for this work would be :-

Field Work		
Hydrogeologist - 5 days @ $260/day	1,300	
Pressure gauge hire and equipment provision	1,200	
Expenses *	300	2,800
Data Analyses and Reporting		
Principal Consultant	230	
Senior Consultant	240	
Hydrogeologist	520	
Drafting	380	
Expenses	300	1,670

Finally, before completion of the report on this aspect it would seem desirable for a further site visit to be made to both study the cases of relevant exploration holes and also to consider various geological aspects with you and your staff.

This visit would also cover other aspects of the problem such as drilling technology and solutions or problem handling. The cost of this is estimated as follows :-

Professional Fees	800	
Expenses	400	1,200

The total cost estimate then for this aspect of your requirements are in total:-

	6,850	
Contingency (10%)	685	$7,535

* (assuming accommodation and meals are provided)

Drilling Approach

Drilling in the Cleveland Mine has been largely unaffected by water flows or pressure prior to recent date, but it is now apparent that at least insofar as the deep exploration core drilling is concerned that high water pressures and high gas/water flows can be expected. At least insofar as deep drilling is concerned, i.e. below mine RL 700m special precautions will have to be taken.

The first precaution is to have a cemented hole collar incorporating a standpipe fitted with valves through which all drilling activities can take place and diversion of pressure achieved. This operation permits hole shut in on completion in the event of high pressure water being intersected.

Secondly, the drilling rigs being used must be appropriately anchored and have hydraulic feed pressure capable of driving the rig against unrelieved hydrostatic pressures as well as supplying adequate pressure at the bit for penetration. In addition, where wireline coring is carried out consideration needs to be made as to the type of bit being used such that transmission of flow and pressure back through the drill pipe is minimal. Finally, the arrangement at the drill head must be such that it is possible to by-pass flow and pressure for sufficiently long to be able to insert and shut in the core barrel prior to pumping it back into a locked-in position.

Overall, the drilling rigs and pumps must have sufficient consistant and reliable power output to be able to overcome all the forces involved.

In general, such rigs are readily available from the normal suppliers, but are not widely used in Australia since drilling against high water heads has not been a major problem. Elsewhere in the world however such operations are common and the technology is well developed and proven.

Operations in the hole, such as pressure testing for permeability between pulls for bit changes, can be considered where water intersections are not identified during drilling, but prove to be a problem when attempting to rerun the drill pipe. If permeability is encountered repeated pressure tests against a pressure sealing gland on the collar valve can be undertaken at various depths until the location of the zone is found. This can then be pressure cemented.

Such operations as are described however are time consuming, difficult and result in opportunities for testing and defining the problem being lost.

It is our understanding that you have awarded a major contract for the exploration and drilling of the Quartz Porphyry orebody. We are of the opinion that you should request your contractor to provide details of how he proposes to proceed with drilling, taking into account the following:-

(i) the need to cement in and provide valves on collars of adequate diameter to shut in - (a) the hole on completion and
(b) the drill pipe to permit pressure testing

(ii) the possibility of intersecting and drilling against waters having a hydrostatic head equivalent to a standing water level of at least mine RL 1400m,

(iii) the probability of significant flows of water and gas within the hole, up to 0.5 m^3/min,

(iv) the need to be able to pump water and grout against unrelieved high pressures.

His replies to these questions can be reviewed by us as to adequacy and reliability and improvements suggested based on our experience of other mines in Australia and overseas.

Our involvement in this would include :-

(i) the preparation of a questionnaire,

(ii) review of equipment specifications,

(iii) report and recommendations on additional equipment and techniques.

Our cost estimate for this work is as follows :-

Professional Fees	1,200	
Expenses	400	
Contingency	160	$1,760

Water/Gas Inflow Amelioration Strategies

It is impossible at this time to assess the specifications which will be involved in developing water inflow control strategies except that it will involve :-

(i) a review of the present proposed investigation programmes,

(ii) extension and or modification of aspects of that programme to obtain specific structural and hydrological data, and

(iii) some testing of techniques to assess their efficacy.

For budget purposes you should perhaps allow the following in future costings :-

Professional Fees	10,000	
Drilling and Testing	40,000	
Expenses	5,000	
Contingency 10%	5,500	$60,500
	Say:	$60,000

As soon as we have a better basis a specific work programme will be costed and presented to you for approval.

We attach herewith our invoice for work undertaken in relation to your programme during September. This largely involved consideration of the data presented to us by you and some carry over expenses from the previous period.

In future we will invoice you monthly at our normal rates. These are based on the Association of Consulting Engineers Australia formula and are based on salary and a multiplier.

These are :-

Principal	Mr. S. Hancock	$53/hr
Associate	Mr. M. Bell	44/hr
Sen Hydrogeologist	Dr. F. Carosone	41/hr
"	Dr. A. Bowden	36/hr
"	Mr. A. Lane	36/hr
Hydrogeologist	Mr. Y.K. Foong	30/hr
"	Mr. J.C. Laver	24/hr
Groundwater Eng	Mrs. K. Schmidt	26/hr
"	Mr. F. Pamminger	23/hr
"	Mr. K. Harvey	23/hr
Drafting		19/hr

Our invoicing will be identified as follows :-

Job No.	Subdivision			
721	1. Evaluation	3,800	(see letter 21/8/81)	
	Data Analysis	1,180		
	Field work analysis and reporting	4,470		
	Site visit	1,200		
	Contingency	685	11,335	
	2. Drilling Approach		1,760	
	3. Amelioration Strategies		60,100	
		Total:	$73,195	

It should be understood that we will not incur any costs over and above those already undertaken on any of these items without your concurrence, and certainly the item 721/3 is included for budget purposes only.

We trust this meets with your approval and look forward to discussing the matters with you. We would be most interested to know how you went on plugging the existing flowing holes.

Regards,

Yours faithfully,
AUSTRALIAN GROUNDWATER CONSULTANTS PTY LTD

STEPHEN HANCOCK
PRINCIPAL CONSULTANT

264

72 269

INVOICE

AUSTRALIAN GROUNDWATER CONSULTANTS PTY LIMITED

GEOHYDROLOGISTS & ENGINEERS

582 ST. KILDA ROAD, MELBOURNE, VICTORIA 3004

CABLES: "SUBAQUA"

Cleveland Tin,

LUINA Tasmania 7321

Attention : Mr. McArthur - Senior Mines Geologist

INVOICE DATE 8th October, 1981

INVOICE No. M 3093 - 9 - 81

OUR JOB No. 721

YOUR ORDER No.

Job No. 721

Professional Fees

Principal Consultant - S. Hancock 3.5 hrs @ $48-00 ph	$ 168 - 00
Expenses -	
Motor Vehicle Hire	51 - 90
	$ 219 - 90

265

Cleveland Tin Limited

72 270

Luina, Tasmania, 7321
Telephone: (004) 46 2135 Telex: AA59051

PFB:MM

23rd September, 1981.

Australian groundwater Consultants Pty. Ltd.,
582 St. Kilda Road,
MELBOURNE. VIC. 3004.

Attention: Mr. S. Hancock - Principal Consultant.

Dear Stephen,

re: Cleveland Mine - Water Analysis Samples

Please find enclosed a list of the samples taken for water analysis showing location, borehole number, date collected, time collected, collar R.L., azimuth, angle and depth.

It should be noted that several changes have been made to the original list of holes, these being:-

1. the inclusion of borehole C1634 (completed after your visit
2. the inclusion of boreholes C1456 and C1528 in place of boreholes C1454 and C1524 (all four holes drilled from the same site). Due to observed water flows it is suspected that an error was made in numbering these holes (i.e. C1456 originally interpreted as C1454; C1528 originally interpreted as C1524).

Regards,

G.J. McArthur
Senior Mine Geologist.

CLEVELAND MINE - WATER ANALYSIS SAMPLES

LOCATION	Borehole No.	Date Collected	Time Collected	Collar R.L. (m)	Azimuth (degree)	Angle (degree)	Depth (metres)
Tailings dam overflow	-	18.9.81	10.45 a.m.	-	-	-	-
Creek flow above mine area	-	18.9.81	11.00 a.m.	-	-	-	-
River flow above mine area	-	18.9.81	11.15 a.m.	-	-	-	-
17 B-South	C1551	18.9.81	2.40 p.m.	1131	112	-38	167
17 B-South	C1554	18.9.81	2.45 p.m.	1131	111	-49	205
17 B-South	C1536	18.9.81	2.55 p.m.	1132	110	-30	158
17 B-South	C1462	18.9.81	3.00 p.m.	1133	110	+11	75
17 B-South	C1456	22.9.81	8.35 a.m.	1133	112	+ 2	83
17 B-South	C1528	22.9.81	8.40 a.m.	1131	112	-45	214
20-22 Decline	C1633	22.9.81	9.00 a.m.	1054	131	-80	658
24-26 Decline	C1627	22.9.81	9.15 a.m.	993	134	-42	202
24-26 Decline	C1634	22.9.81	9.25 a.m.	993	130	-62	383
24-26 Decline	C1608	22.9.81	9.30 a.m.	988	133	-49	208
24-26 Decline	C1611	22.9.81	9.35 a.m.	988	133	-69	252
24-26 Decline	C1615	22.9.81	9.40 a.m.	988	-	-90	421

261

Cleveland Tin Limited

72 272

Luina, Tasmania, 7321
Telephone: (004) 46 2135 Telex: AA59051

2nd June, 1982
ED/lc

Stephen Hancock,
Australian Groundwater Consultants,
26 Wellington Street,
ST. KILDA. VIC. 3182

Dear Stephen,

Please find enclosed four figures of pressure monitored diamond drill holes. The results represent work carried over the last four months. Pressure of work has caused delays in sending these results.

Most of these holes have been sealed with aluminium packers because of the trouble they've caused. A scaffolding used by diamond drillers collapsed under the weight of rods leaning against it and broke the pipe and valve fitted to the collar of hole C.1633. We have a sealed bull hose over it but recent pressures of 500 kpa and up to 600 kpa have possibly justified permanent sealing with grout. Hole C.1615, the vertical hole on 25 level decline, has been sealed permanently with an aluminium packer. The Mines Inspector ordered the sealing fo the hole. A veil of carbon dioxide was detected seeping down the decline about a foot off the floor in concentrations at about the legal limit (0.5%). Because of the heavy traffic right by the collar it was thought safest to seal it permanently below the collar rather than just put a tap at the collar.

Mining has commenced in the loading bay where C.1627 and C.1634 are collared. A small temporary concrete buttress has been placed around hole C.1627 and a new hole C.1637 near the sidewall of the loading bay. One hole, C.1634, collared right in the centre of the loading bay has been sealed permanently with a packer.

Figure 1. locates the holes C.1633, C.1627 and C.1637 used in the tests.

Figure 2. shows daily recordings (when convenient) of the three holes. These were generally observed in the morning from about 9.00 a.m. to 11.00 a.m. on the dates shown. Although not shown recent pressures over the last few weeks on hole C.1633 have been in the order of 500 kpa. Some water samples were collected for isotopic studies by the Mines Department on hole C.1633. Just after the valve was closed the presure crept slowly to 600 kpa from 500 kpa over a matter of minutes. To date this is the highest pressure observed at the collar in any hole in the mine.

Figure 3. shows pressure observations over half and minute intervals for holes C.1633 and C.1631 after the valve of C.1627 was opened.

.../2

Figure 4. shows pressure observations in holes C.1637 and C.1627 after the valve of C.1627 was closed. Although drilled at right angles the collars of the 2 holes are close together.

A new series of holes has begun from a short platform just above 26 level drilling southward. Out of 3 holes only one to date has encountered any significant gas and water under pressure at about 900m RL - (100m below sealevel) on the footwall side of the porphyry intrusive. Drilling continues on that hole.

In figure 2. there is a vague trend showing an overall decrease in pressure over the period observations were made. Recent pressure increases in hole C.1633 to about 500 kpa have been noted. Could these changes reflect water table changes related to seasonal rainfall variations considering January to April is fairly dry here in Luina?

Hopefully you will find some of these results interesting and be in a position to comment on these results and any long term problems we may encounter whilst drilling or mining in that area.

Yours faithfully,

E.V. Dronseika,
Mine Geologist.

Enc.

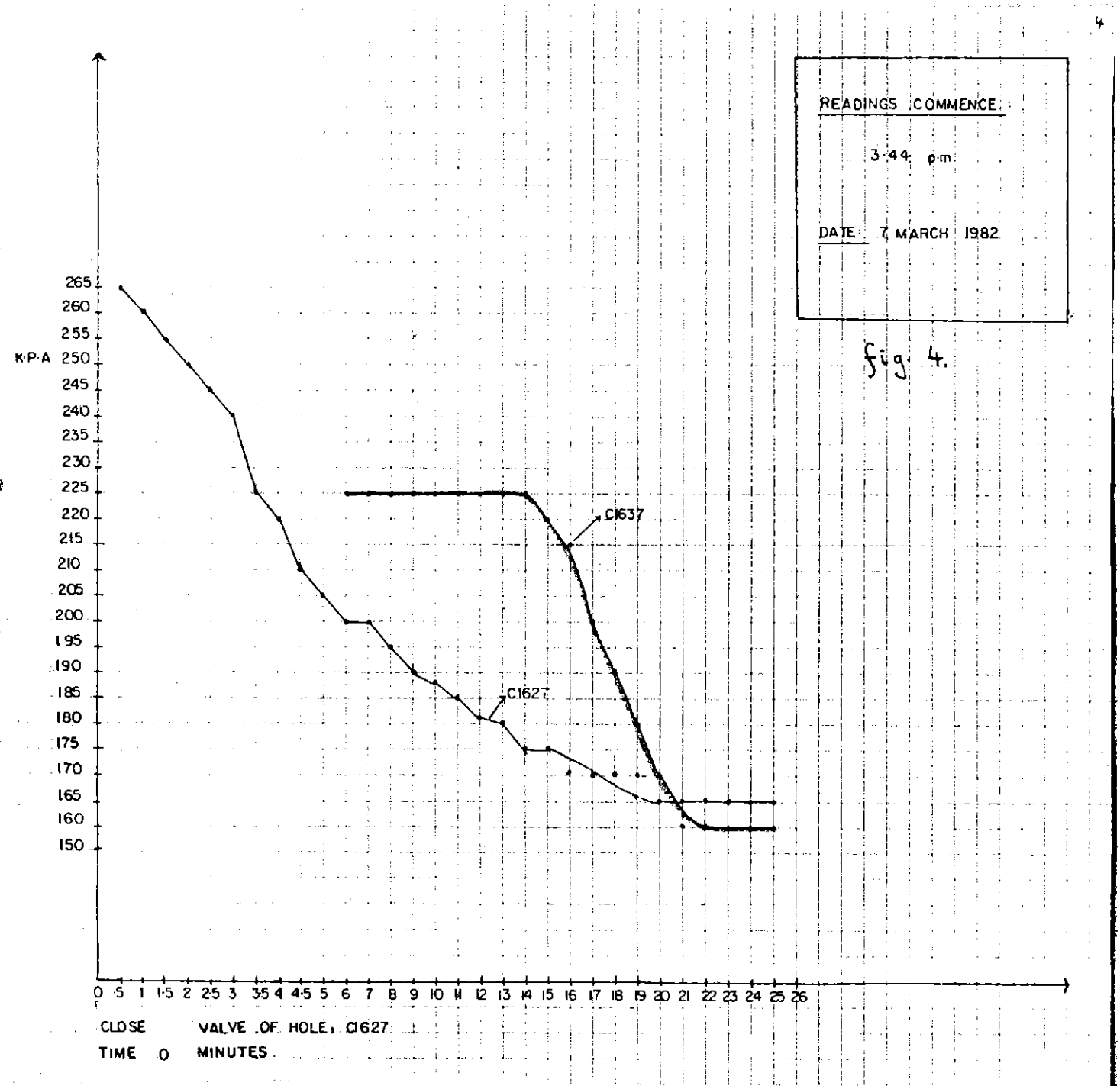

READINGS COMMENCE
3·44 p·m
DATE 7 MARCH 1982
K·P·A
265
260
255
250
245
240
235
230
225
220
215
210
205
200
195
190
185
180
175
170
165
160
150
C1637
C1627
0 ·5 1 1·5 2 2·5 3 3·5 4 4·5 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
CLOSE VALVE OF HOLE, C1627
TIME 0 MINUTES

Fig. 4.

270

SGS Australia Pty. Ltd.

72 275

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

AUSTRALIAN GROUNDWATER CONSULTANTS PTY
582 St. Kilda Road, Melbourne
Victoria 3004

Attn: Stephen Hancock
Principal Consultant

CC:
CLEVELAND MINE
LUINA, TASMANIA 7321

Attn: Mr. G. McArthur
Senior Mine Geologist

Our ref. La/0129
Your ref. JSH:DK:721
Date received 25.9.81
Date completed 29.10.81
Issued at SYDNEY

Date: 29th October 1981

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	CREEK		RIVER		TAILINGS DAM	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	75.2		80.5		875	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	54		60		760	
Total Hardness (EDTA) as mg/L $CaCO_3$	14		20		480	
Calculated Hardness as mg/L $CaCO_3$						
pH	6.8		6.9		7.0	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	7.4	0.322	8.2	0.357	16	0.70
Potassium K^+	0.73	0.019	0.93	0.024	10.9	0.28
Calcium Ca^{++}	2.3	0.115	2.6	0.130	140	6.99
Magnesium Mg^{++}	2.5	0.206	4.6	0.378	25	2.06
		0.662		0.889		10.03
Chloride Cl^-	14	0.394	14	0.394	14	0.39
Carbonate $CO_3^=$	Nil		Nil		Nil	
Bicarbonate HCO_3^-	16	0.262	27.8	0.457	25	0.41
Sulphate $SO_4^=$	< 0.2		0.8	0.016	465	9.69
Nitrate NO_3^-	0.65	0.010	0.50	0.008	2.0	0.03
Fluoride F^-	0.04	0.002	0.05	0.003	8.6	0.45
		0.668		0.878		10.97
Total Alkalinity $CaCO_3$	13.3	0.266	22.9	0.458	20.6	0.41
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of

271

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

72 276

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

AUSTRALIAN GROUNDWATER CONSULTANTS
PTY. LTD.
582 St. Kilda Road, Melbourne
Victoria 3004

Attn: Stephen Hancock
Principal Consultant

cc: CLEVELAND MINE
LUINA, TASMANIA 7321

Attn: Mr. G . McArthur
Senior Mine Geologist

CERTIFICATE OF WATER ANALYSIS

Date: 29th October 1981

SOURCE OF WATER						
SAMPLE No.	C1456		C1462		C1528	
DATE OF COLLECTION						
Conductivity ($25^{o}C \mu$ mhos cm^{-1})	420		457		500	
Resistivity ($25^{o}C$ ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	296		340		314	
Total Hardness (EDTA) as mg/L $CaCO_3$	200		230		210	
Calculated Hardness as mg/L $CaCO_3$						
pH	7.6		7.9		8.1	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^{+}	12	0.522	12	0.522	13	0.566
Potassium K^{+}	2.50	0.064	2.4	0.061	2.00	0.051
Calcium Ca^{++}	44	2.196	51.0	2.545	55	2.745
Magnesium Mg^{++}	20	1.645	26.9	2.212	24	1.974
		4.427		5.340		5.336
Chloride Cl^{-}	17.5	0.494	21	0.592	26	0.733
Carbonate $CO_3^{=}$	Nil		Nil			
Bicarbonate HCO_3^{-}	97	1.590	114	1.868	177	2.901
Sulphate $SO_4^{=}$	130	2.708	145	3.020	92	1.916
Nitrate NO_3^{-}	0.55	0.009	0.55	0.009	.50	0.008
Fluoride F^{-}	1.48	0.078	1.72	0.091	1.24	0.065
		4.879		5.580		5.623
Total Alkalinity $CaCO_3$	80	1.600	93.7	1.874	14.5	2.900
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms.

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 277

Australian Groundwater Consultants

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C1536		C1551		C1554	
DATE OF COLLECTION						
Conductivity ($25^{\circ}C$ μ mhos cm^{-1})	320		315		278	
Resistivity ($25^{\circ}C$ ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	118		240		210	
Total Hardness (EDTA) as mg/L $CaCO_3$	140		160		130	
Calculated Hardness as mg/L $CaCO_3$						
pH	8.1		8.1		8.2	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	14	0.609	14	0.609	13	0.566
Potassium K^+	2.70	0.069	2.6	0.066	1.9	0.049
Calcium Ca^{++}	42	2.096	39	1.946	36	1.796
Magnesium Mg^{++}	12	0.987	16	1.316	10.2	0.839
		3.659		3.937		3.250
Chloride Cl^-	24.6	0.694	24.6	0.694	26	0.733
Carbonate $CO_3^=$			Nil		Nil	
Bicarbonate HCO_3^-	166	2.720	194	3.179	159	2.606
Sulphate $SO_4^=$	16	0.333	11	0.229	9	0.187
Nitrate NO_3^-	0.48	0.008	0.42	0.007	0.44	0.007
Fluoride F^-	1.0	0.053	1.44	0.076	0.46	0.024
		3.808		4.185		3.557
Total Alkalinity $CaCO_3$	136	2.720	159	3.180	130	2.600
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities Australia. The test(s) reported herein

273

SGS Australia Pty. Ltd.

72 278

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

Australian Groundwater

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C1608		C1611		C1615	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	1275		1600		1575	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	1,130		1,420		1,260	
Total Hardness (EDTA) as mg/L $CaCO_3$	780		980		820	
Calculated Hardness as mg/L $CaCO_3$						
pH	8.2		7.8		7.8	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	28	1.22	58	2.52	88	3.83
Potassium K^+	5.9	0.15	10.0	0.26	14.3	0.37
Calcium Ca^{++}	185	9.23	220	10.98	190	9.48
Magnesium Mg^{++}	78	6.42	100	8.23	102	8.39
		17.02		21.99		22.07
Chloride Cl^-	28	0.79	35	0.99	49	1.38
Carbonate $CO_3^=$	Nil		Nil		Nil	
Bicarbonate HCO_3^-	370	6.06	600	9.83	790	12.95
Sulphate $SO_4^=$	520	10.83	600	12.50	360	7.50
Nitrate NO_3^-	0.40	< 0.01	0.45	< 0.01	0.42	< .01
Fluoride F^-	2.08	0.11	1.76	0.09	2.52	0.13
		17.80		23.42		21.97
Total Alkalinity $CaCO_3$	300	6.00	492	9.94	645	12.90
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 279

Australian Groundwater

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C 1627		C1633		C1634	
DATE OF COLLECTION						
Conductivity ($25^{\circ}C$ μ mhos cm^{-1})	1310		3,650		2,500	
Resistivity ($25^{\circ}C$ ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	930		2,700		1,800	
Total Hardness (EDTA) as mg/L $CaCO_3$	550		700		900	
Calculated Hardness as mg/L $CaCO_3$			460		630	
pH	8.2		8.6		8.2	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	115	5.00	760	33.06	350	15.23
Potassium K^+	15.8	0.40	110	2.81	44	1.13
Calcium Ca^{++}	87	4.34	36	1.80	100	4.99
Magnesium Mg^{++}	78	6.42	111	9.13	127	10.44
		16.16		46.80		31.79
Chloride Cl^-	49	1.38	316	8.91	133	3.75
Carbonate $CO_3^=$	Nil		39.5	1.32		
Bicarbonate HCO_3^-	900	14.75	2110	34.58	1500	24.59
Sulphate $SO_4^=$	70	1.46	21	0.44	16	0.33
Nitrate NO_3^-	0.38	< .01	0.85	.01	0.45	< .01
Fluoride F^-	2.96	0.16	14.8	0.78	5.6	0.30
		17.76		46.04		28.98
Total Alkalinity $CaCO_3$	738	14.75	1730	34.58	1230	24.60
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This laboratory is registered by the National Association of Testing Authorities, Australia. The test/s reported herein have been performed in accordance with its terms of

SGS Australia Pty. Ltd.

NEW SOUTH WALES
74 McEvoy St., Alexandria, Sydney, N.S.W. 2015
Telephone 699 7625 Telex: SGSSYD AA22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park
Telephone 458 1421 Telex: SGSPTH AA92624

Australian GroundWater

Our ref La.0129

Your ref

Date received

Date completed

Issued at

ANALYTICAL REPORT

	Sample Ref.	mg/L Fe	mg/L Mn	mg/L Zn			µg/L Cu	µg/L Pb	µg/L As		
1	C1456A	12.6	3.3	0.088			7.1	16	32		
	1462A	6.3	3.3	0.125			1.5	7.1	3		
3	1528A	12.4	1.65	0.245			8.8	13	32		
	1536A	1.7	0.315	0.017			1.55	15	2.5		
	1551A	1.6	0.340	0.025			48	6.7	6		
6	1554A	6.3	0.640	0.045			14.8	10.4	7		
	1608A	7.1	1.620	0.021			1.7	15	19		
8	1611A	6.9	2.7	0.029			3.1	35	23		
	1615A	7.9	1.710	0.030			18.4	35	12		
	1627A	7.0	0.470	2.000			12.7	40	2		
11	1633A	21.0	0.610	0.026			2.9	40	18		
	1634A	17.7	0.660	0.065			9.4	35	7		
13	CREEK A	0.040	0.015	0.020			1.6	2.1	2		
	RIVER A	0.230	0.010	0.014			1.4	1.5	1		
15	TAILINGS DAM A	9.8	5.2	0.062			10.7	12	5		
16											
18											
20											

72 281 GJM

276

The Australian
Mineral Development
Laboratories

Flemington Street, Frewville,
South Australia 5063
Phone Adelaide 79 1662
Telex AA 82520

Please address all
correspondence to
P.O. Box 114 Eastwood
SA 5063
In reply quote:

amdel 3/43/6/0 - AC 982/82

NATA CERTIFICATE

14 September 1981

REPORT COMPLETE

The Manager
Cleveland Tin Limited
LUINA TASMANIA 7321

REPORT AC 982/82

YOUR REFERENCE:	Order Number 16899
IDENTIFICATION:	As listed
DATE RECEIVED:	20 August 1981

D.K. Rowley
Manager
Analytical Chemistry Division

for Norton Jackson
Managing Director

dam

Pilot Plant: Osman Place
Thebarton S.A.
Telephone 43 8053
Branch Laboratory: Perth

This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration. This document shall not be reproduced except in full.

Cleveland Tin Limited

Sample of mine gas from DDH C1633

Results of Analysis

Oxygen plus argon	0.22% mol vol
Nitrogen	0.96
Carbon monoxide	not detected (<250 ppm)
Carbon dioxide	98.8 by difference
Methane	0.04
Higher hydrocarbons	not detected (<20 ppm)

FOLEY ZONE DRILL HOLES - GROUNDWATER CONTROL

Hole No.	Collar Location	Collar Azimuth (degrees)	Collar Dip (Degrees)	Wooden Plug (Seeled)	Aluminium Plug (Seeled)	No. Problems	Remarks
C1485	17 B Sth.Drive Gd Section	132°	-75°			X	
C1501	17 B Sth.Drive Gj Section	312°	-75°			X	
C1570	20/22L/Bay J Section	312°	-80°			X	
C1608	25 L/Bay	132°	-47°			X	
C1611	25 L/Bay	132°	-69°			X	
C1615	25 L/Bay		-90°		X		
C1627	25 L/Bay Ga Section	133°	-42°		X		
C1633	20/22 L/Bay J Section	132°	-80°		X		Plug temporary with Bullhose and Clamps. Dangerous - High Pressure.
C1634	25 L/Bay Ga Section	132°	-64°		X		
C1637	25 L/Bay Ga Section	200°	-50°		X		
C1642	25 L/Bay Ga Section	200°	+15°		X		
C1713	20/22 L/Bay 4960 E	200°	-58°			X	
C1730	25/26 D/D Plat.5000 E	207°	-13°		X		
C1741	25/26 D/D Plat.5000 E	207°	-39°		X		
C1754	25/26 D/D Plat.5040 E	200°	-39°	X			
C1786	22 L/Bay 5080 E	207°	-54°			X	
C1800	22 L/Bay 5080 E	207°	-39°			X	
C1803	25 L/Bay 5040 E	199°	-48°		X		
C1809	25 L/Bay 5040 E	199°	-21°		X		
C1811	25/26 D/D Plat.5000 E	207°	-5°		X		
C1822	25 L/Bay 5040 E	199°	-9°		X		
C1824	25 L/Bay 5040 E	199°	-36°	X			
C1826	25 L/Bay 4920 E	200°	-32°	X			
C1832	25/26 D/D Plat.5000 E	209°	+ 5°30"			X	
C1833	25 L/Bay 4920 E	200°	-22°	X			
C1840	25 L/Bay 4920 E	200°	-9°	X			
C1842	25/26 D/D Plat.5000 E	200°	+16°			X	
C1852	25 L/Bay 4960 E	193°	-38°	X			
C1860	25 L/Bay 4960 E	193°	-27°	X			
C1865	25 L/Bay 4960 E	193°	-14°	X			
C1869	25 L/Bay 4880 E	220°	-38°	X			

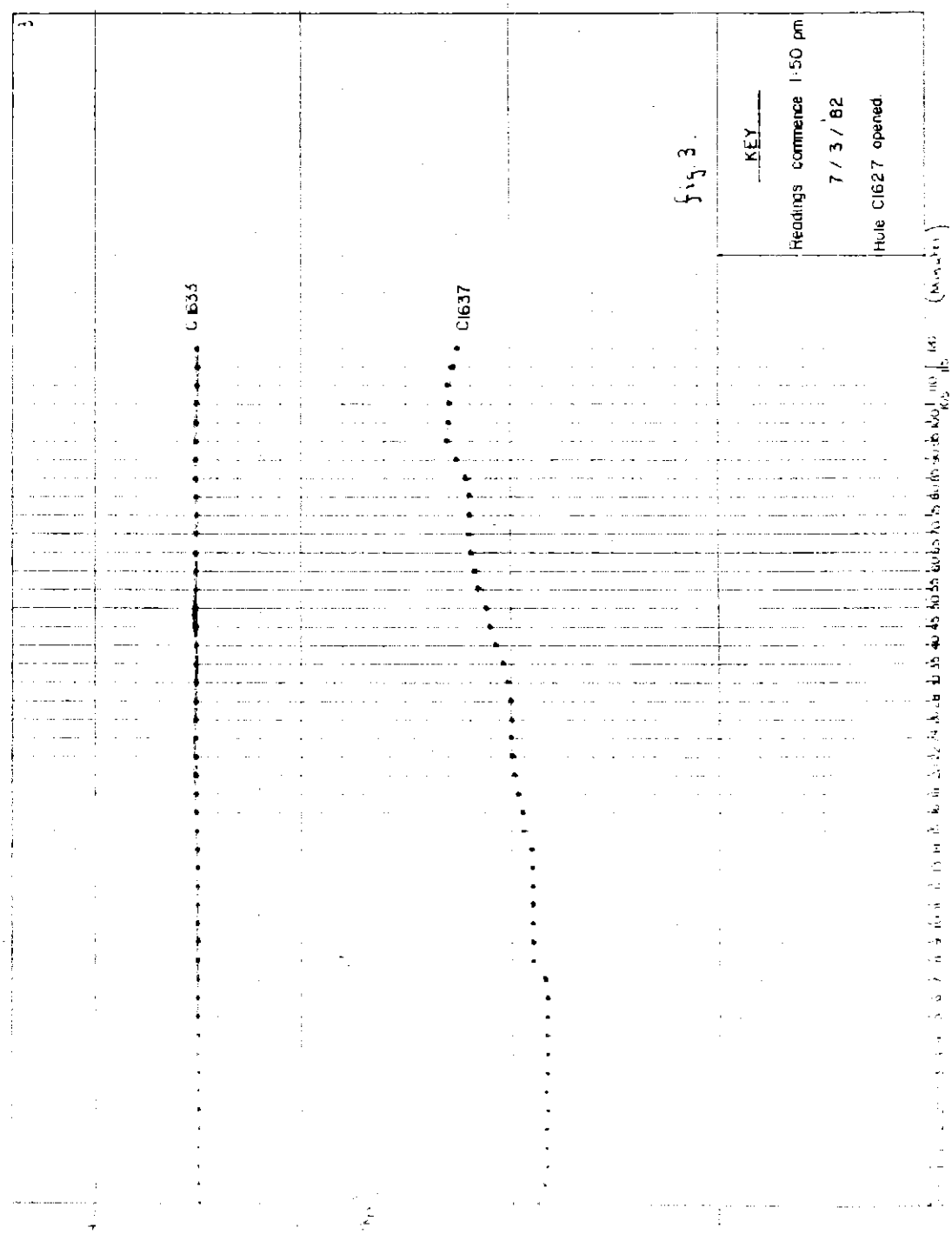

KEY
Readings commence 1:50 pm
7 / 3 / 82
Hole C1627 opened.
C1633
C1637

Fig. 3.

72 285

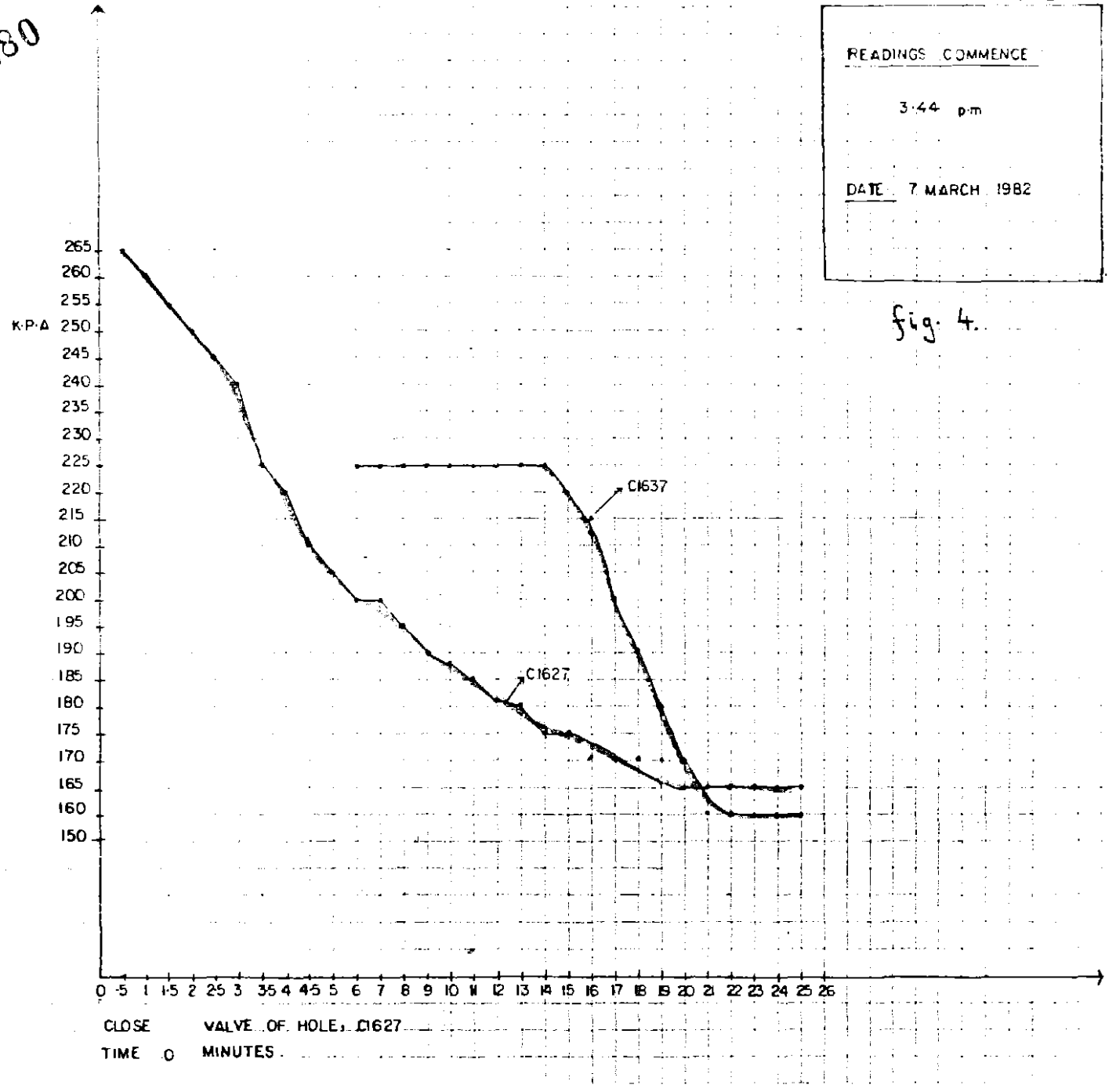
280

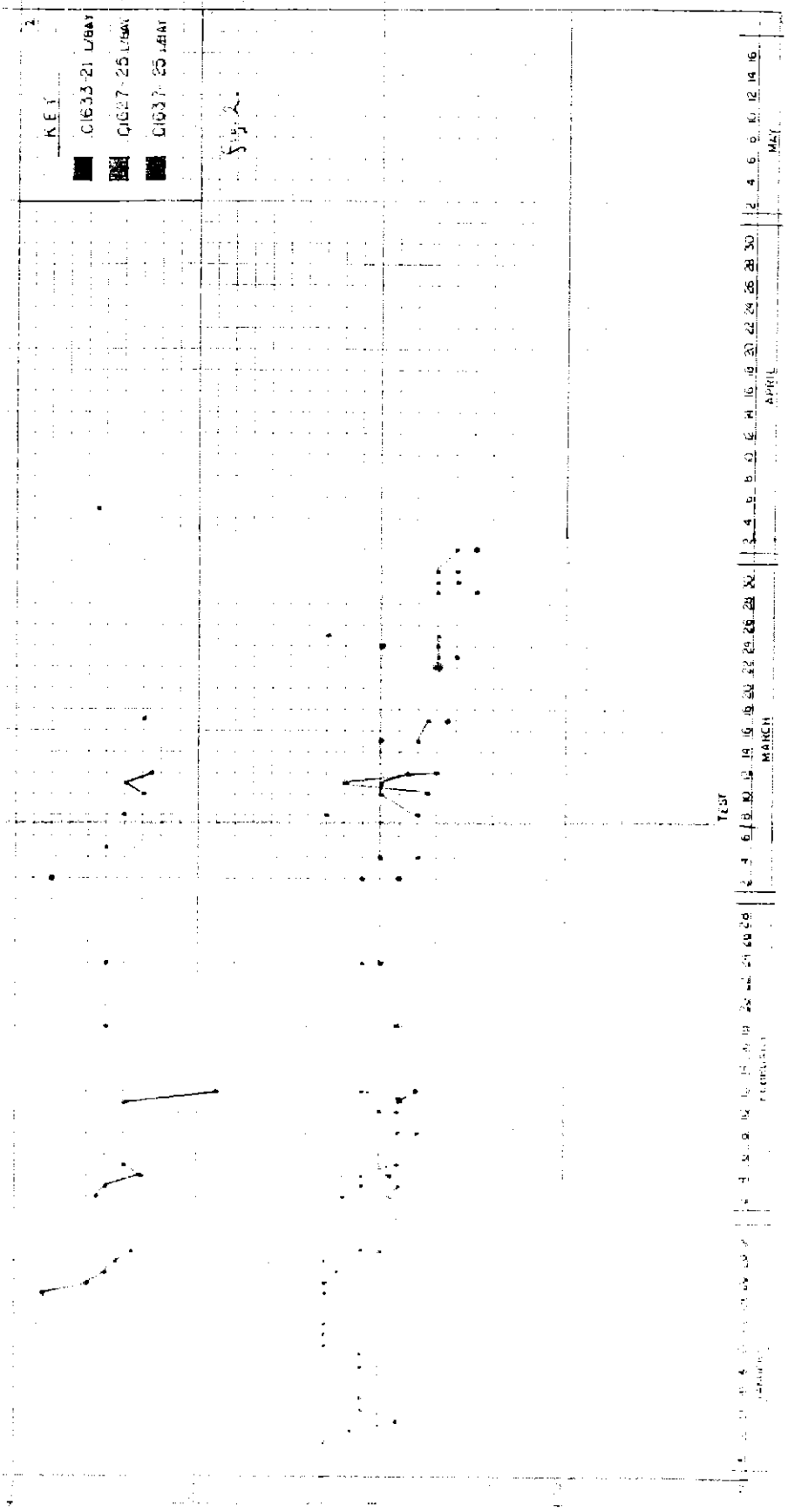
READINGS COMMENCE

3·44 p.m

DATE 7 MARCH 1982

fig. 4.




KEY
MARCH
APRIL
MAY

282

72 287

CLEVELAND TIN LIMITED

Job 721

December 1981

CLEVELAND MINE

WATER INFLOW PROBLEMS

Hydrochemical Results and Evaluations

AUSTRALIAN
GROUNDWATER
CONSULTANTS
Pty. Limited

CONTENTS

		Page
1.	INTRODUCTION	1
2	GENERAL PARAMETERS vs DEPTH	1
2.1	Total Dissolved Solids	1
2.2	Temperature	1
2.3	Chloride	2
2.4	Bicarbonate	2
2.5	Other Ions	2
3	SCHOELLER PLOTS	2
4	PIPER DIAGRAMS	3
5	TRACE ELEMENTS	3
6	CARBON DIOXIDE	4
7	IMPACT OF THE HYDROCHEMISTRY	4
8	FORWARD PROGRAMME	5
9	CONCLULSIONS	5
10	RECOMMENDATIONS	5

TABLES

NO.	
1	SCHOELLER'S CLASSIFICATION
2	FREE CARBON DIOXIDE EVALUATION

FIGURES

NO.	
1	PLAN PROJECTION
2	SCHEMATIC LONGITUDINAL PROJECTION
3	TDS vs DEPTH
4	TEMPERATURE vs DEPTH
5	CHLORIDE vs DEPTH
6	BICARBONATE vs DEPTH
7	SODIUM vs DEPTH
8	CALCIUM vs DEPTH
9	MAGNESIUM vs DEPTH
10	SULPHATE vs DEPTH

FIGURES Cont.

NO.	
11	PIPER TRILINEAR - LUINA
12	SCHOELLER DIAGRAM BORE C1456
13	" C1462
14	" C1528
15	" C1536
16	" C1551
17	" C1554
18	" C1608
19	" C1611
20	" C1615
21	" C1627
22	" C1633
23	" C1634
24	" CREEK
25	" RIVER
26	TAILINGS DAM
27	TRACE ELEMENTS BORE C1456
28	" C1462
29	" C1528
30	" C1536
31	" C1551
32	" C1554
33	" C1608
34	" C1611
35	" C1615
36	" C1627
37	" C1633
38	" C1634

APPENDIX

NO.	
I	WATER ANALYSES REPORT

1. INTRODUCTION

Water analyses have recently been received from SGS Australia Ltd of the samples of mine water sent for evaluation. These have been studied to identify their chemical characteristics as a guide to the genesis of the water and their consistency of character.

The technique used in these studies have included plots of various measured parameters against depth of hole bottom -

- study of Schoeller diagrams of gross parameters,
- study of Piper Trilinear diagrams, and
- study of the trace elements analysed

The actual analysed results as presented by SGS Australia Ltd are included as Appendix I. Table 1 presents a general statement of the holes from which waters were taken for analysis and the results therefrom.

2. GENERAL PARAMETERS vs. DEPTH

2.1 Total Dissolved Solids (TDS)

The plot of TDS vs. depth was undertaken to determine whether there was consistency in TDS increase with depth being taken as a possible analog for distance of travel. Dependent on which value of TDS is used (AGC ex EC or SGS by evaporation) it is apparent that there is a steady increase in TDS with RL decrease to bottom of hole. Only three holes fall outside the relationship, these being :-

- C1615 which appears less saline than would be expected for the bottom hole depth, and
- C1456 and 1462 which are more saline than would be expected.

The latter two are really not significant since they are quite shallow and lie in the range of salinity which seems to be the lower limit for infiltrated waters.

The plot of C1615 however suggests that either the hole intersected a highly permeable conduit about RL 200m which is fed from that level, or via a path with different character to the other holes. The results do not tie up with either of the water intersection zones possible for that hole hence, the anomaly is at present unresolved.

2.2 Temperature

As an indication of water movement in the wells the temperature of the water flow is a good indication. However, the very low flows which apply for many of the holes can result in the true temperatures being partly obscured.

There are fewer points in this plot and in general the results are consistent. While C1615 and C1633 show markedly higher temperature than would appear to be normal for their depth. The depth/temperature gradient between these is similar to that for the shallower holes. Since they are the high rate discharge wells it seems possible that the other waters may be cooled by contact with cooler rocks at low flow rates.

2.3 Chloride

The only source for chloride ions in water is from oceanic origins or solution of connate waters. The latter are not expected to be significant in the formation around the Cleveland Mine, hence the variation in chloride is a good base against which to judge variations of other ions.

In general, the plot shows a small increase in Chloride level with depth with C1634 and C1633 showing very much higher levels. This is indicative of stagnant waters undergoing either osmotic concentration or density concentration.

2.4 Bicarbonate

The plot of bicarbonate as milli-equivalents against RL shows a general but variable increase with depth. Again C1615 is anomalously low but this is less because of the less well defined trend.

2.5 Other Ions

Of the other ions :-

Sodium matches the chloride ion plot quite closely at shallow depths but shows marked variations in C1633.

Calcium and Magnesium do not show any level of real fit, rather a broad scatter.

Sulphate shows no relation to depth at all.

3. SCHOELLER PLOTS

The Schoeller Plots of milli-equivalent concentrations of the gross parameters fall into six classes, five if the tailings waters are included. These are presented in Table 2 and the Schoeller plots as Figures 12 - 26.

The probable progenitor water for the mine must be considered to be the creek waters which shows the characteristics of Na> Mg > Ca and CL> HCO_3 >> SO_4. These then become the base for comparison for other waters.
The first group of waters excluding the river and tailings dam include all these waters intersected above RL 1000. These are all Ca > Mg > Na which indicates the exchange of Mg for Na on the mineral lattices in the sequence as well as hydrolysis of limestones and perhaps dolomites.

At the same time the same group of waters are oxidizing sulphides to sulphates and the products of hydrolysis of carbonate minerals are released as HCO_3 ions. The latter progressively dominates SO_4 as the waters move deeper with their oxidation potential becoming exhausted.

The second group commences with C1608 at bottom of hole RL at 840m and includes C1611 and C1615 to RL 569 but not C1627 or C1634 through the first two at least cover the same depth range. The cations range in this group is a progression from the former group but has Na proportion on the decline. In fact, in this group Na has increased markedly in real terms but not at the same rate as the Ca and Mg contents. This is probably due to the combined action of limestone hydrolysis and magnesiumexchange for sodium ions on chlorites and other micaceous minerals in the rock mass.

The anions accompanying this second group are variable with sulphate being significantly increased to be higher than both chloride and even the bicarbonate in at least the shallower two holes. This seems likely to be due to their being waters from within an ore body whereas C1615 may derive its water from outside the ore body.

The third group is C1627 on its own and has Mg> Na > Ca and HCO_3 > SO_4 > Cl. Again, this may be a local anomaly both in the cations and anions since the hole has not apparently drilled through the quartz porphyry contact zone ore body.

The final group includes C1633 and C1634 and is a very characteristic water. The waters are more saline than any of the others by a factor of 2 or more. They are similar to the river water but have a higher HCO_3 proportion. They both tap much the same geological environment though at different depths. Other anomalies suggest the two waters could be closely related.

4. PIPER DIAGRAMS

Piper diagrams are a plot of the variations in milli-equivalent proportions within a group of waters and they allow different groups to be identified and the hydrochemical evolution of waters to be traced. The critical portion of the plot is the gradient which combines the anion and cation plots. The Piper plot of the Cleveland waters is presented as Figure 39.

In Figure 26 it is apparent that the tailings dam waters are not in evidence in any of the shallow groundwaters. It is also apparent that for most of the waters the groundwaters are recharged by the stream but are not significantly contributary to them.

The most active zone of water circulation includes holes C1462, C1456 and C1608 which pass down through C1611, C1528 and C1615 to stagnate in the remainder. This may overstate the case however, since clearly much water mixing exists at least through the first group and two sources of bicarbonate exist namely from soil bacteria and from hydrolysis of carbonates.

Holes C1627, C1634 and C1633 are truely stagnant waters. They are sourced from the river and creek waters but they are not undergoing active change. They appear to be in a cell by themselves and only by repeated analysis would their trend be revealed. The feeder waters to them appear to be through C1611 and C1615.

5. TRACE ELEMENTS

The analytical results of the trace elements are plotted as signatures on Figures 27 to 38 but the scale changes and unit changes should be noted.

In general, the shallower waters above RL 900m are extremely variable with Fe varying from 1.6 to over 10 mg/L and Mn varying from less than 1.0 to over 30 mg/L. Zinc, copper, lead and arsenic are similarly variable and show no consistent pattern. The problem appears likely to result from mixing of waters in this most active circulation region with frequent variation in oxidation potential, even though all the waters are now in a strongly reducing state (negative redox potential).

288

The deeper waters tend to show a more even pattern for these trace metals. Fe is generally high and becomes higher with depth. Mn is relatively consistent throughout at levels less than 3mg/l with a tendency to decline with depth. Zinc is anomalously high in C1627 but is generally higher in C1634, otherwise it is reasonably stable.

Copper is variable and probably reflects the variability of the mineralization, being highest in the holes where zinc also is highest, i.e. C1627. Lead follows much the same trend.

All trace element values of the groundwaters are well in excess of any levels in the local creeks but the tailings dam has comparable values.

6. CARBON DIOXIDE

Table 2.

Table 3 presents the results of the free carbon dioxide determinations made based on the bicarbonate content, the pH and the temperature as measured in the field. Holes C1627, C1633 and C1615 have very significant levels of free CO_2.

The actual volume which will be released per volume of water however depends on the temperature and pressure at which the carbon dioxide was taken into solution and the pressure on release.

The carbon dioxide seems to derive largely from acid hydrolysis of limestones by sulphate waters. This process seems to be most active in depths below RL 800m. At these depths the bicarbonate concentration increases by a factor of four within 100m whereas Cl^- only increases by two. This indicates that the CO_2 is probably taken into solution under a hydrostatic head of 550m (RL 800m to creek level). Naturally on release at the surface the volume increases by this factor and hence, for C1633 the volume of gas to water at discharge will be approximately 2.5:1 or 71% of the flow at least.

7. IMPACT OF THE HYDROCHEMISTRY

The evaluation of the hydrochemistry indicates that in general, the waters intercepted in drilling the new ore body associated with the quartz porphyry intrusive seem to fall into two groups.

The first group includes those which have tapped the footwall side shallow, e.g. C1608 and C1611 and which are part of a general groundwater cell which is associated with the shallower waters to the south.

The second group includes C1627, C1634 and C1633 which appear to be a separate cell of groundwaters recharged probably from the north via the limestones and perhaps being confined to the hanging wall of the Quartz Porphyry intrusive. Hole C1615 shows some characteristics which suggest that it may be a composite.

The deep waters analysed to date appear to be in storage and may pump out with time, but the temperature anomaly in C1615 and the general character of the waters suggests that they have direct access to the surface via a regional system through the limestones and that some water inflow may already be occurring with oxidation of sulphides creating heat in C1615 at least.

Clearly, the waters at depth and along the hanging wall of the intrusives (northern end) will carry substantial gas volumes but this will be largely carbon dioxide. Pumpage from this zone does not seem likely to induce oxygenated waters into the ore zone, but there is the possibility of some

8. FORWARD PROGRAMME

There is clearly a need to establish the extent of hydraulic interconnection between the hanging wall and footwall groundwater cells surrounding the Quartz Porphyry intrusive. In addition, there is need to monitor recovery and pressure decline rates with flow shut off and outflow on the holes intersecting the hanging wall cell.

Ultimately, it will be essential to carry out some drilling in order to identify the feeder conduits for the zone so that a grouting programme or some other sort of programme can be undertaken in order to mitigate or minimize any excessive mine inflow problems which may be identifed.

9. CONCLUSIONS

The waters intersected in the drilling of the deeper sections of the ore body surrounding the Quartz Porphyry intrusive appear on present data to be largely separate from the other waters intersected by drilling in the mine, and to be essentially isolated on the hanging wall side of the ore body. The waters have come through a largely non-mineralized limestone sequence and are essentially in store at depth due probably to the flow path being blocked by the intrusive.

The extent to which these waters will be recharged and to which flow will be maintained to openings, remains to be identified by hydraulic testing, but it is clear that at least for the period of flow there will be a major carbon dioxide release associated with them.

Of critical importance is the conducting of controlled hydraulic tests across the Quartz Porphyry intrusives to determine whether uncontrolled inflows around the Quartz Porphyry will cause oxygenated waters to inflow through the sulphide rich zones of the ore body. Some evidence exists that this may be happening, but it is very tenuous at present and of no real concern at this stage.

10. RECOMMENDATIONS

Since drilling is proceeding on site and hydraulic control works have been or are due to be implemented, it seems appropriate that before further work is undertaken, a further site conference should be held to bring all parties up to date.

Future work seems likely to include :-

- further sampling to detect significant hydrochemical trends,
- hydraulic testing of holes intersecting waters,
- structural mapping to identify and correlate fracture zones.

Australian Groundwater Consultants Pty Ltd
December 1981

TABLES

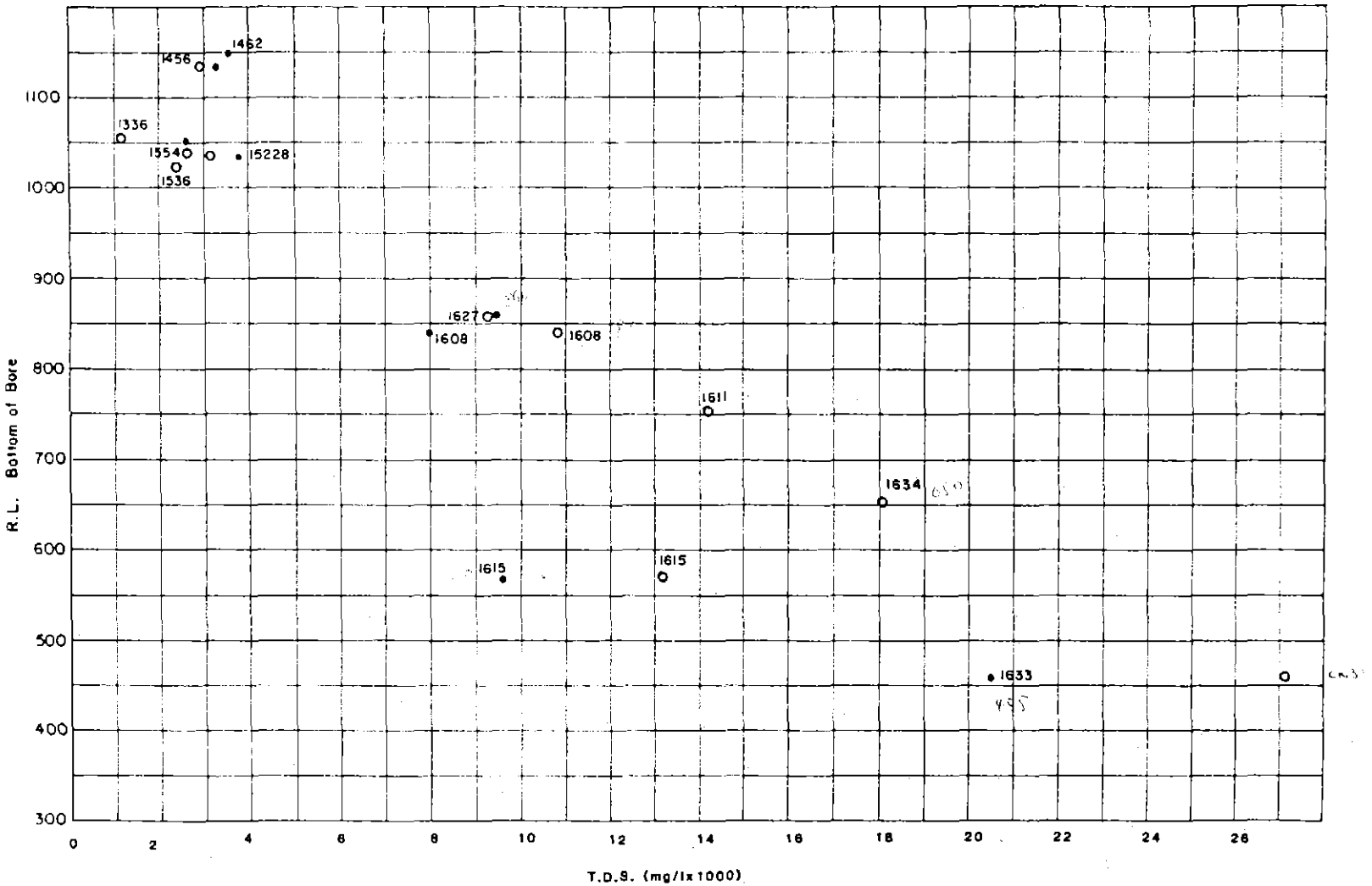
TABLE 1 : SCHOELLER'S CLASSIFICATION

Hole No.	B.H.R.L.	T.D.S.	Chloride	SO_4^{-2}	HCO_3^-	Cations	Anions
Creek	-	54					
River	-	60	N	N	L	Na>Mg>Ca	$Cl>HCO_3\gg SO_4$
Tailings	-	760	N	N	L	Na>Mg>Ca	$HCO_3>Cl>SO_4$
1456	1136	296	N	Av	L	Ca≫Mg>Na	$SO_4>HCO_3>Cl$
1462	1150	340	N	N	L	Ca>Mg>Na	$SO_4>HCO_3>Cl$
1528	1035	314	N	N	N	Ca>Mg>Na	$HCO_3>SO_4>Cl$
1536	1040	118	N	N	N	Ca>Mg>Na	$HCO_3>Cl>SO_4$
1551	1025	240	N	N	N	Ca>Mg>Na	$HCO_3>Cl>SO_4$
1554	1020	210	N	N	N	Ca>Mg>Na	$HCO_3>Cl>SO_4$
1608	840	1130	N	Av	N	Ca>Mg≫Na	$SO_4>HCO_3>Cl$
1611	750	1420	N	Av	H	Ca>Mg≫Na	$SO_4>HCO_3>Cl$
1615	569	1260	N	Av	H	Ca>Mg≫Na	$HCO_3>SO_4>Cl$
1627	860	930	N	N	H	Mg>Na>Ca	$HCO_3>SO_4\geqslant Cl$
1633	455	2700	N	N	H	Na≫Mg>Ca	$HCO_3\gg Cl>SO_4$
1634	650	1800	N	N	H	Mg≫Mg>Ca	$HCO_3\gg Cl>SO_4$

TABLE 2 : FREE CARBON DIOXIDE EVALUATION

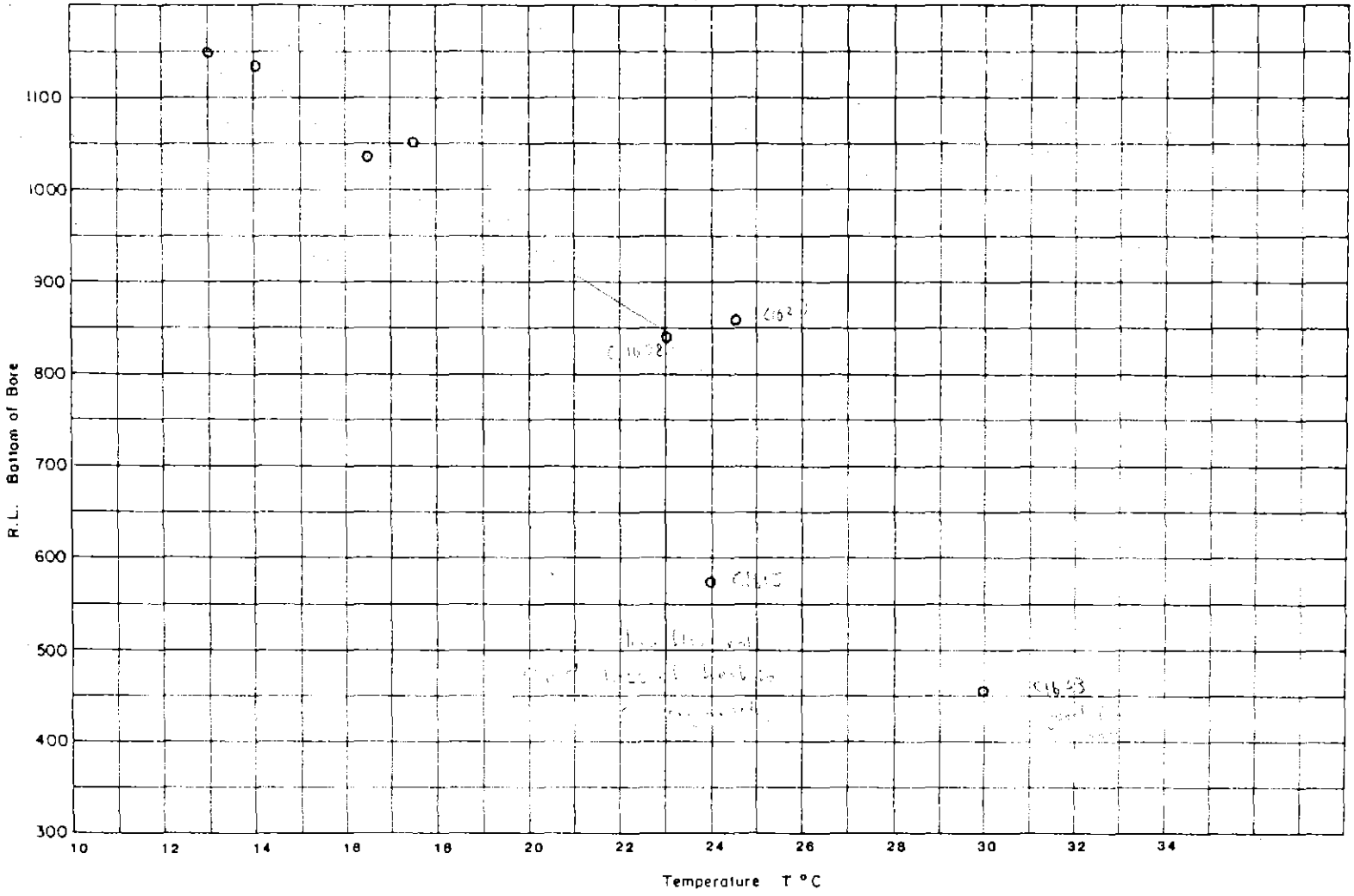
T.D.S.	Hole No.	RL (m)	pH	HCO_3 mg/L	HCO_3/CO_2 Ratio	Free CO_2 mg/L
2700	1633	455	6.0	2110	0.47	4489
1260	1615	569	5.8	790	0.28	2821
-	1634	650	-	-	-	-
-	1611	750	-	-	-	-
1130	1608	840	8.2	370	68.0	5.4
930	1627	860	5.8	900	0.28	3214

FIGURES



DRAWN	REVISIONS				NOTES:	Australian Groundwater Consultants Pty Limited Hydrologists and Engineers	CLEVELAND TIN LTD
TRACED	No.	Date		Appd.	Data		T.D.S. — DEPTH
APPROVED							DRG. No FIG 3

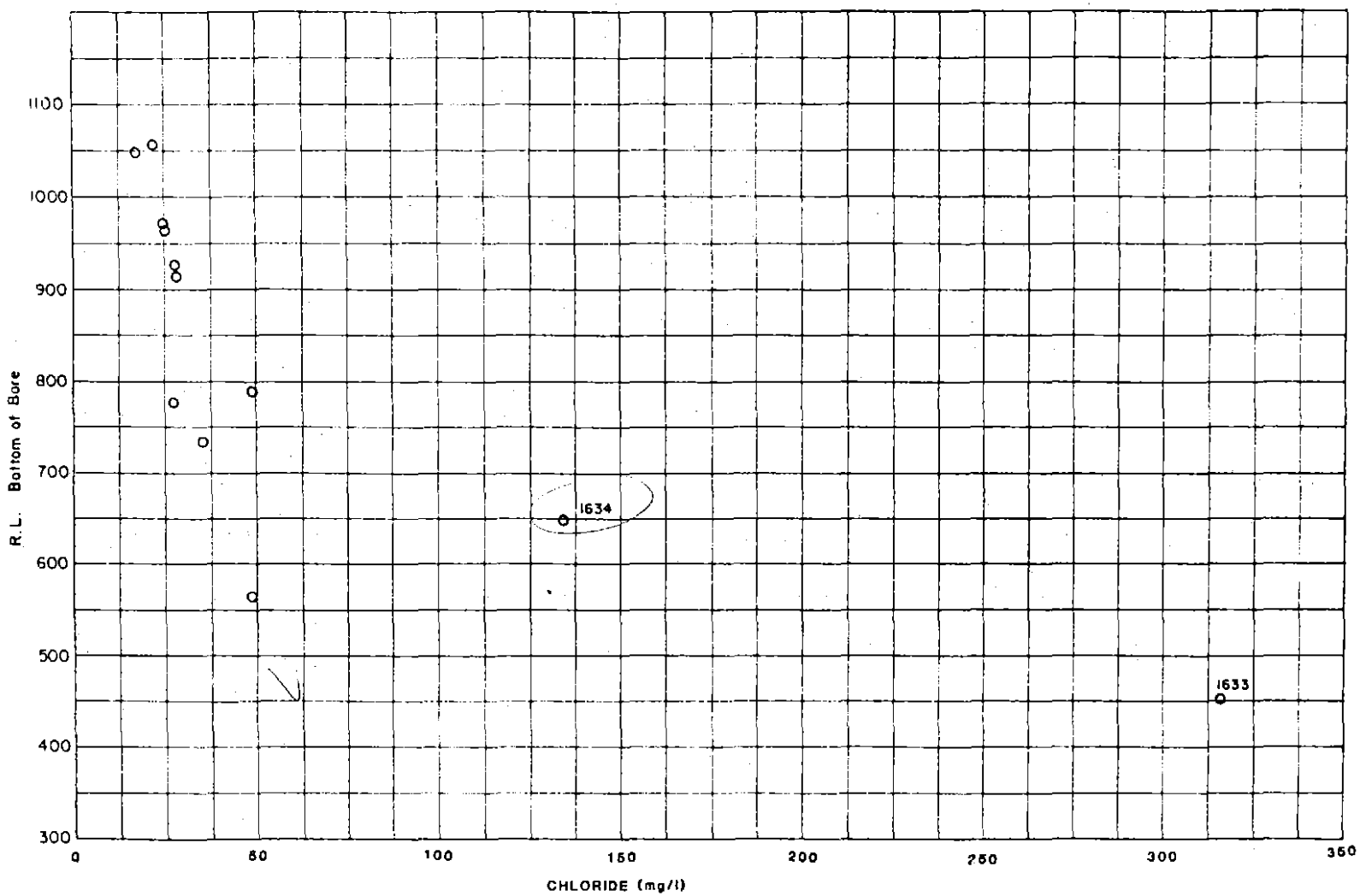
295



DRAWN	REVISIONS	NOTES: Data.	CLEVELAND TIN LTD
TRACED	No. Date Appd.		TEMP. — DEPTH
APPROVED		Australian Groundwater Consultants Pty Limited	DRG NO. Fig. 4

72 300

296

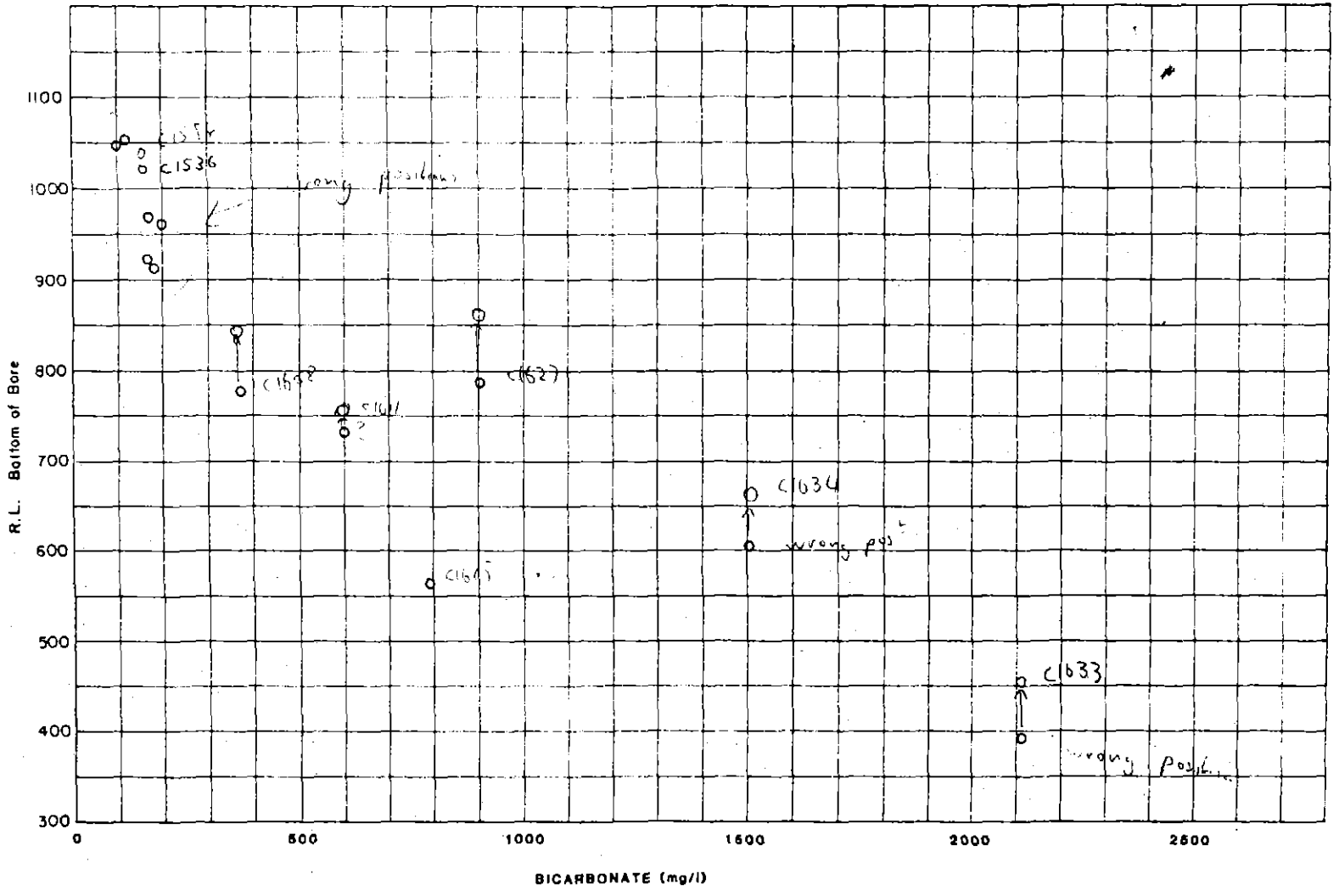


DRAWN	REVISIONS	NOTES:	CLEVELAND TIN LTD
TRACED	No. Date Amd.	Date	Cl^- — DEPTH
APPROVED			DRG. No. FIG 5

Australian Groundwater Consultants Pty Limited
Hydrogeologists and Engineers

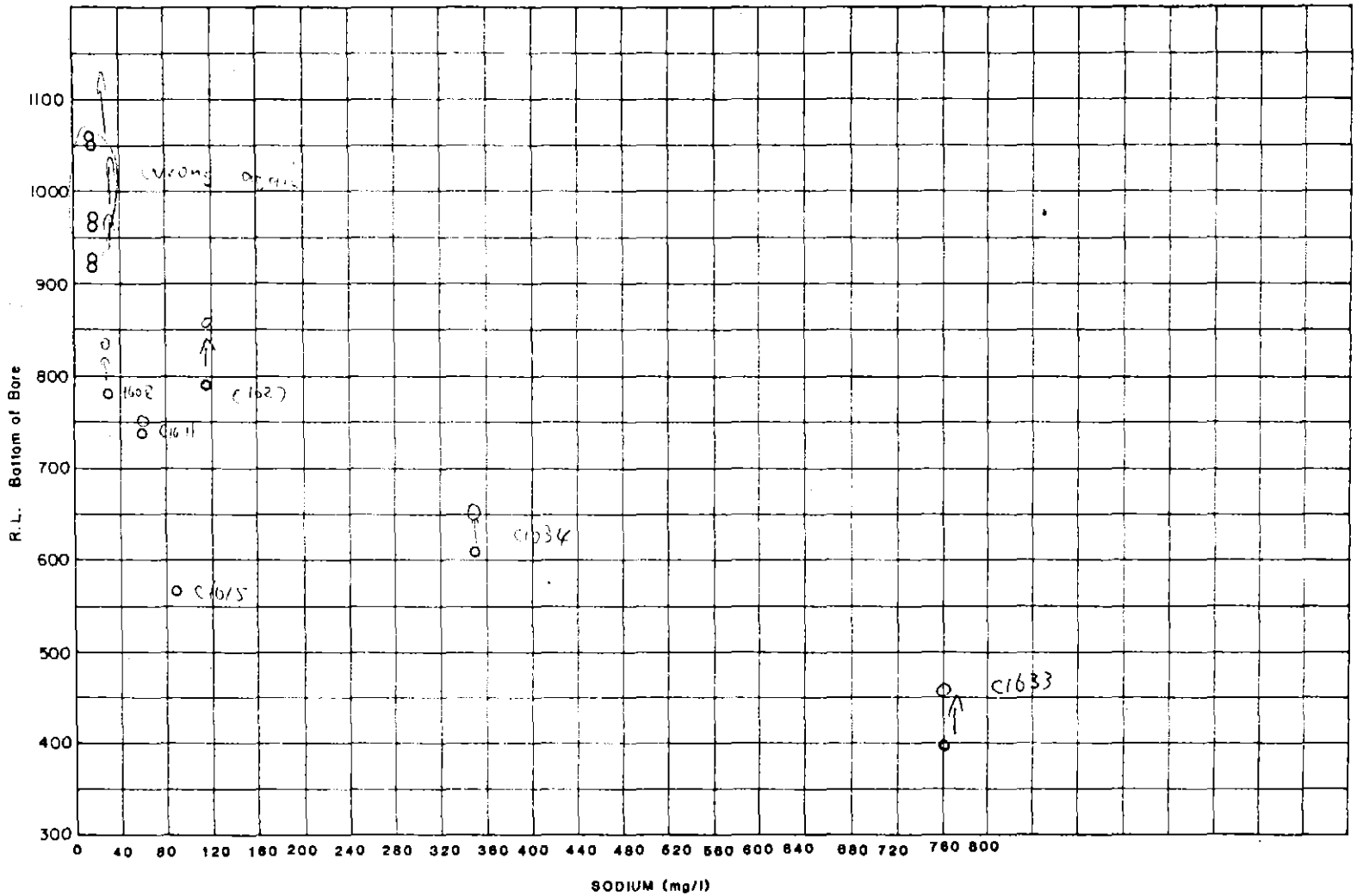
72 301

297



DRAWN	REVISIONS				NOTES:	Australian Groundwater Consultants Pty Limited	CLEVELAND TIN LTD
TRACED	No.	Date		Appd.	Date	Hydrologists and Engineers	HCO_3^- — DEPTH
APPROVED							DRG No. Fig 6

72 302



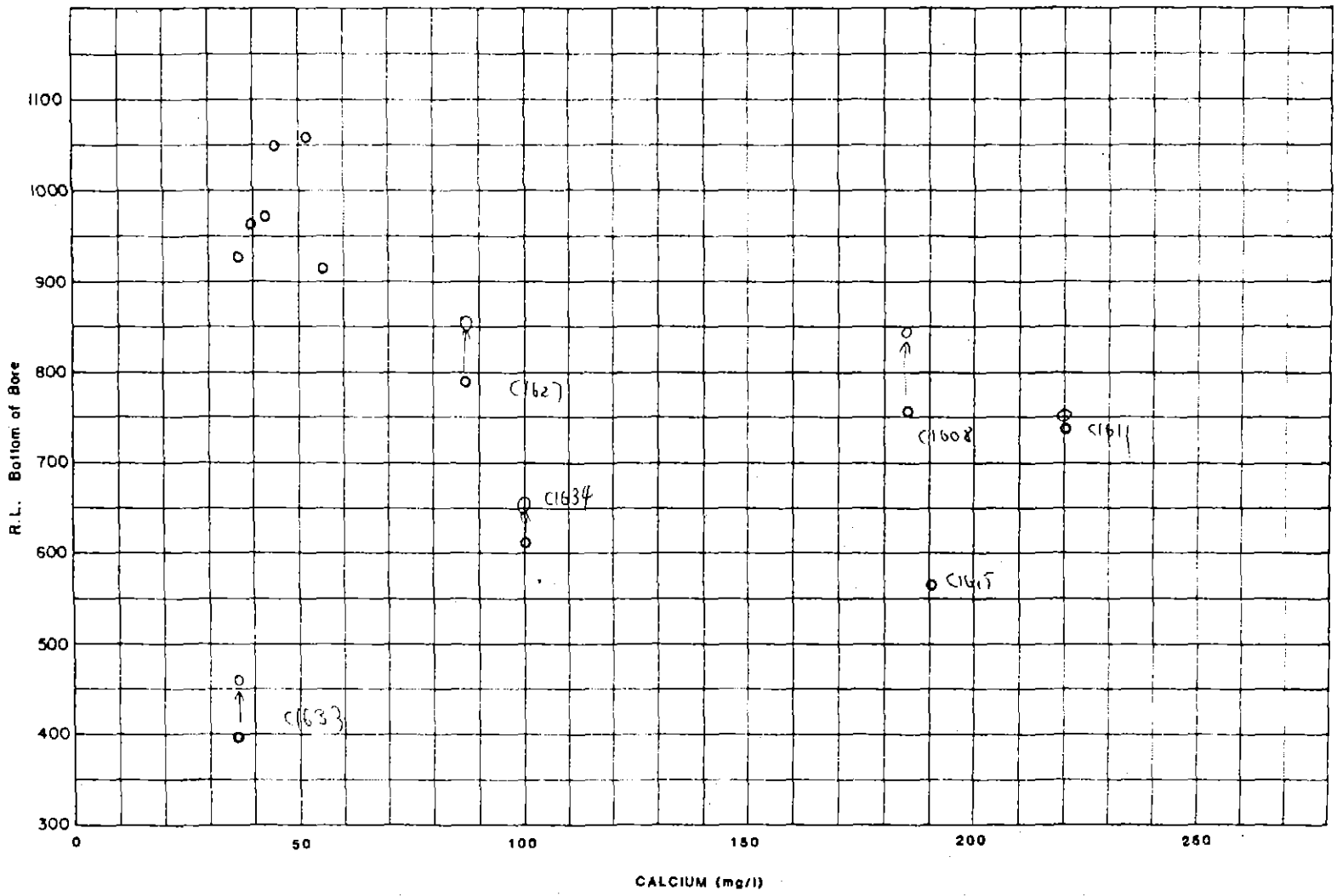
DRAWN	REVISIONS			NOTES
TRACED	No.	Date	Appd.	Date
APPROVED				

Australian Groundwater Consultants Pty Limited
Geohydrologists and Engineers

CLEVELAND TIN LTD

Na^+ — DEPTH

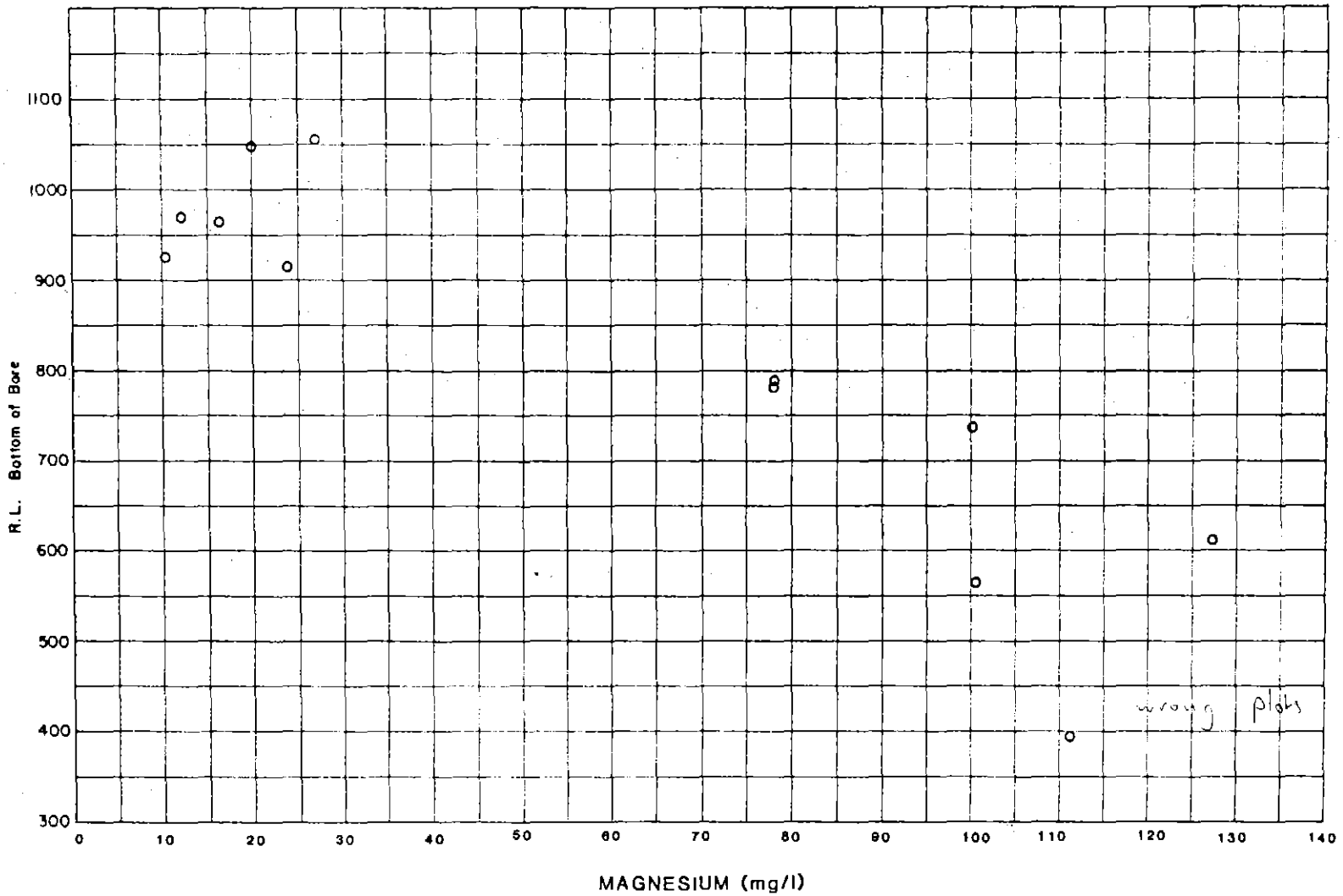
DRG No. FIG 7



DRAWN	REVISIONS	NOTES:	Australian Groundwater Consultants Pty Limited	CLEVELAND TIN LTD
TRACED	No. Date	Date	Geohydrologists and Engineers	Ca^{++} — DEPTH
APPROVED	Appd.			DRG. No. FIG 8

72 304

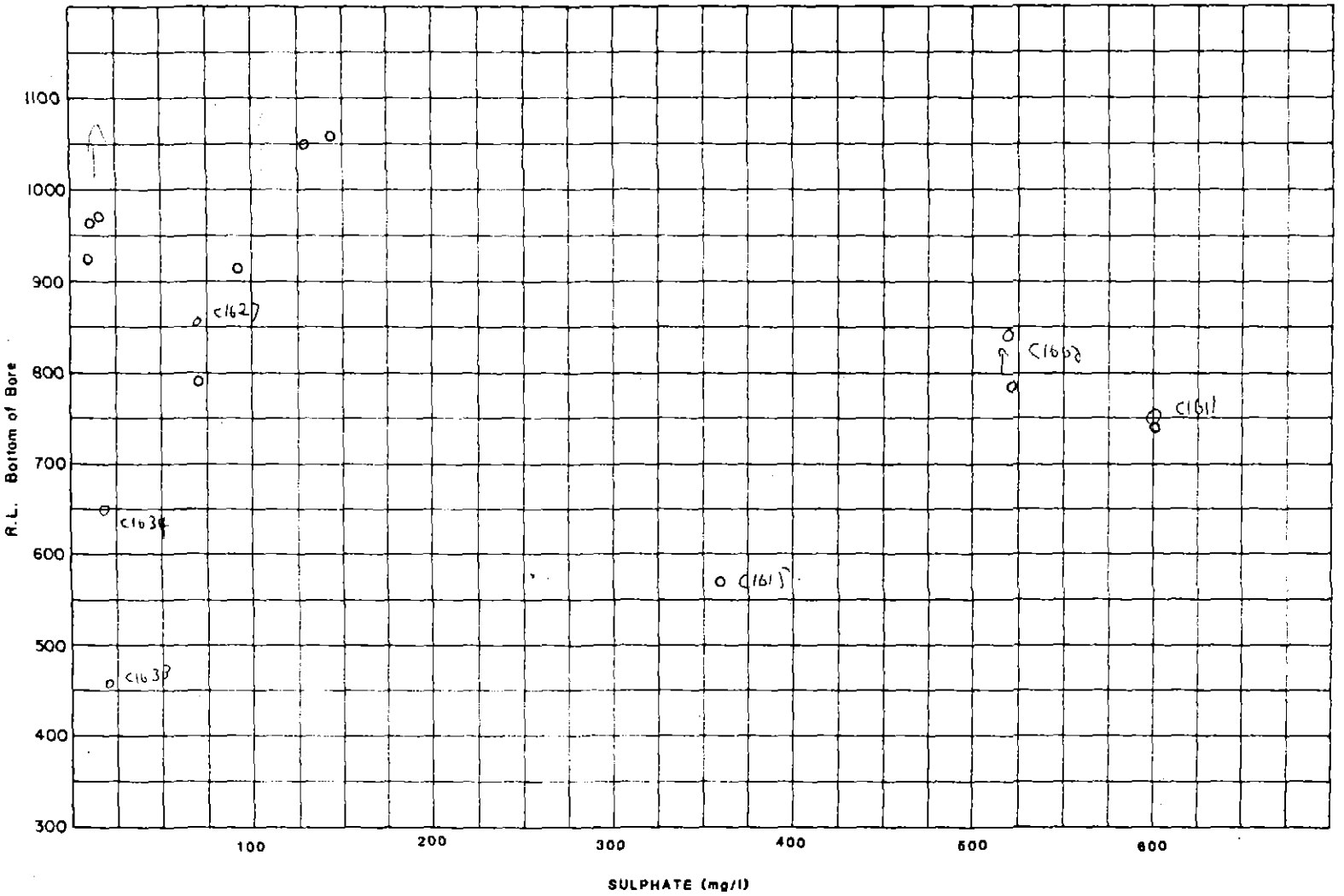
300



DRAWN	REVISIONS	NOTES:	CLEVELAND TIN LTD
TRACED	No. Date Amdt	Data	Mg^{++} — DEPTH
APPROVED			DRG. No. FIG 9

Australian Groundwater Consultants Pty. Limited
Hydrologists and Engineers

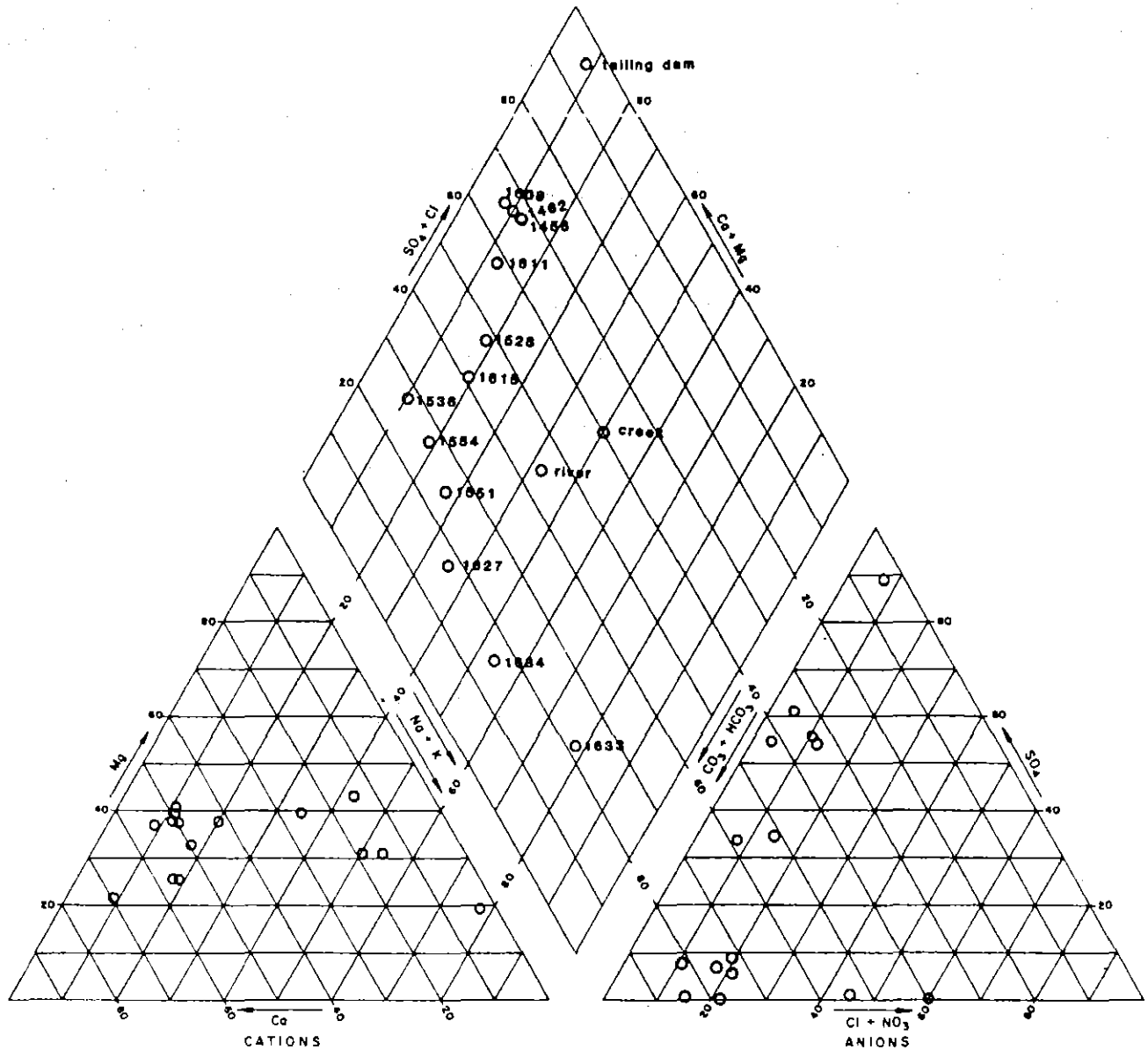
72 305



DRAWN	REVISIONS				NOTES:	Australian Groundwater Consultants Pty Limited	CLEVELAND TIN LTD
TRACED	No.	Date		Appd.	Date		$SO_4^=$ – DEPTH
APPROVED							ORG. No. FIG 10

72 306

302

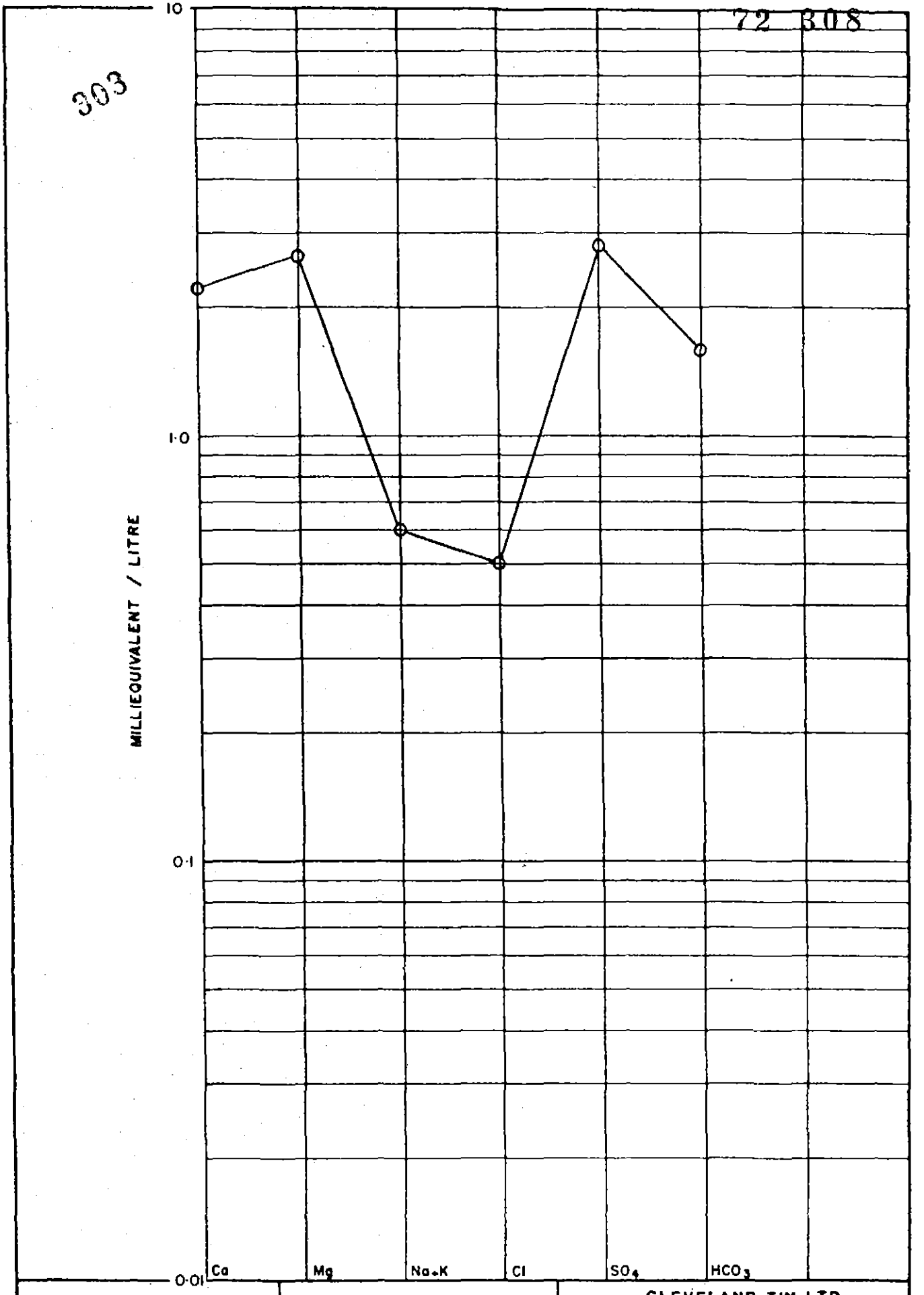


DRAWN	REVISIONS			NOTES	CLEVELAND TIN LTD.
TRACED	No	Date	Appd		PIPER TRILINEAR.
APPROVED				Australian Groundwater Consultants Pty Limited Geohydrologists and Engineers	LUINA Fig 11

72 307

72 308

303



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

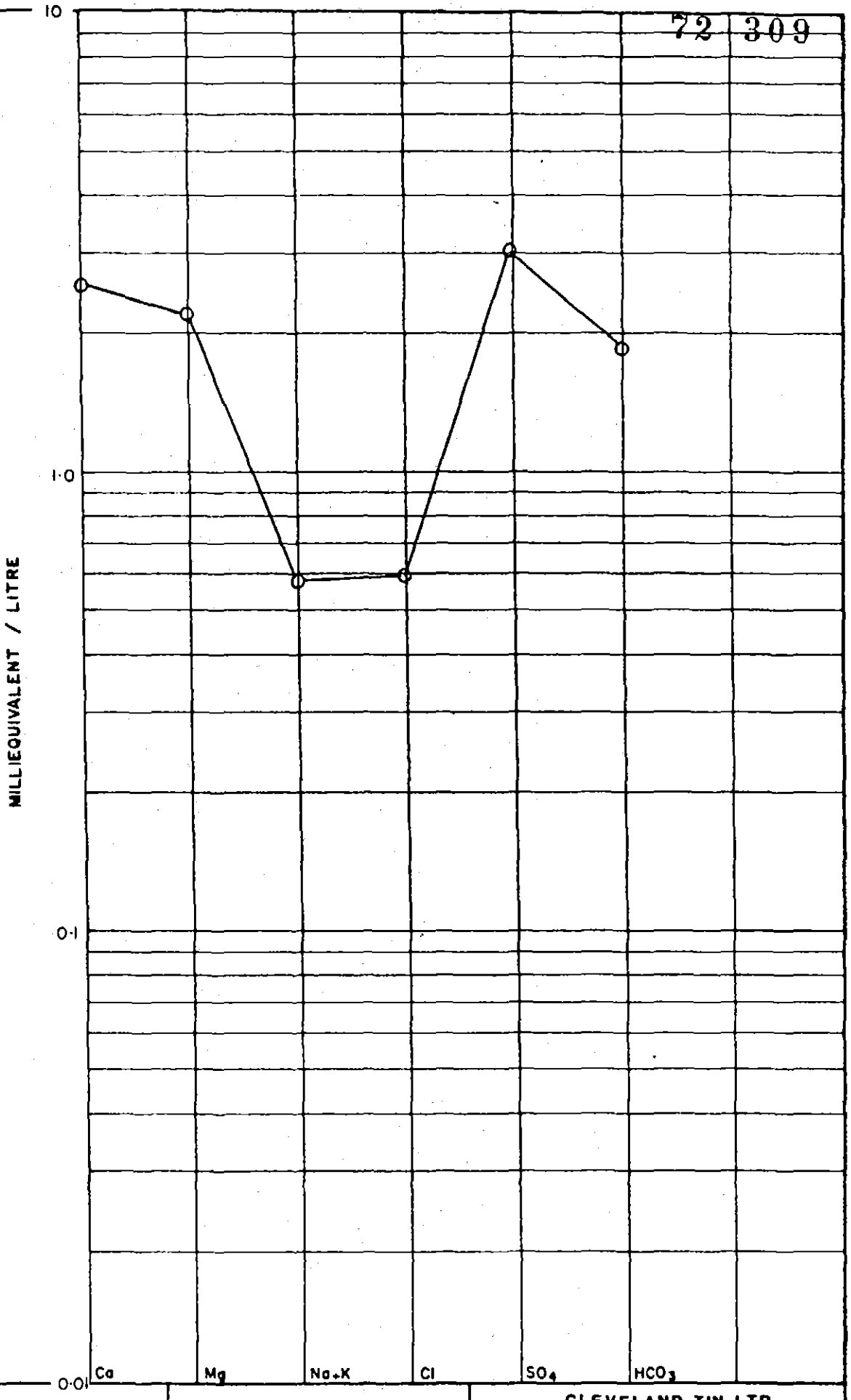
SCHOELLER DIAGRAM

BORE No. C1456

Job. No. 721 *Fig. 12*

72 309

304



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

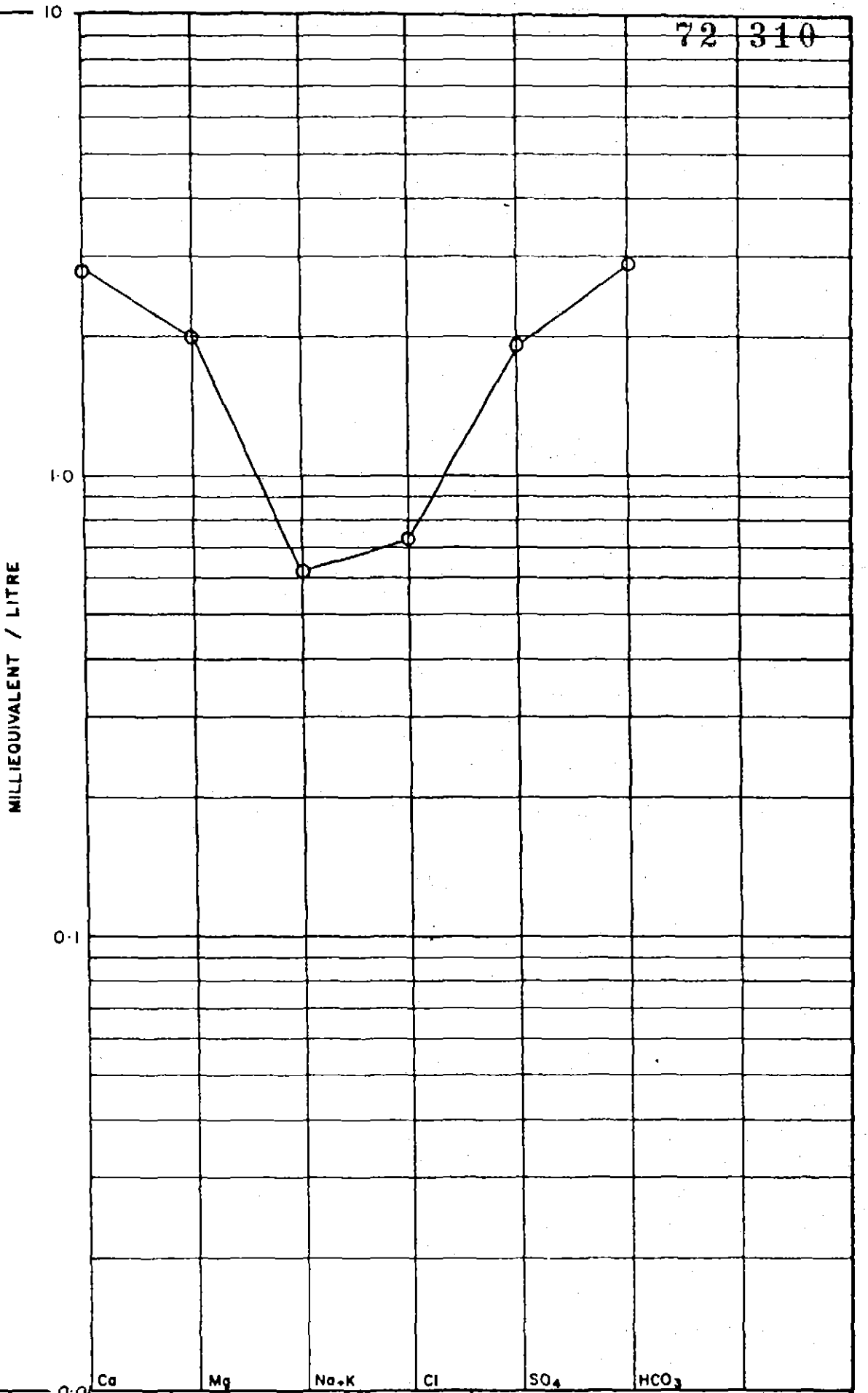
SCHOELLER DIAGRAM

BORE No. C1462

Job. No. 721 Fig. 13

305

72 310



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

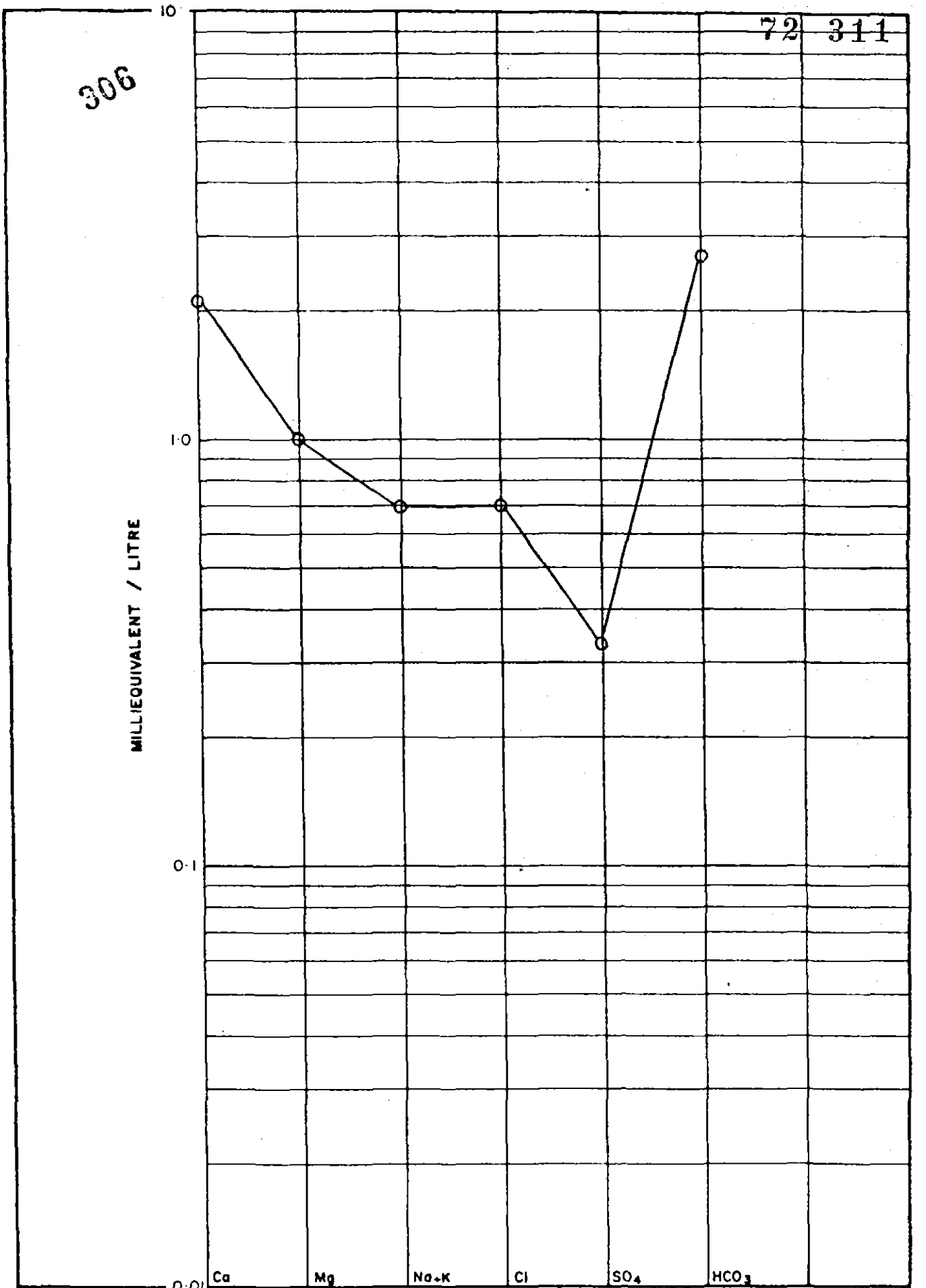
SCHOELLER DIAGRAM

BORE No. C1528

Job No. 721 Fig. 14

306

72 311



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

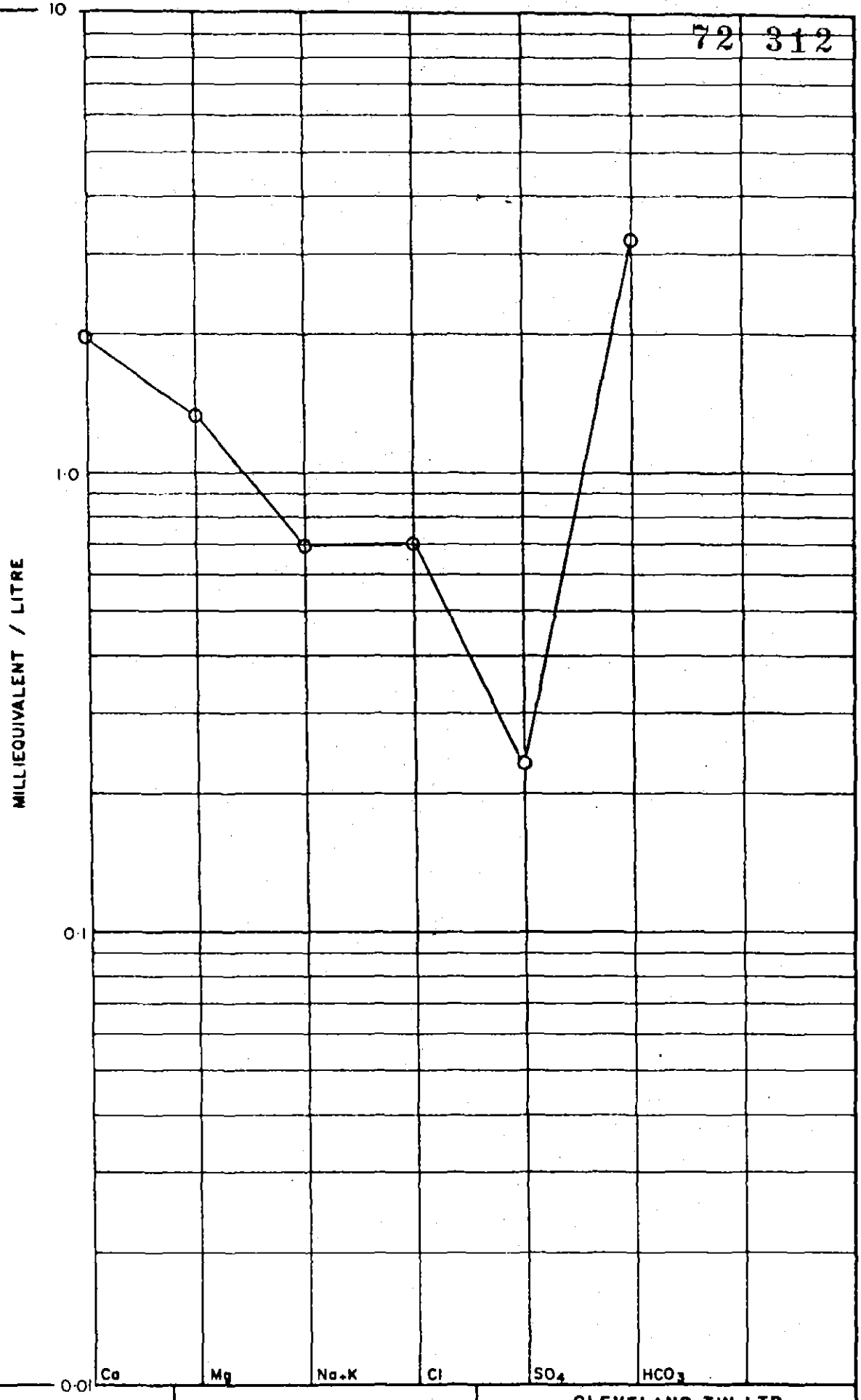
SCHOELLER DIAGRAM

BORE No. C1536

Job. No. 721 *Fig.* 15

307

72 312



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

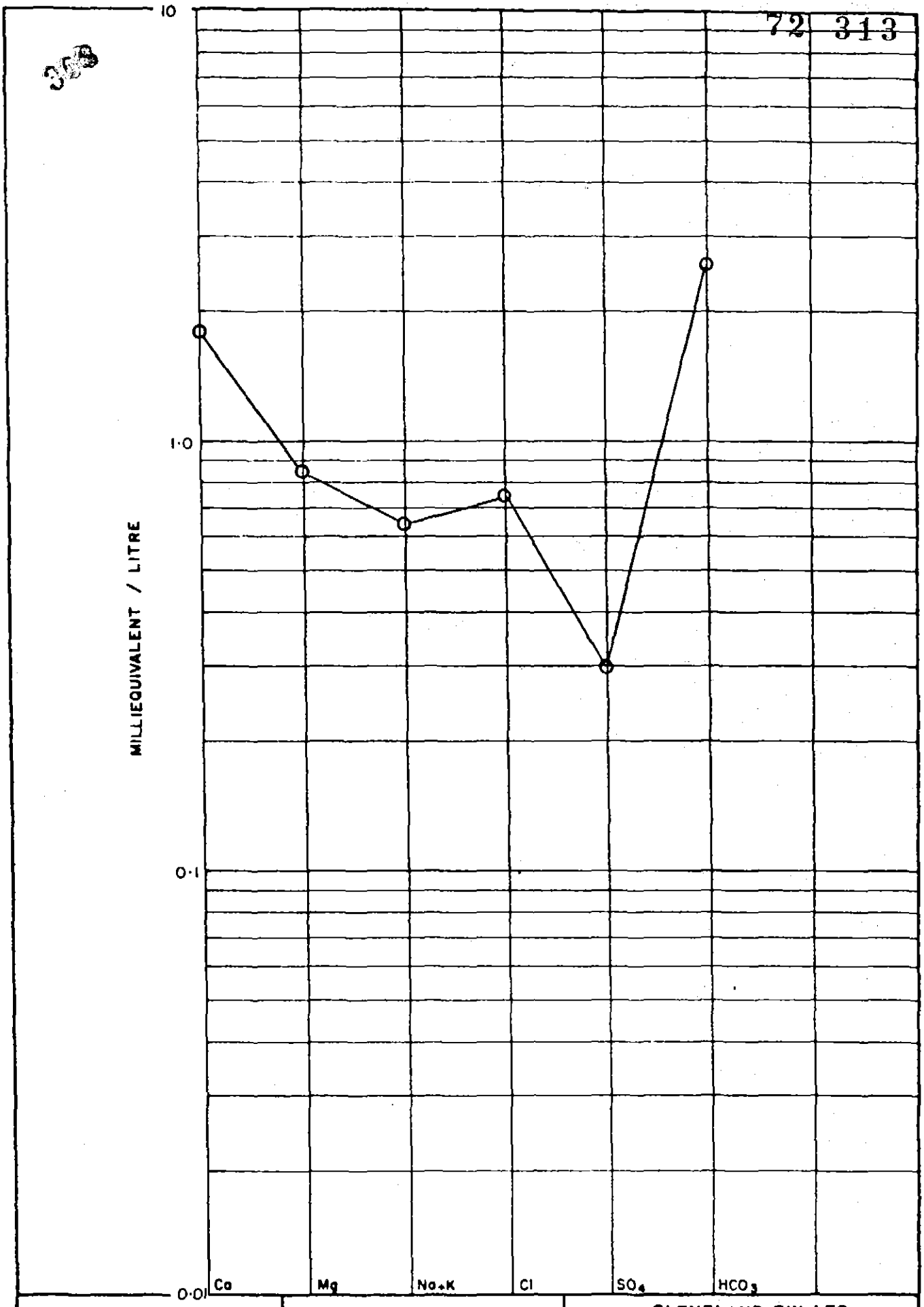
CLEVELAND TIN LTD.

SCHOELLER DIAGRAM

BORE No. C1551

Job. No. 721 Fig. 16

72 313



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

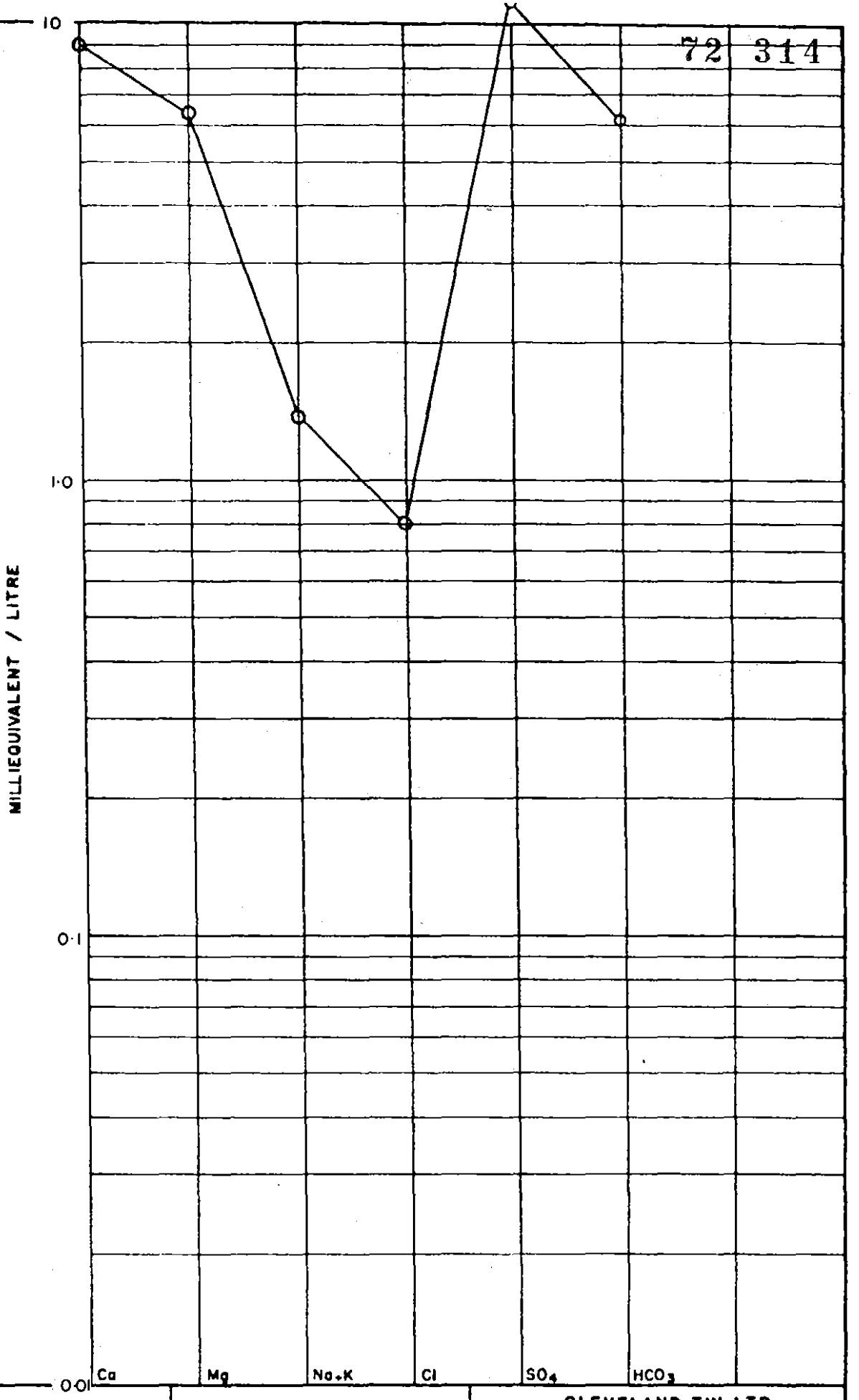
SCHOELLER DIAGRAM

BORE No. C1554

Job. No. 721 Fig. 17

309

72 314



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

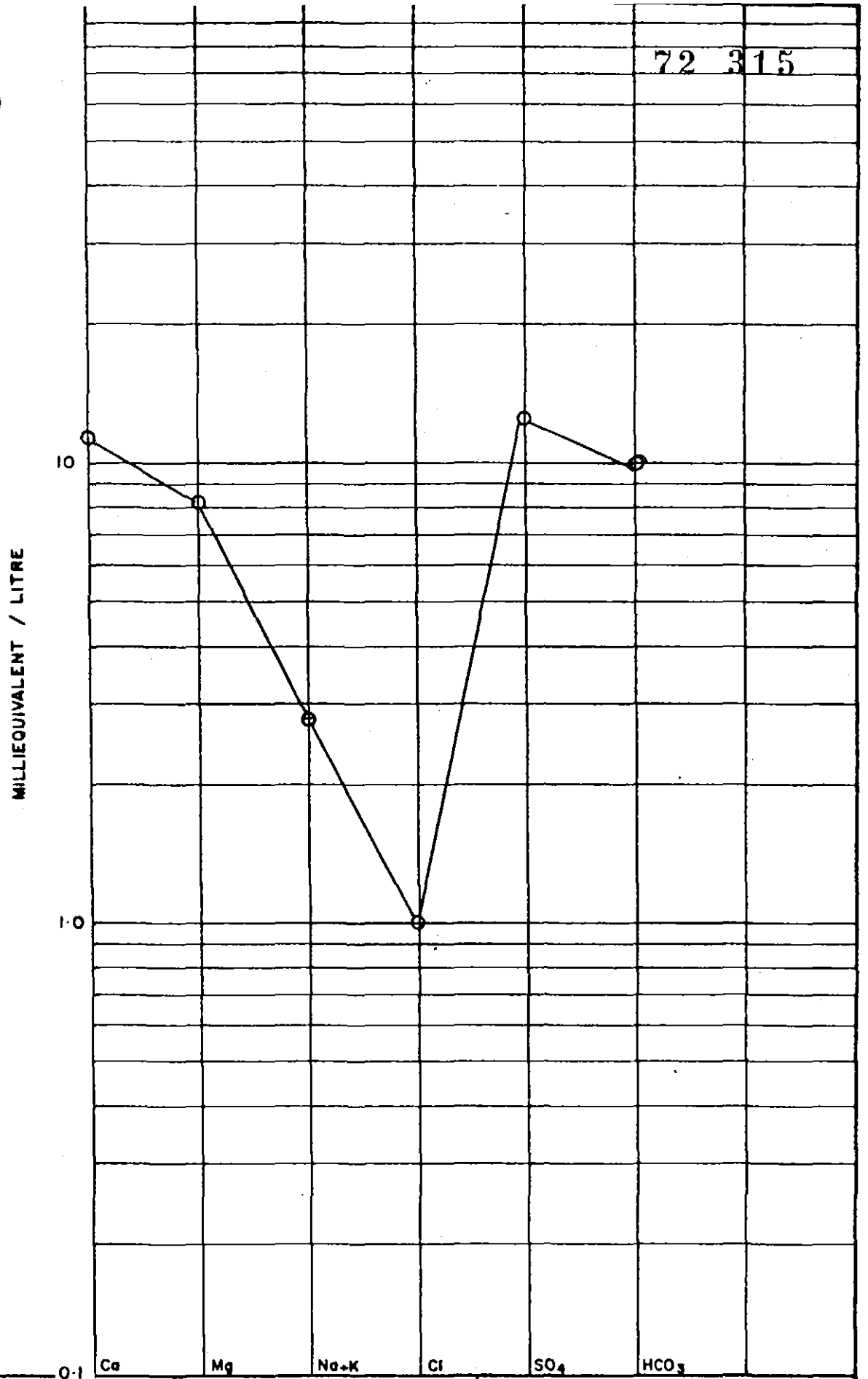
SCHOELLER DIAGRAM

BORE No. C1608

Job. No. 721 Fig. 18

310

72 315



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

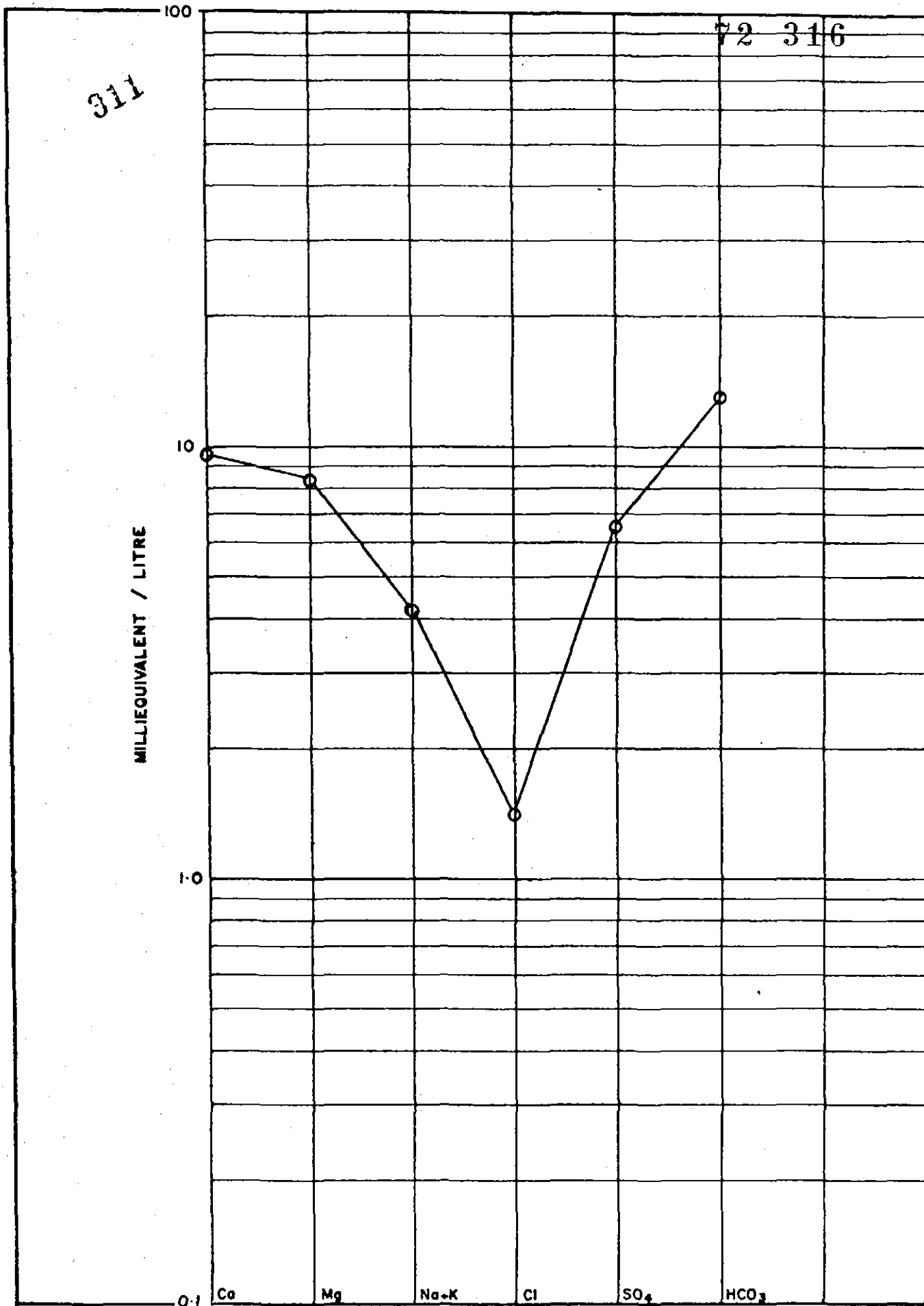
SCHOELLER DIAGRAM

BORE No. C1611

Job No. 721 Fig. 19

72 316

311



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

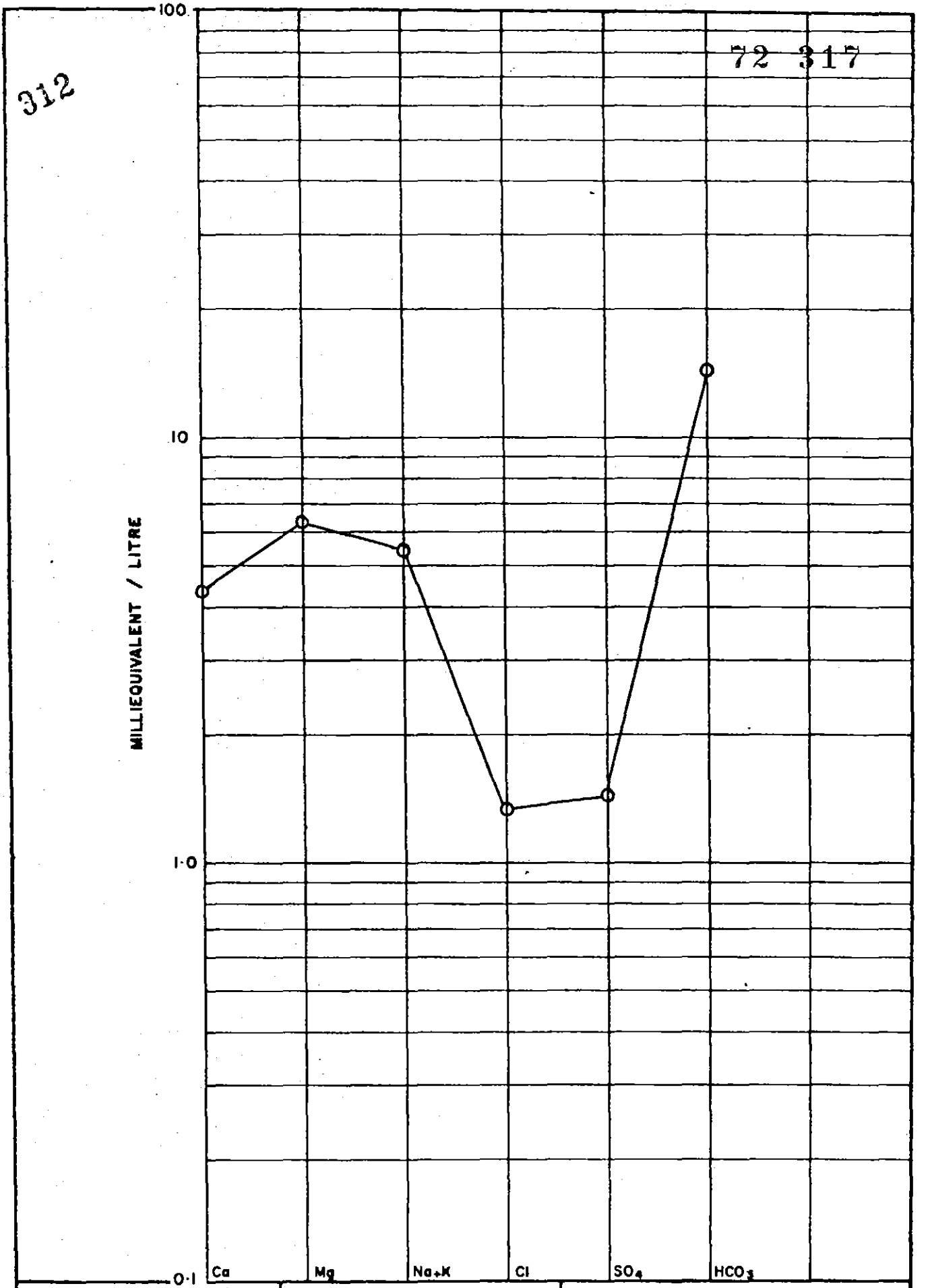
SCHOELLER DIAGRAM

BORE No. C1615

Job. No. 721 Fig. 20

312

72 317



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

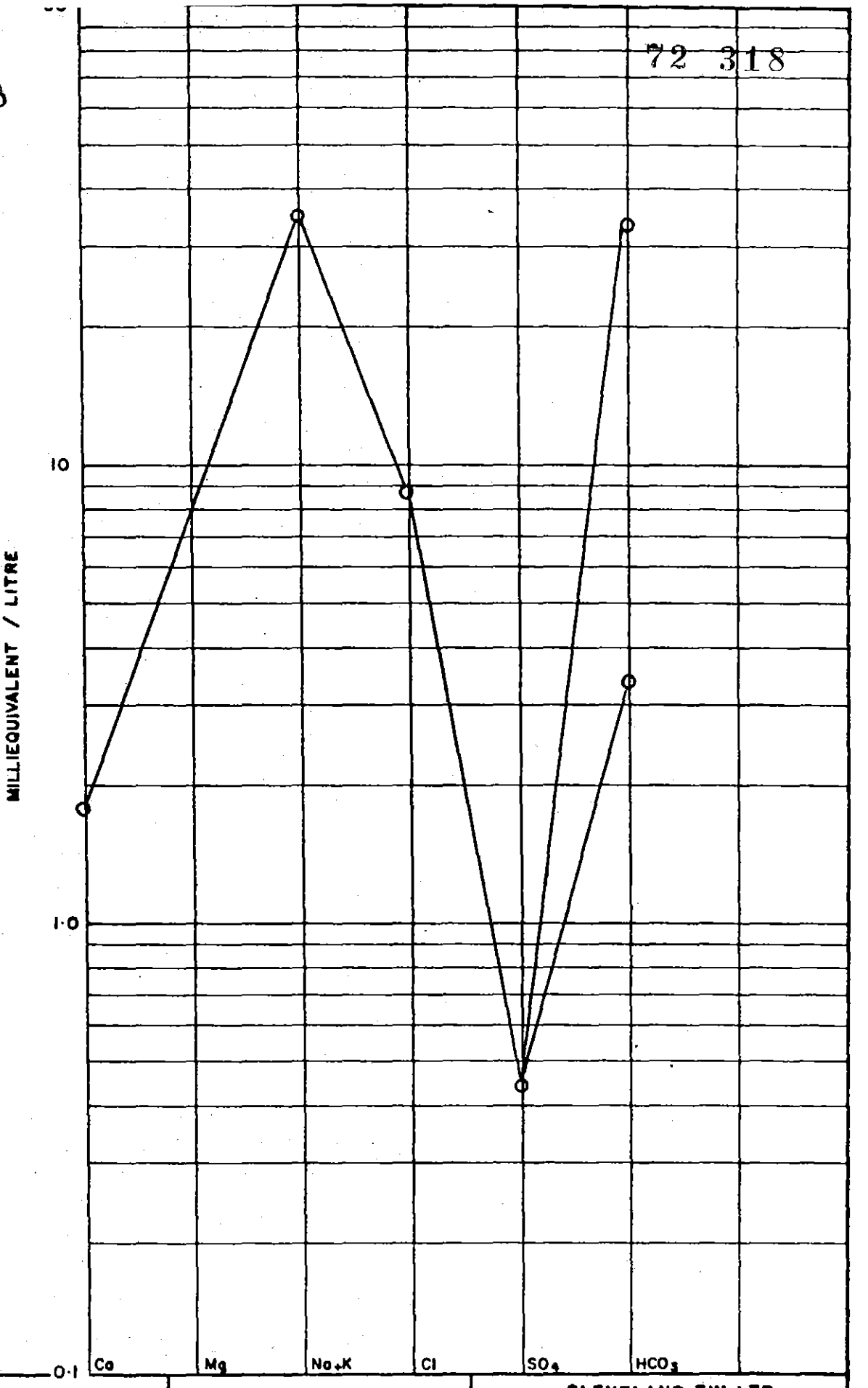
SCHOELLER DIAGRAM

BORE No. C1627

Job. No. 721 Fig. 21

313

72 318



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

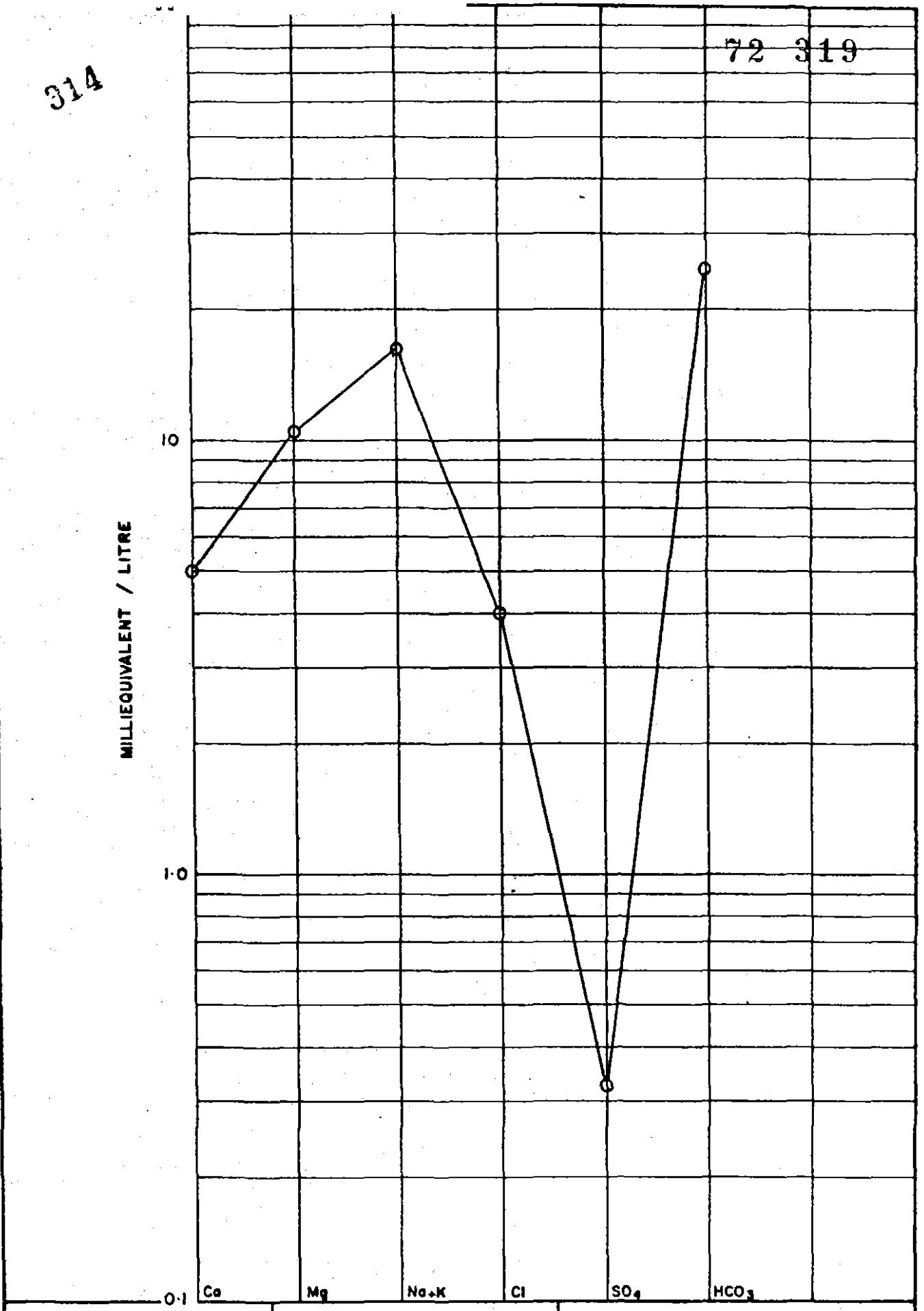
SCHOELLER DIAGRAM

BORE No. C1633

Job. No. 721 Fig. 22

314

72 319



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

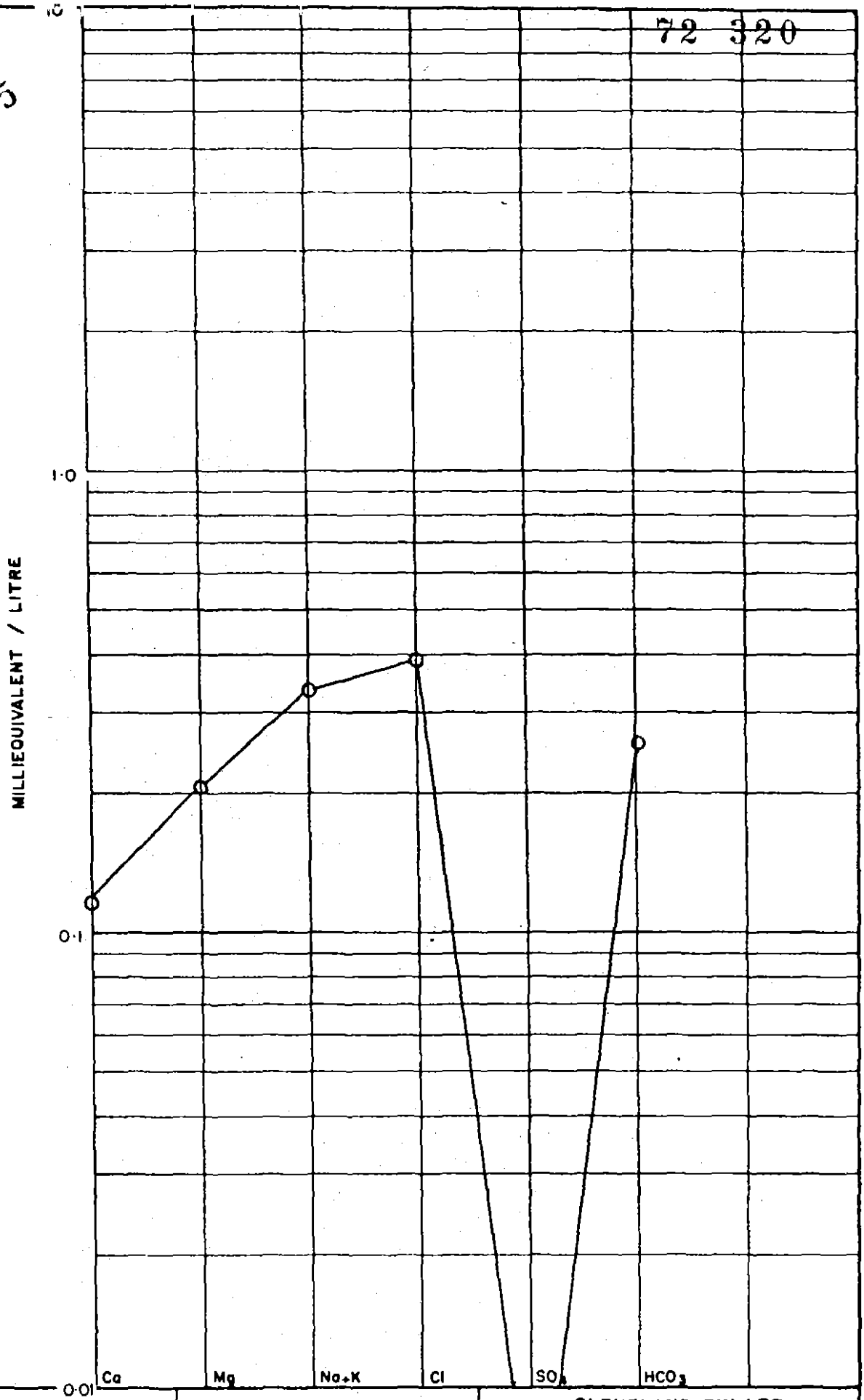
SCHOELLER DIAGRAM

BORE No. C1634

Job No. 721 Fig. 23

315

72 320



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

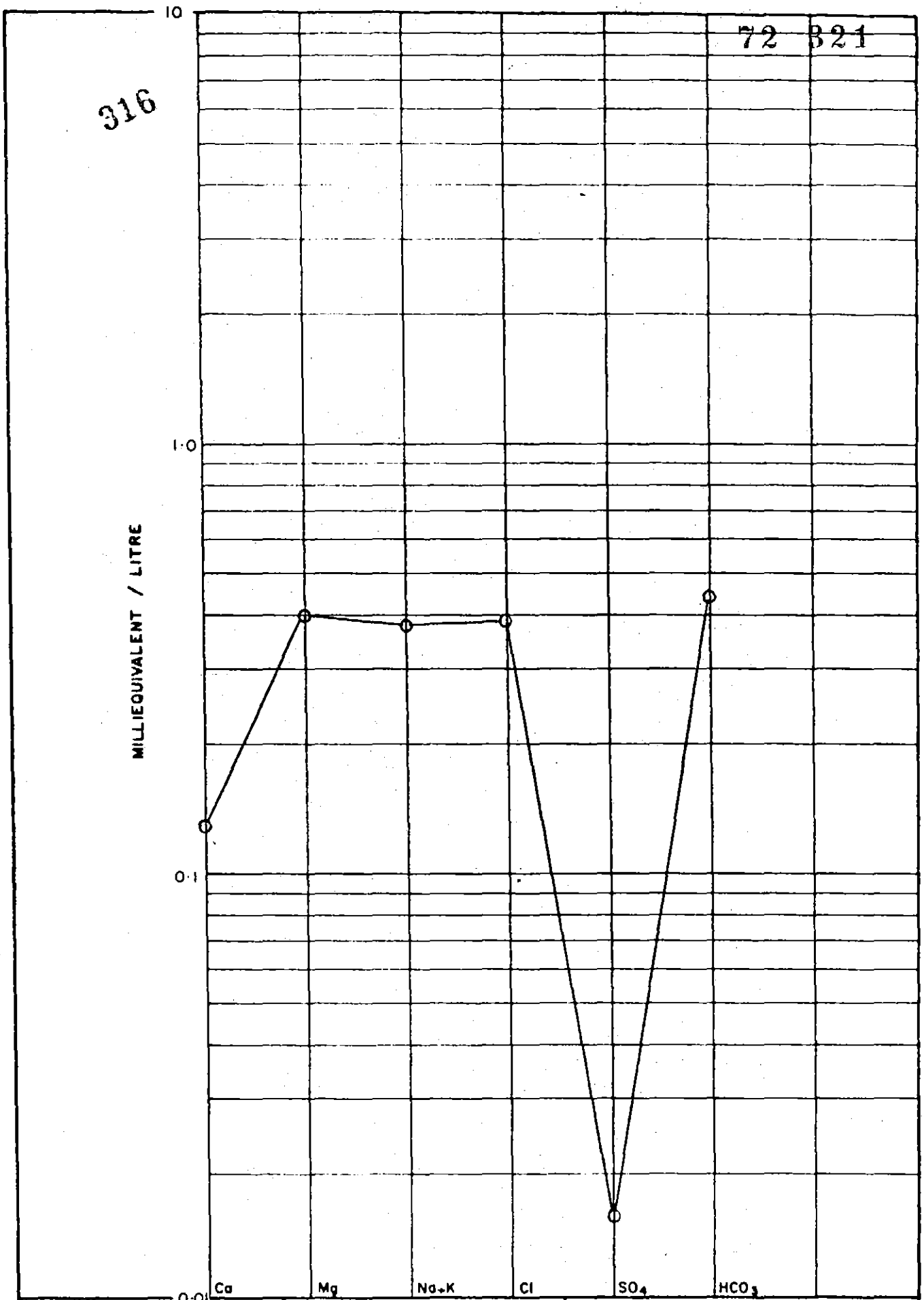
SCHOELLER DIAGRAM

CREEK

Job. No. 721 Fig. 24

316

72 321



Australian Groundwater Consultants Pty Limited

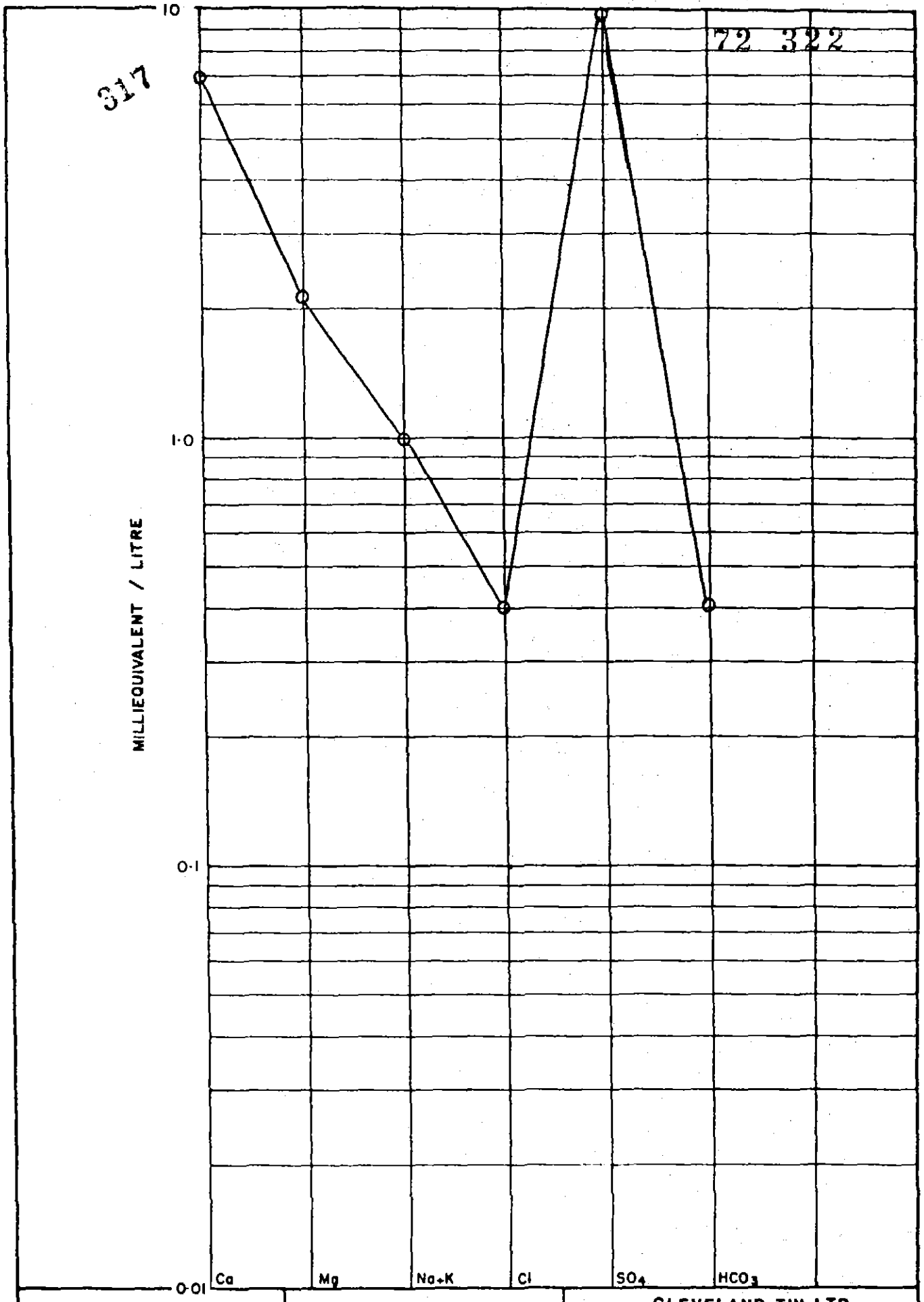
Groundhydrologists and Engineers

CLEVELAND TIN LTD.

SCHOELLER DIAGRAM

RIVER

Job. No. 721 Fig. 25



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

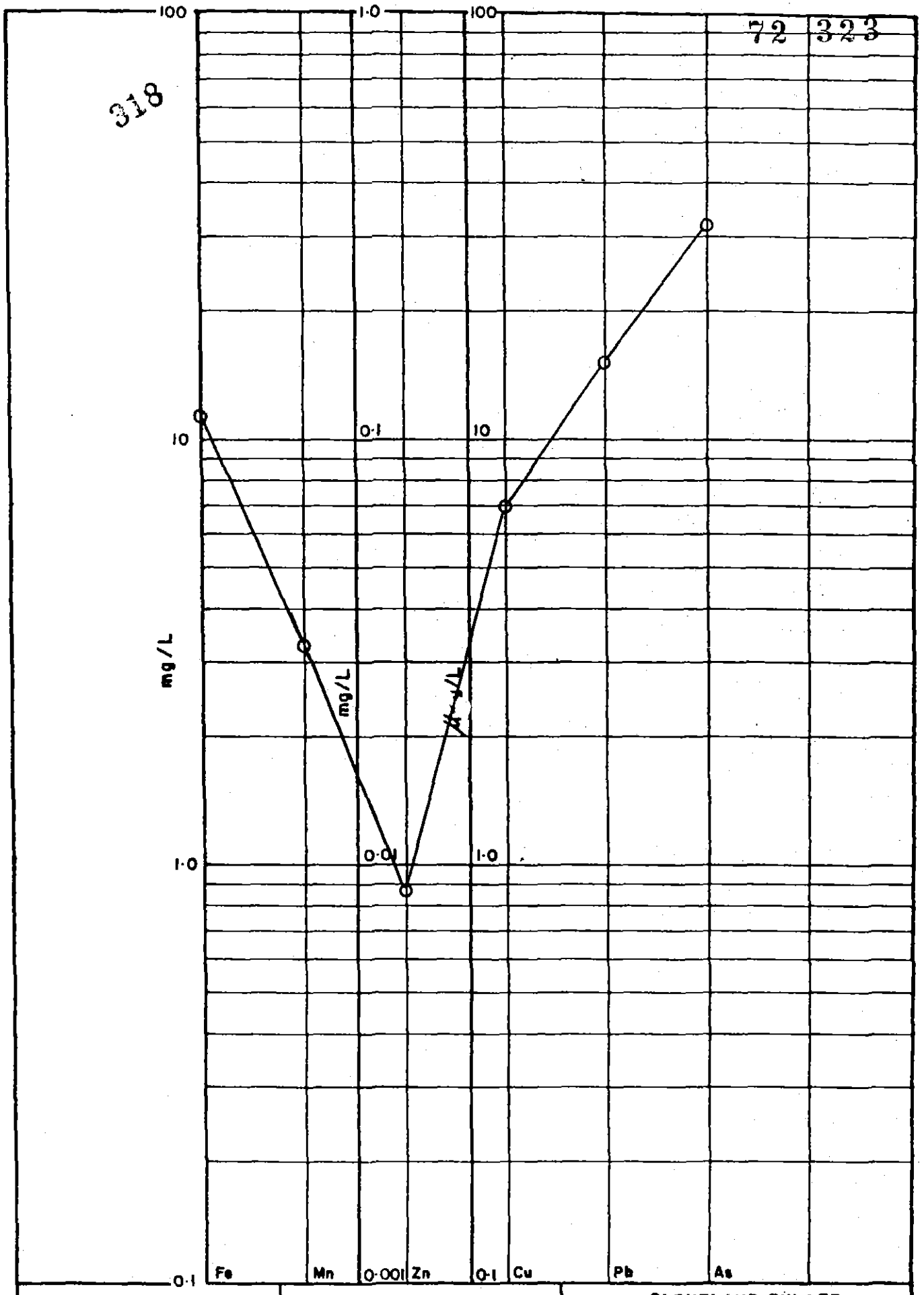
SCHOELLER DIAGRAM

TAILING DAM

Job. No. 721 Fig. 28

72 323

318



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

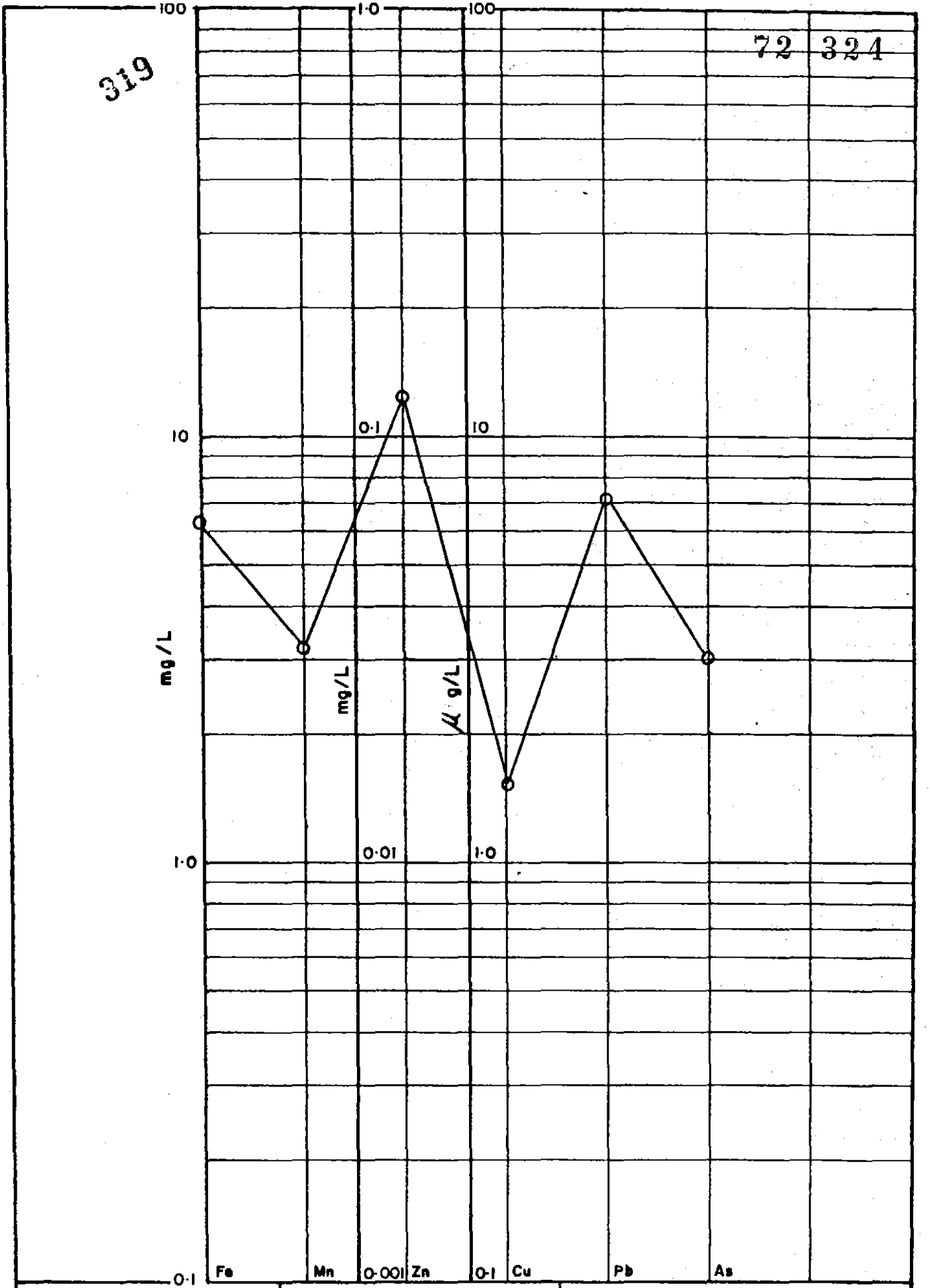
TRACE ELEMENTS

BORE No. C1456

Job. No. 721 Fig. 27

319

72 324



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

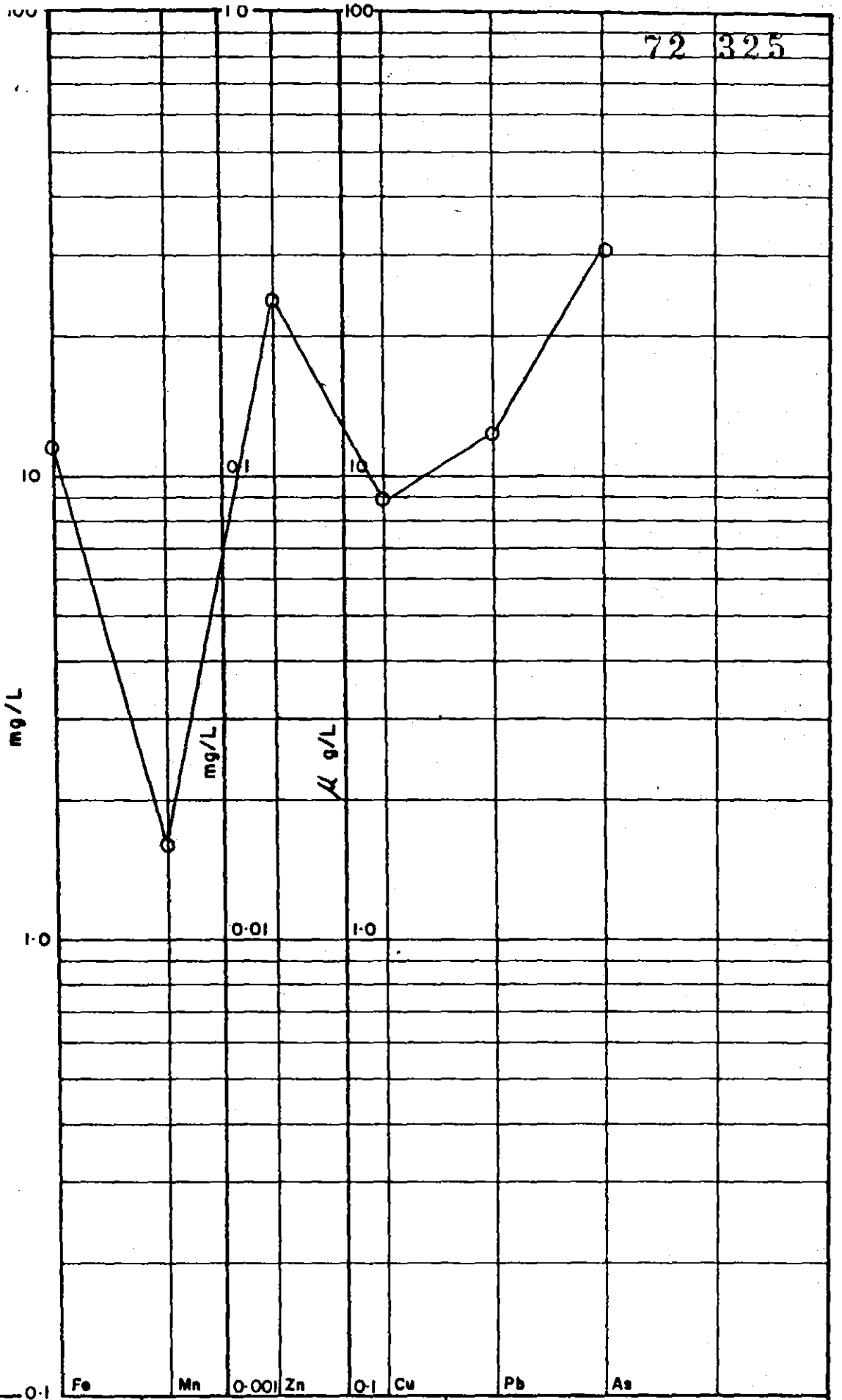
TRACE ELEMENTS

BORE No. C1462

Job. No. 721 Fig. 28

72 325

320



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

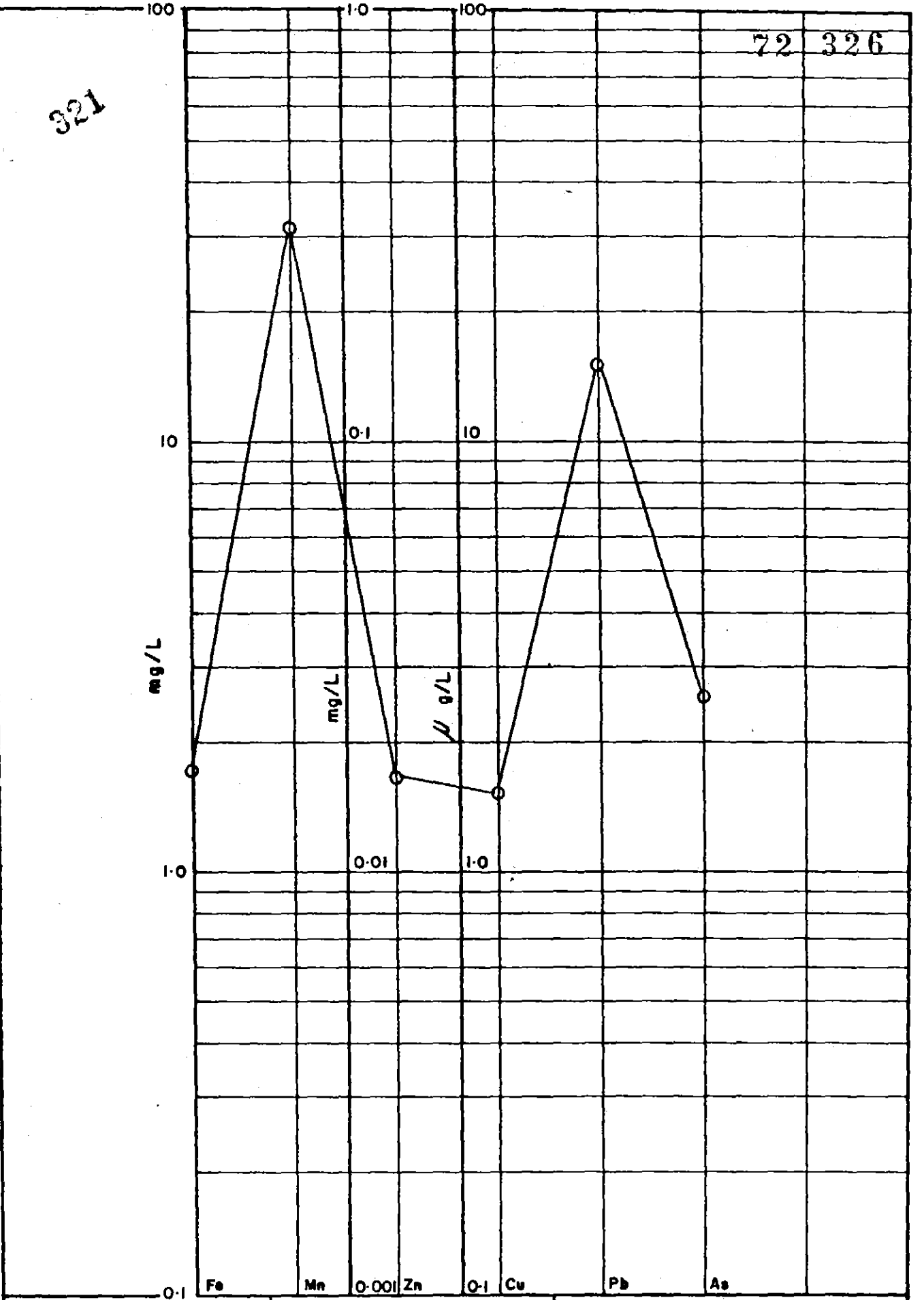
TRACE ELEMENTS

BORE No. C1528

Job. No. 721 Fig. 29

72 326

321



Australian Groundwater Consultants Pty Limited

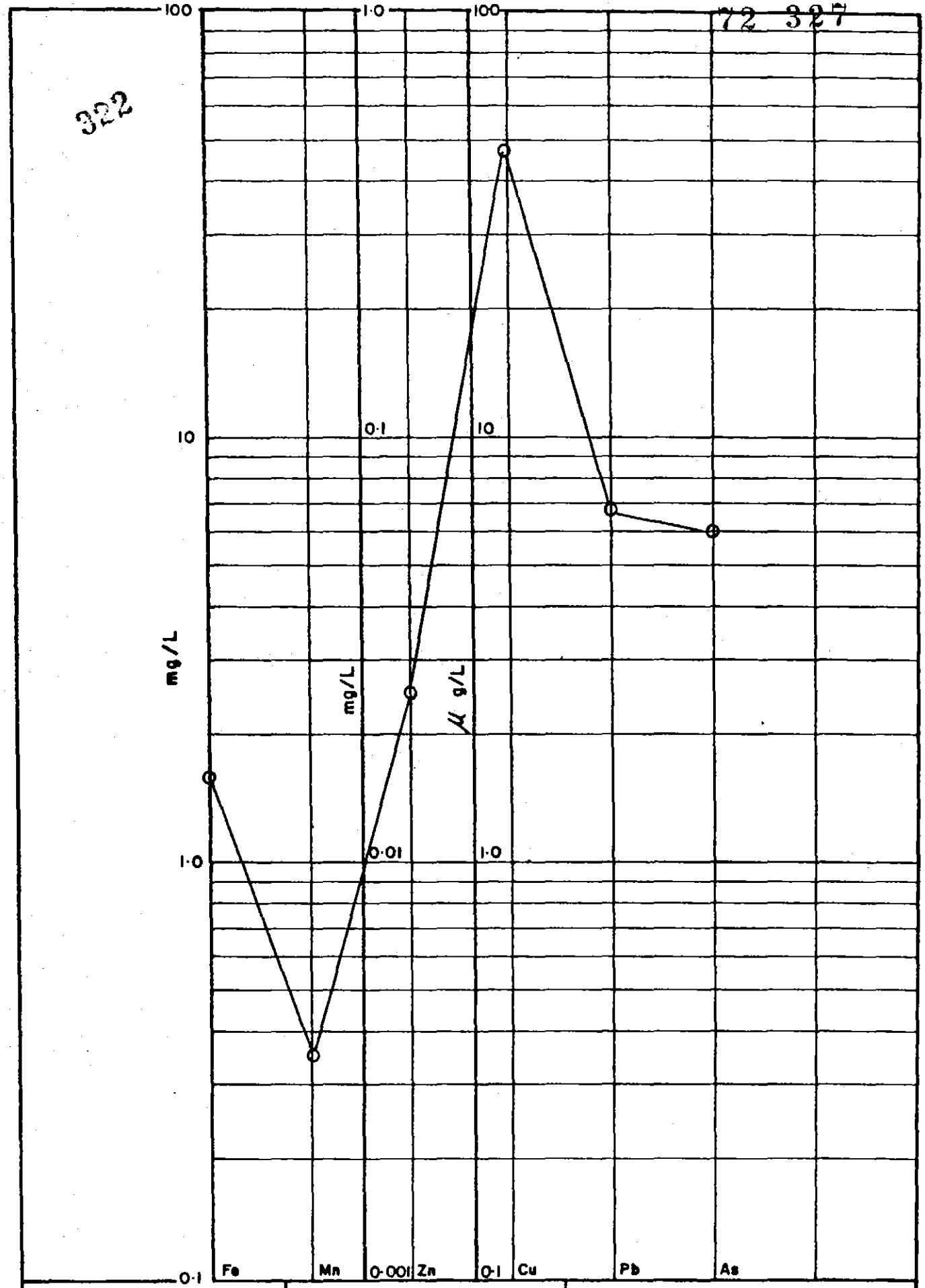
Geohydrologists and Engineers

CLEVELAND TIN LTD.

TRACE ELEMENTS

BORE No. C1536

Job No. 721 Fig. 30



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

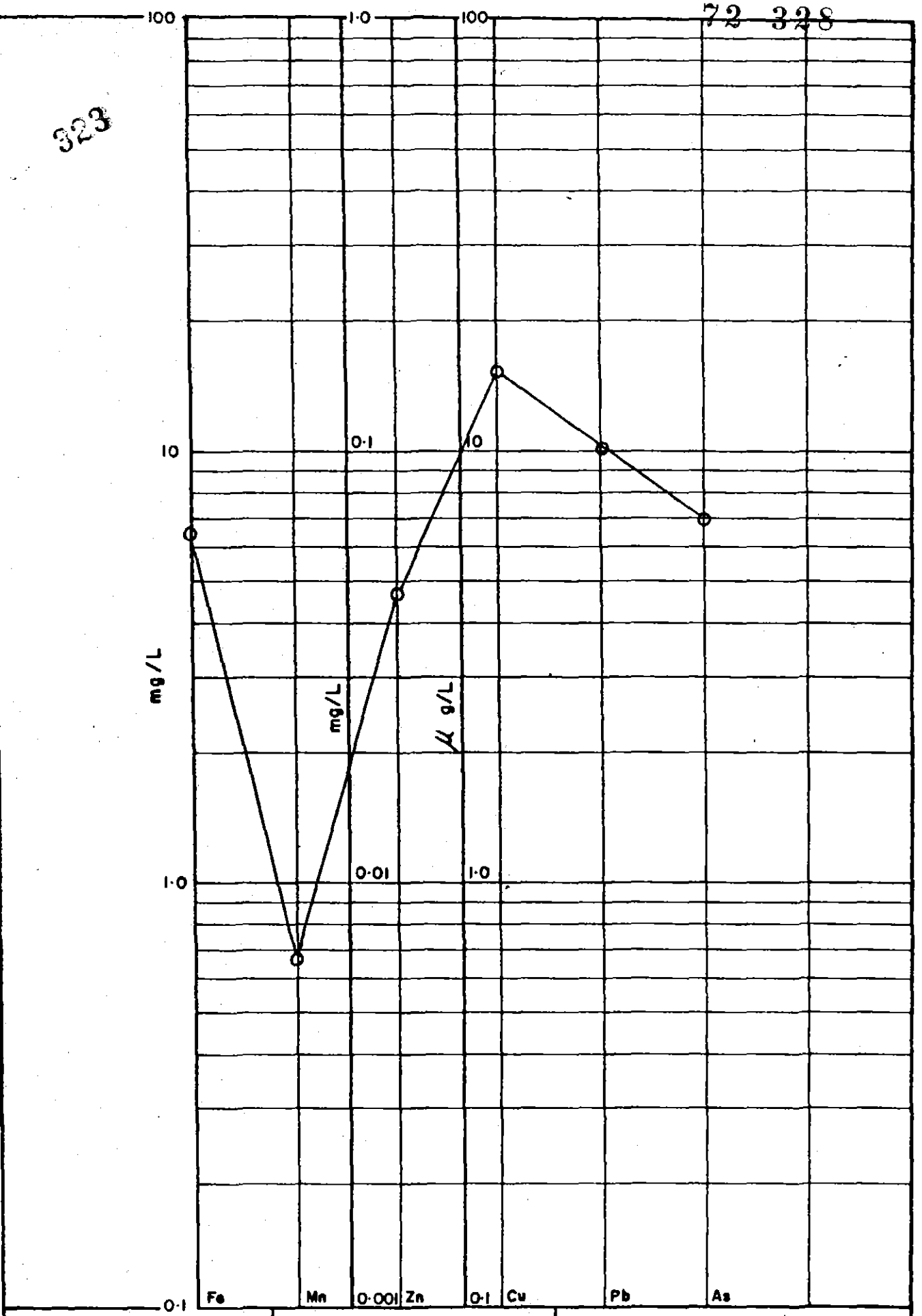
TRACE ELEMENTS

BORE No. C1551

Job No. 721 Fig. 31

72 328

323



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

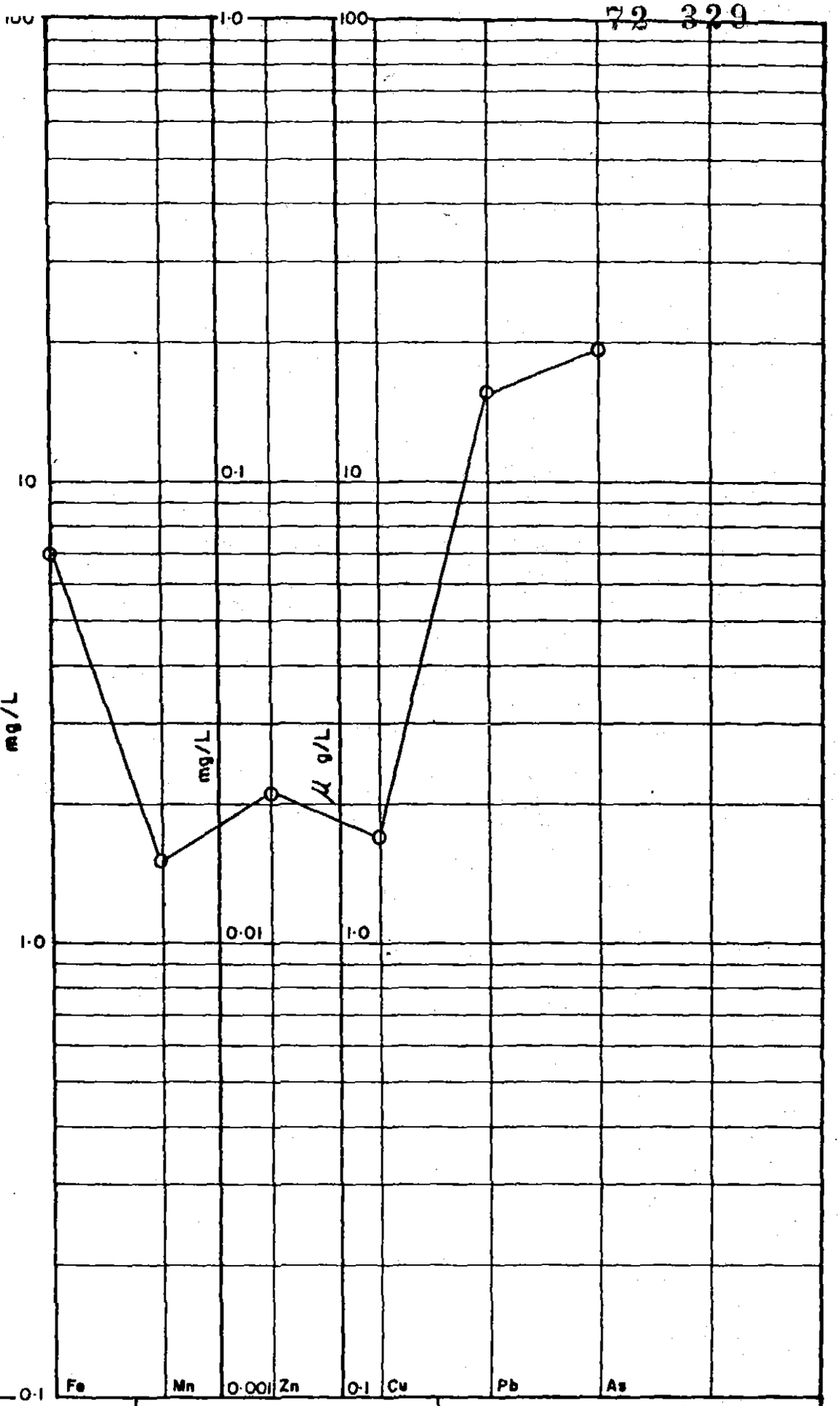
TRACE ELEMENTS

BORE No. C1554

Job. No. 721 Fig. 32

72 329

324



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

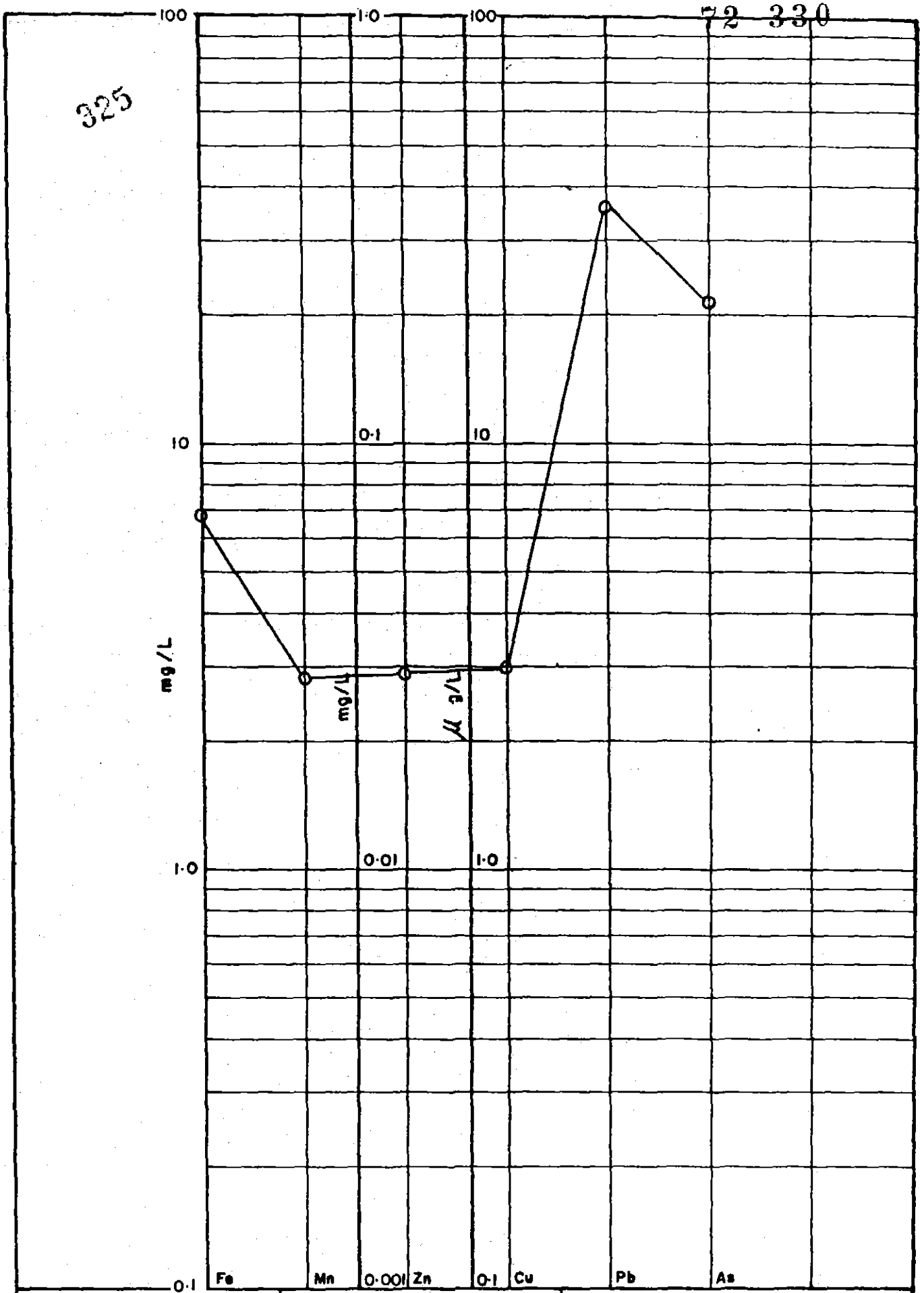
TRACE ELEMENTS

BORE No. C1608

Job. No. 721 *Fig.* 33

72 330

325



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

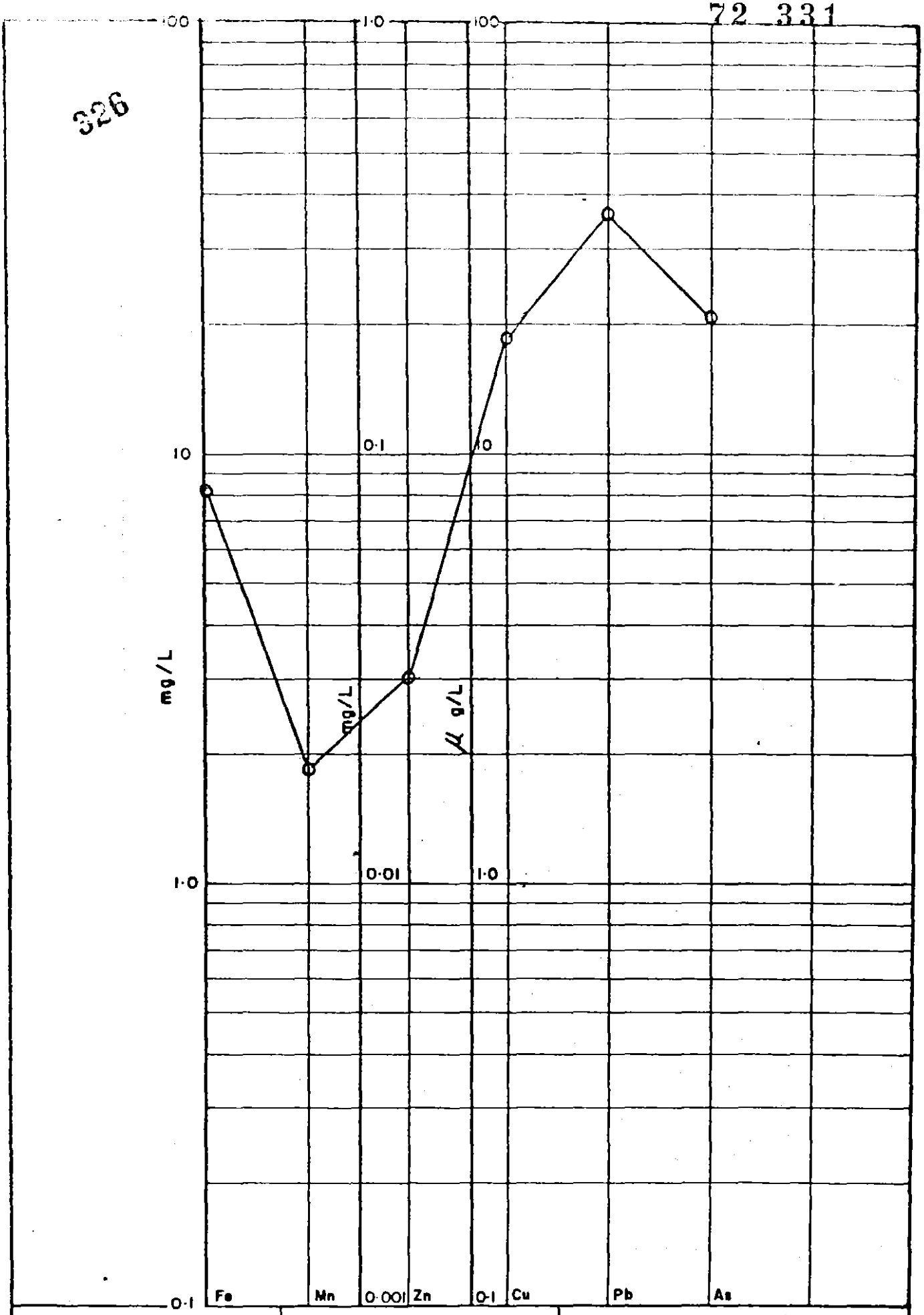
TRACE ELEMENTS

BORE No. C1611

Job. No. 721 Fig. 34

72 331

326



Australian Groundwater Consultants Pty Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

TRACE ELEMENTS

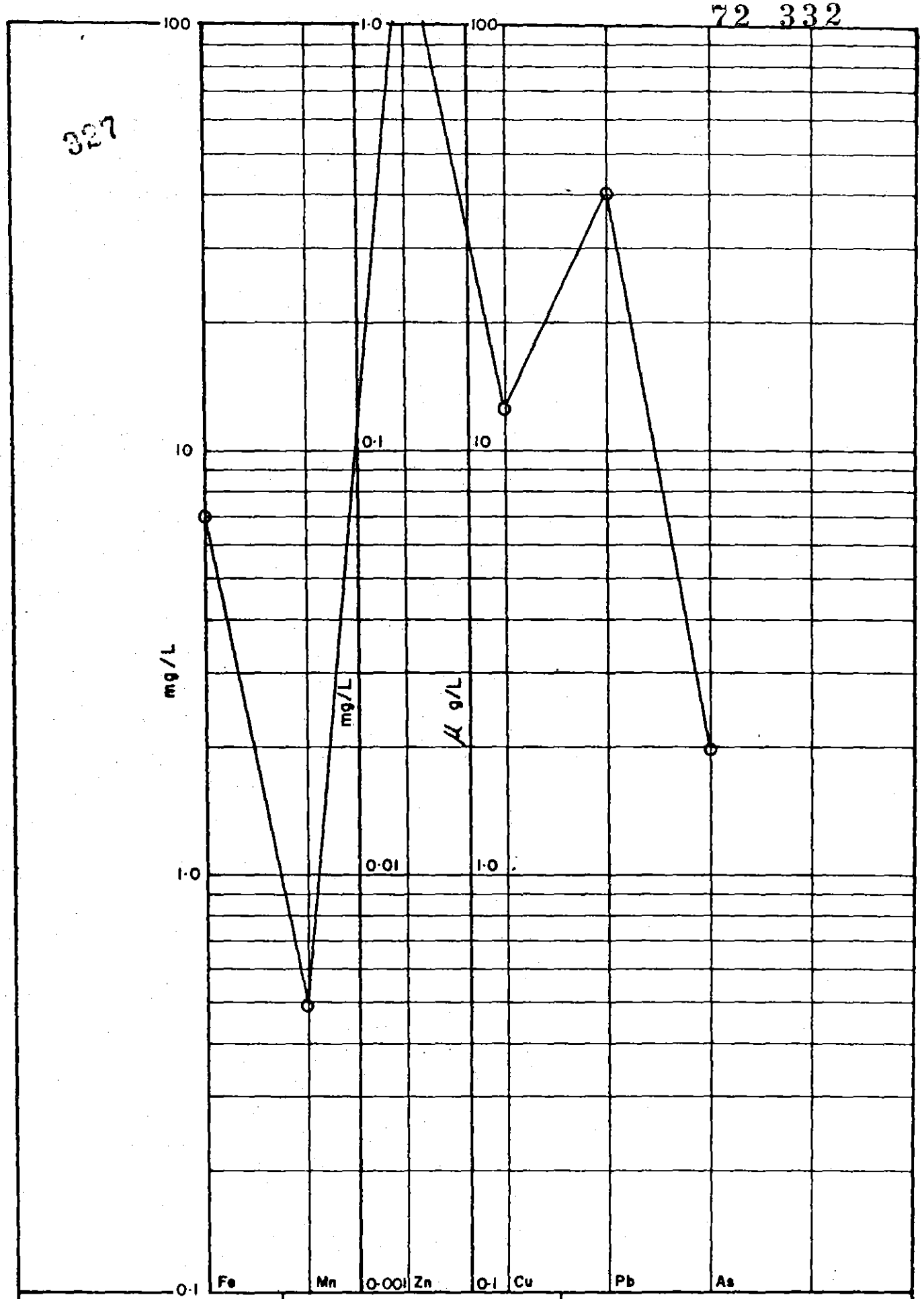
BORE No. C1615

Job No. 721

Fig. 35

72 332

327



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

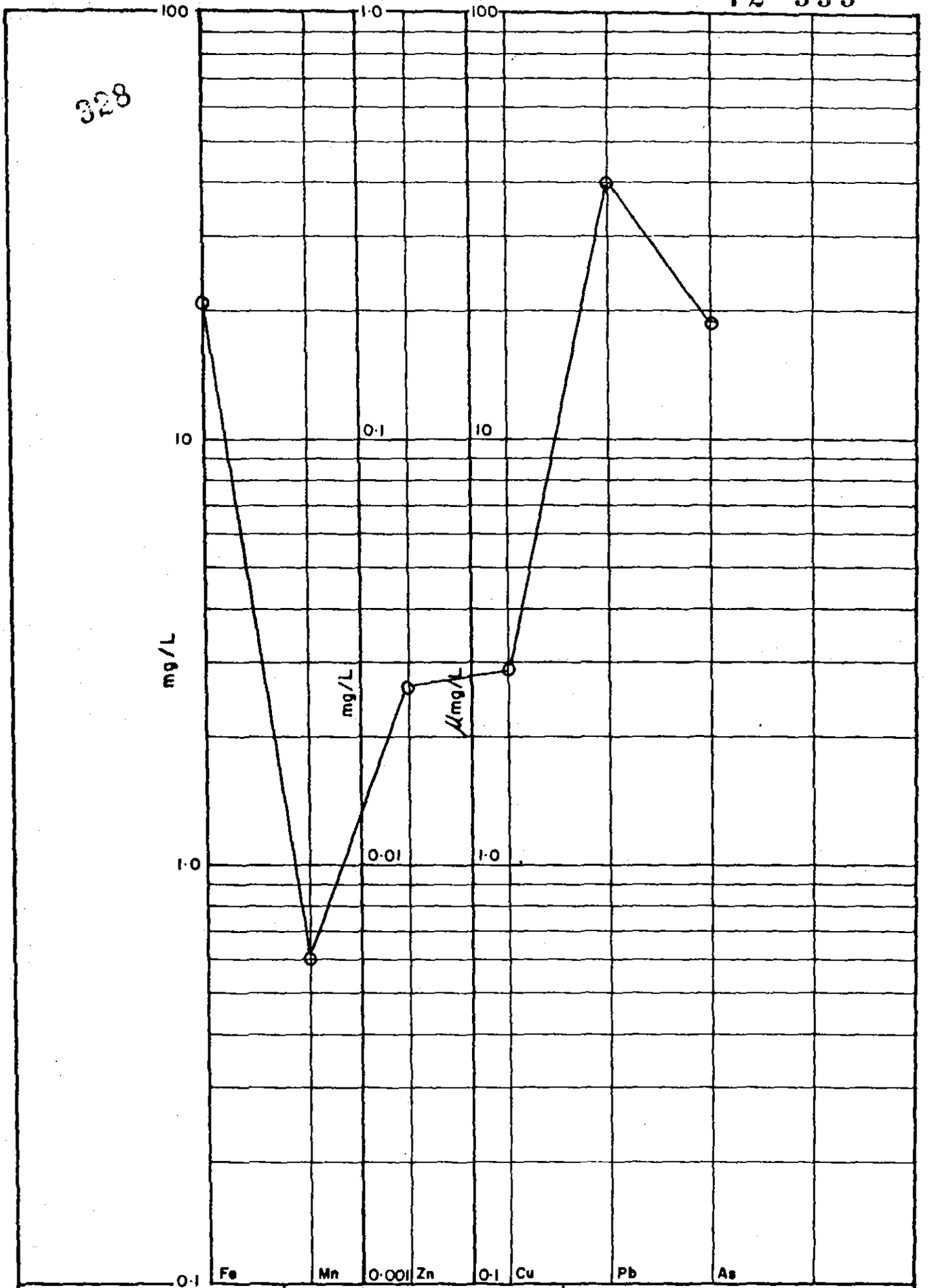
TRACE ELEMENTS

BORE No. C1627

Job No. 721 Fig. 36

72 333

328



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

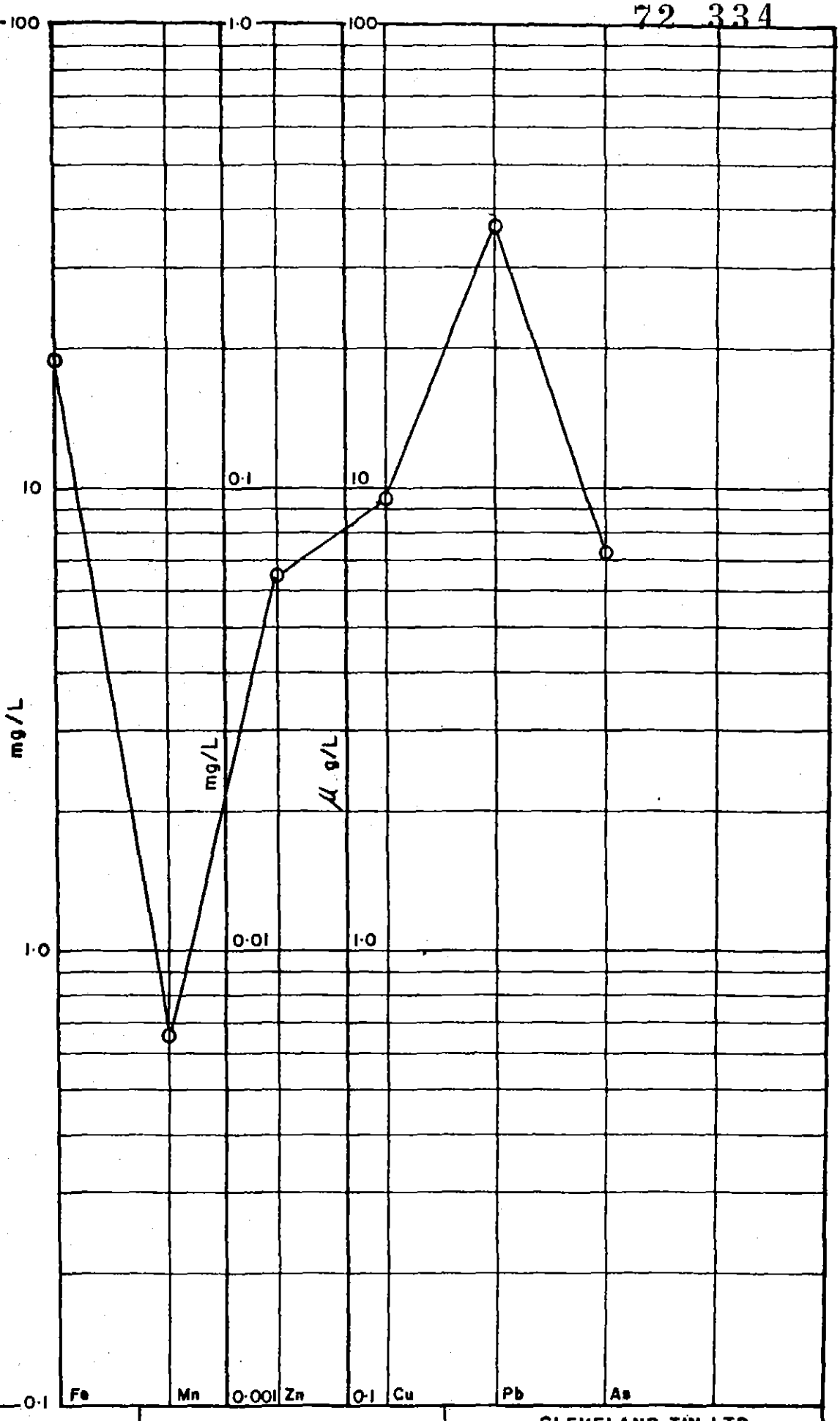
TRACE ELEMENTS

BORE No. C1633

Job. No. 721 Fig. 37

72 334

339



Australian Groundwater Consultants Pty. Limited

Geohydrologists and Engineers

CLEVELAND TIN LTD.

TRACE ELEMENTS

BORE No. C1634

Job. No. 721 Fig. 38

APPENDIX I

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 336

AUSTRALIAN GROUNDWATER CONSULTANTS PTY. LT
582 St. Kilda Road, Melbourne
Victoria 3004

Attn: Stephen Hancock
Principal Consultant

CC:
CLEVELAND MINE
LUINA, TASMANIA 7321

Attn: Mr. G. McArthur
Senior Mine Geologist

Our ref. La/0129
Your ref. JSH:DK:721
Date received 25.9.81
Date completed 29.10.81
Issued at SYDNEY

Date: 29th October 1981

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	CREEK		RIVER		TAILINGS DAM	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	75.2		80.5		875	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	54		60		760	
Total Hardness (EDTA) as mg/L $CaCO_3$	14		20		480	
Calculated Hardness as mg/L $CaCO_3$						
pH	6.8		6.9		7.0	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	7.4	0.322	8.2	0.357	16	0.70
Potassium K^+	0.73	0.019	0.93	0.024	10.9	0.28
Calcium Ca^{++}	2.3	0.115	2.6	0.130	140	6.99
Magnesium Mg^{++}	2.5	0.206	4.6	0.378	25	2.06
		0.662		0.889		10.03
Chloride Cl^-	14	0.394	14	0.394	14	0.39
Carbonate $CO_3^=$	Nil		Nil		Nil	
Bicarbonate HCO_3^-	16	0.262	27.8	0.457	25	0.41
Sulphate $SO_4^=$	< 0.2		0.8	0.016	465	9.69
Nitrate NO_3^-	0.65	0.010	0.50	0.008	2.0	0.03
Fluoride F^-	0.04	0.002	0.05	0.003	8.6	0.45
		0.668		0.878		10.97
Total Alkalinity $CaCO_3$	13.3	0.266	22.9	0.458	20.6	0.41
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 337

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

AUSTRALIAN GROUNDWATER CONSULTANTS
PTY. LTD.
582 St. Kilda Road, Melbourne
Victoria 3004

Attn: Stephen Hancock
Principal Consultant

cc: CLEVELAND MINE
LUINA, TASMANIA 7321

Attn: Mr. G . McArthur
Senior Mine Geologist

CERTIFICATE OF WATER ANALYSIS

Date: 29th October 1981

SOURCE OF WATER						
SAMPLE No.	C1456		C1462		C1528	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	420		457		500	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	296		340		314	
Total Hardness (EDTA) as mg/L $CaCO_3$	200		230		210	
Calculated Hardness as mg/L $CaCO_3$						
pH	7.6		7.9		8.1	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	12	0.522	12	0.522	13	0.566
Potassium K^+	2.50	0.064	2.4	0.061	2.00	0.051
Calcium Ca^{++}	44	2.196	51.0	2.545	55	2.745
Magnesium Mg^{++}	20	1.645	26.9	2.212	24	1.974
		4.427		5.340		5.336
Chloride Cl^-	17.5	0.494	21	0.592	26	0.733
Carbonate $CO_3^=$	Nil		Nil			
Bicarbonate HCO_3^-	97	1.590	114	1.868	177	2.901
Sulphate $SO_4^=$	130	2.708	145	3.020	92	1.916
Nitrate NO_3^-	0.55	0.009	0.55	0.009	.50	0.008
Fluoride F^-	1.48	0.078	1.72	0.091	1.24	0.065
		4.879		5.580		5.623
Total Alkalinity $CaCO_3$	80	1.600	93.7	1.874	14.5	2.900
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 338

Australian Groundwater Consultants

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C1536		C1551		C1554	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	320		315		278	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	118		240		210	
Total Hardness (EDTA) as mg/L $CaCO_3$	140		160		130	
Calculated Hardness as mg/L $CaCO_3$						
pH	8.1		8.1		8.2	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	14	0.609	14	0.609	13	0.566
Potassium K^+	2.70	0.069	2.6	0.066	1.9	0.049
Calcium Ca^{++}	42	2.096	39	1.946	36	1.796
Magnesium Mg^{++}	12	0.987	16	1.316	10.2	0.839
	3761	~~3.659~~		3.937		3.250
Chloride Cl^-	24.6	0.694	24.6	0.694	26	0.733
Carbonate $CO_3^=$			Nil		Nil	
Bicarbonate HCO_3^-	166	2.720	194	3.179	159	2.606
Sulphate $SO_4^=$	16	0.333	11	0.229	9	0.187
Nitrate NO_3^-	0.48	0.008	0.42	0.007	0.44	0.007
Fluoride F^-	1.0	0.053	1.44	0.076	0.46	0.024
		3.808		4.185		3.557
Total Alkalinity $CaCO_3$	136	2.720	159	3.180	130	2.600
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 339

Australian Groundwater

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C1608		C1611		C1615	
DATE OF COLLECTION						
Conductivity ($25^{\circ}C \mu$ mhos cm^{-1})	1275		1600		1575	
Resistivity ($25^{\circ}C$ ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	1,130		1,420		1,260	
Total Hardness (EDTA) as mg/L $CaCO_3$	780		980		820	
Calculated Hardness as mg/L $CaCO_3$						
pH	8.2		7.8		7.8	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^{+}	28	1.22	58	2.52	88	3.83
Potassium K^{+}	5.9	0.15	10.0	0.26	14.3	0.37
Calcium Ca^{++}	185	9.23	220	10.98	190	9.48
Magnesium Mg^{++}	78	6.42	100	8.23	102	8.39
		17.02		21.99		22.07
Chloride Cl^{-}	28	0.79	35	0.99	49	1.38
Carbonate $CO_3^{=}$	Nil		Nil		Nil	
Bicarbonate HCO_3^{-}	370	6.06	600	9.83	790	12.95
Sulphate $SO_4^{=}$	520	10.83	600	12.50	360	7.50
Nitrate NO_3^{-}	0.40	< 0.01	0.45	< 0.01	0.42	< .01
Fluoride F^{-}	2.08	0.11	1.76	0.09	2.52	0.13
		17.80		23.42		21.97
Total Alkalinity $CaCO_3$	300	6.00	492	9.94	645	12.90
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of

SGS Australia Pty. Ltd.

Formerly General Superintendence Company Pty. Ltd.

LABORATORY DIVISION

NEW SOUTH WALES
74 McEvoy St., Alexandria, N.S.W., 2015
Telephone: 699 7625. Telex 22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park, 6107
Telephone: 458 1421. Telex 92624

72 340

335

Australian Groundwater

Our ref. La 0129

Your ref.

Date received

Date completed

Issued at

CERTIFICATE OF WATER ANALYSIS

SOURCE OF WATER						
SAMPLE No.	C 1627		C1633		C1634	
DATE OF COLLECTION						
Conductivity (25°C μ mhos cm^{-1})	1310		3,650		2,500	
Resistivity (25°C ohms. metre)						
Total Dissolved Solids (mg/L @ 180° C)	930		2,700		1,800	
Total Hardness (EDTA) as mg/L $CaCO_3$	550		700		900	
Calculated Hardness as mg/L $CaCO_3$			460		630	
pH	8.2		8.6		8.2	
	mg/L	mEq/L	mg/L	mEq/L	mg/L	mEq/L
Sodium Na^+	115	5.00	760	33.06	350	15.23
Potassium K^+	15.8	0.40	110	2.81	44	1.13
Calcium Ca^{++}	87	4.34	36	1.80	100	4.99
Magnesium Mg^{++}	78	6.42	111	9.13	127	10.44
		16.16		46.80		31.79
Chloride Cl^-	49	1.38	316	8.91	133	3.75
Carbonate $CO_3^=$	Nil		39.5	1.32		
Bicarbonate HCO_3^-	900	14.75	2110	34.58	1500	24.59
Sulphate $SO_4^=$	70	1.46	21	0.44	16	0.33
Nitrate NO_3^-	0.38	< .01	0.85	.01	0.45	< .01
Fluoride F^-	2.96	0.16	14.8	0.78	5.6	0.30
		17.76		46.04		28.98
Total Alkalinity $CaCO_3$	738	14.75	1730	34.58	1230	24.60
Total Iron Fe						
Silica SiO_2						
Manganese Mn						

This Laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

336

SGS Australia Pty. Ltd.

72 341

NEW SOUTH WALES
74 McEvoy St., Alexandria, Sydney, N.S.W. 2015
Telephone 699 7625 Telex: SGSSYD AA22395

WESTERN AUSTRALIA
80 Railway Parade, Queens Park
Telephone 458 1421 Telex: SGSPTH AA92624

Australian GroundWater

Our ref ..... La 0129

Your ref .....

Date received .....

Date completed .....

Issued at .....

ANALYTICAL REPORT

	Sample Ref.	mg/L Fe	mg/L Mn	mg/L Zn			µg/L Cu	µg/L Pb	µg/L As		
1	C1456A	12.6	3.3	0.088			7.1	16	32		
2	1462A	6.3	3.3	0.125			1.5	7.1	3		
3	1528A	12.4	1.65	0.245			8.8	13	32		
4	1536A	1.7	0.315	0.017			1.55	15	2.5		
5	1551A	1.6	0.340	0.025			48	6.7	6		
6	1554A	6.3	0.640	0.045			14.8	10.4	7		
7	1608A	7.1	1.620	0.021			1.7	15	19		
8	1611A	6.9	2.7	0.029			3.1	35	23		
9	1615A	7.9	1.710	0.030			18.4	35	12		
10	1627A	7.0	0.470	2.000			12.7	40	2		
11	1633A	21.0	0.610	0.026			2.9	40	18		
12	1634A	17.7	0.660	0.065			9.4	35	7		
13	CREEK A	0.040	0.015	0.020			1.6	2.1	2		
14	RIVER A	0.230	0.010	0.014			1.4	1.5	1		
15	TAILINGS DAM A	9.8	5.2	0.062			10.7	12	5		
16											
17											
18											
19											
20											

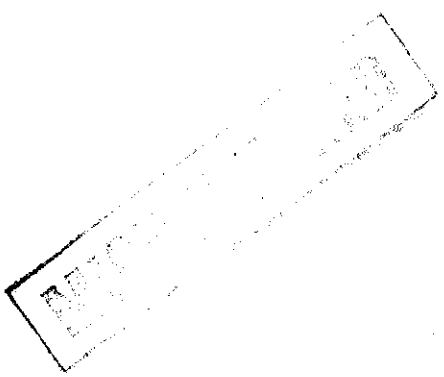
72 342

337

D of M. | A.O. | C.G. | E.O. | D.S.M.E | Registrar
Received 2 - SEP 1983 | E & IL
Answered
DEPT. OF MINES
REF. No. 8084/83

GEOLOGICAL ASSESSMENT OF THE FOLEY ZONE MINERALIZATION AT CLEVELAND MINE, TASMANIA.

DIAGRAMS AND PHOTOGRAPHIC PLATES



LIST OF DIAGRAMS

1. 9 Level Assay Plan - Zinc
2. " " " " - Copper
3. " " " " - Chromium
4. " " " " - Cobalt
5. " " " " - Total Tin
6. " " " " - Lead
7. " " " " - Bismuth
8. Longit. Proj. Halls - Zinc distrib.
9. " " " - Lead "
10. " " " - Bismuth "
11. Plan of 32 level R.L. 850m
12. Schematic Longit. Proj. of Quartz - Porphyry
13. Quartz Porphyry Exposure 25 level.
14. Paragenetic Mineral Sequence.
15. Section 4960E. Vein/alteration distribution - Phase V3 (Quartz)
16. " " " " " - Phase V4 and V5 (Quartz-sericite)
17. " " " " " - Phase V6 (Quartz-molybdenite)
18. " " " " " - Phase V7 (Quartz-wolframite)
19. " " " " " - Phase V8 (Quartz-siderite)
20. " " " " " - Phase V9 (Topaz-pyrite)
21. Assay Profile DDH C1713
22. Vein Number - Dip Distribution DDH C1615
23. Vein orientations - Stereographic Projection
24. Vein Mapping Plan - 21 Level Battery Access Drive
25. Vein Number - Size Distribution DDH C1615
26. % Thickness - Size Distribution DDH C1615
27. Vein Number (<1cm) - Size Distribution DDH C1615
28. % Thickness - Size Distribution DDH C1608
29. Vein Size Distribution DDH C1713

30. Vein Density vs Assays DDH C1754
31. Longit. Proj. of Halls B Lens Mineralogy
32. Longit. Proj. of Henry's Lens
33. Vein Stockwork Khazakstan Deposit U.S.S.R. (after Scherba)
34. Assay Profile DDH C1637
35. Assay Profile DDH C1642
36. Long. Proj. Halls B Lens. Exploration Target.

LIST OF PHOTOGRAPHS

1. - Discordant topazized quartz porphyry intrusive contact (left) with shale (right) 25 level decline.
2. - Topazized quartz porphyry apophysis (outlined in red) within shale and sandstone in 25 level decline. Distance between yellow marks 1m.
3. - Aerial photograph of mine workings showing east-west trending Foley lineament.
4. - Remnant zoned feldspar in sericitized quartz porphyry. Dark spots are tourmaline. DDH C1615 - 189.3m.
5. - Topazized, pyrite-cassiterite bearing quartz porphyry. DDH C1713 - 209.6m scale in cms.
6. - Topazized quartz porphyry with pyrite "ghost" after original feldspar. DDH C1615 - 247.9m.
7. - Topaz-pyrite altered porphyry (top) with grey sericite alteration (below). Relict feldspars (brown) are replaced by siderite. DDH C 1615 - 208.8m.
8. - Sericite-illite altered (greisenized) sandstone cut by later quartz veins. DDH C1713 - 195.6m.
9. - Grey sericite alteration and yellow illite alteration contact in quartz porphyry. Fine dark spots are wolframite and sphalerite. DDH C1713 - 227.5m.
10. - Yellow illite alteration (left) with kaolinite alteration (centre) and sericite alteration (right) in quartz porphyry. DDH C1633 - 542.8m.
11. - Kaolinite altered quartz-porphyry. DDH C1713 - 201.8m.
12. - Multi-pulse illite altered sericite veins (V3, V4) cut by later sericite - quartz veins (V5). DDH C1634 - 106.6m.
13. - Cross cutting veins sub-horizontal multi-pulse mineralized vein (V7) cutting earlier near-vertical compounded quartz veins (Ve & V6). DDH C1754 - 170.4m.
14. - Composite quartz veins with phases V6, V7 & V9 (vertical-right side) cutting earlier quartz sericite veins V4. DDH C1634 - 159.8m.

15. - Localized siderite replacement of multi-pulse quartz-sericite veins (V4). Mineralized quartz vein (V7) at bottom. DDH C1634 - 138.8m.
16. - Wolframite bearing quartz vein (V7). Note molybdenite selvage on vein contact. Illite-flourite in centre of vein. 21 battery access drive east side-wall.
17. - Wolframite blade with inclusions of bismuthinite and native bismuth, minor molybdenite against wolframite. Quartz with yellow interstitial illite. Blade is approx. 14mm long. DDH C1634 - 145.4m.
19. - Arsenopyrite-pyrite-tourmaline vein (V8) with silicified contacts against weakly biotite altered sandstone. DDH C1637 - 60.5m. scale in cms.
20. - Pyrite-quartz-chalcopyrite-sphalerite vein (V8) in topaz altered mineralized quartz porphyry. DDH C1634 - 108.9m.
21. - Brown siderite replacement after earlier multiple sericite and quartz veins. DDH 1637 - 94.10m.
22. - Quartz-topaz-pyrite vein (V9). 21 Battery Access Drive east sidewall.
23. - Numerous very thin late quartz-topaz-pyrite veinlets (V9). Veinlets form directly up-dip from porphyry 60m below. 21 Battery Access Drive west sidewall.
24. - Dense compound veining (bottom half of tray). DDH C1637 -81m.
25. - Multiple invasions of several vein phases (V3, V6, V7, V8, V9) producing one apparent vein. DDH C1803 - 102.7m.
26. - Well mineralized zone. Dark spots in quartz veins are wolframite. DDH C1754 - 148m.
27. - Stage V6 and V7 mineralized veins (vertical) forming composite (side by side) single vein at top. Early stage V3 vein horizontally. 21 Battery Access Drive west sidewall.
28. - Highly irregular gashing and "stoping" flat quartz veins. 21 Battery Access Drive loading bay.
29. - Early stage V3 vein tension gash type junction. Higher

vein on right side indicates possible porphyry centre to the right. 21 Battery Access Drive east sidewall.

30. - Siderite-sericite bleached sandstone with dark grey tourmaline alteration. Mineralized vein (V7) with topaz-pyrite centre (V9) on left. DDH C1754 - 146.5m.

31. - Intense tourmaline altered quartz porphyry (top left) against bleached (siderite, sericite, clay altered) sandstone. DDH C1633 -496.9m.

32. - Interconnecting flat near barren quartz veins (V3). Note dark tourmaline alteration adjacent vein in bleached sandstones. 21 Battery Access Drive west sidewall.

33. - Siderite, sericite, clay altered (bleached) sandstone surrounded by brown biotite altered sandstone. 21 Battery Access Drive east sidewall. 1m between white paint marks.

34. - Wolframite clots (circled) in green biotite-flourite-sellaite altered Henry's lode. DDH C1754 - 61.1m.

35. - Sericite-tourmaline matrix breccia with quartz, country-rock fragments. Sericitized porphyry on extreme left. Sandstone on right. DDH C1741 - 99.1m.

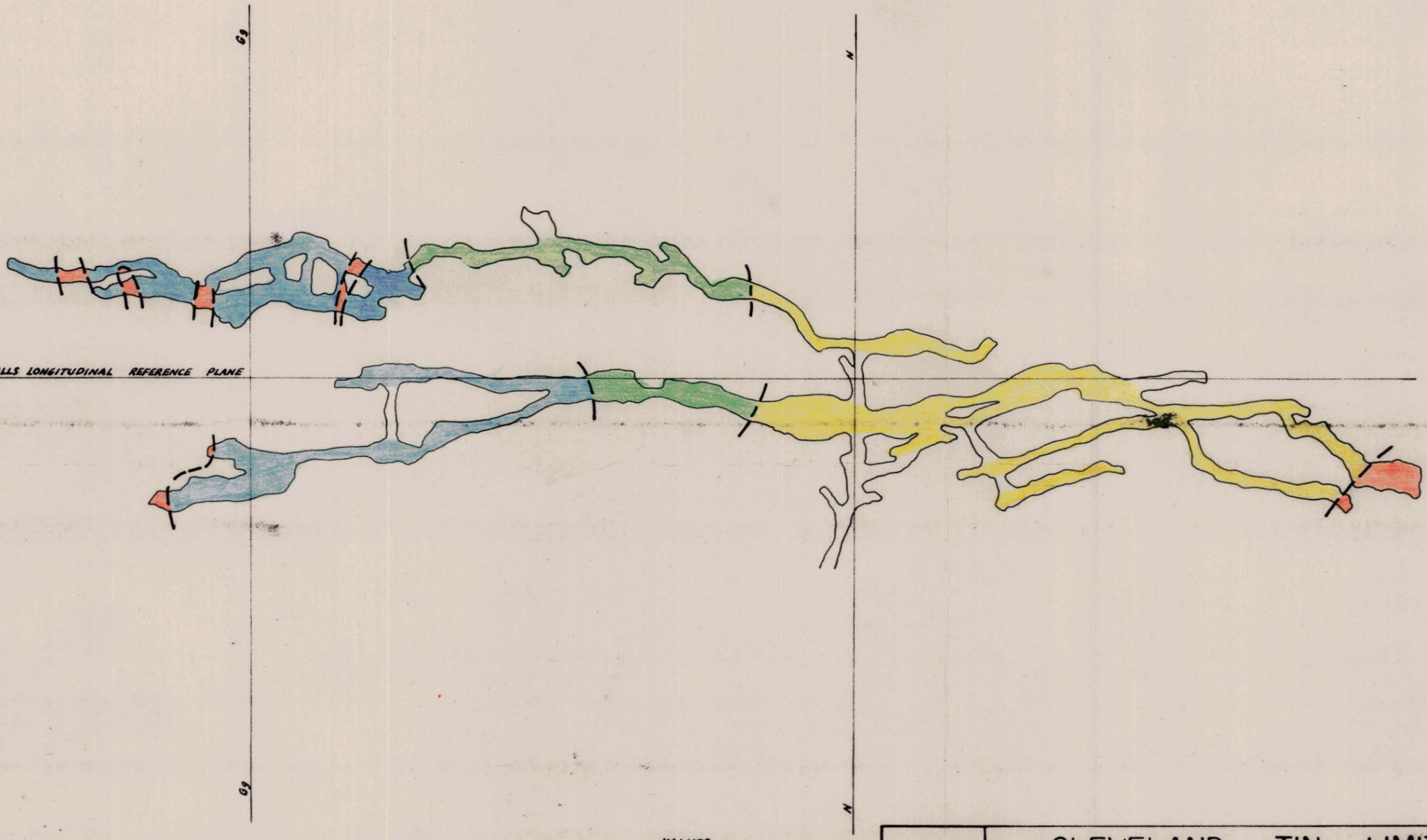
36. - Very late stage pyrite-marcasite vughy breccia. DDH C1811 - 90.1m.

37. - Native bismuth (white) and bismuthinite (grey) in quartz-sellaite altered tin lode (Henry's). DDH C1842 - 42.9m.

38. - Heavily topazized Henry's lode (left) against topaz-flourite vein V9 (right). 21 Battery Access Drive west sidewall.

39. - 15mm to 65mm particle size "accept" from photometric sorter.

40. - 15mm to 65mm particle size "reject" from photometric sorter.



VALUES
- > 4000 ppm
- 400 → 4000 ppm
- 200 → 400 ppm
- < 200 ppm

0m 50m 100m

5 cm

343

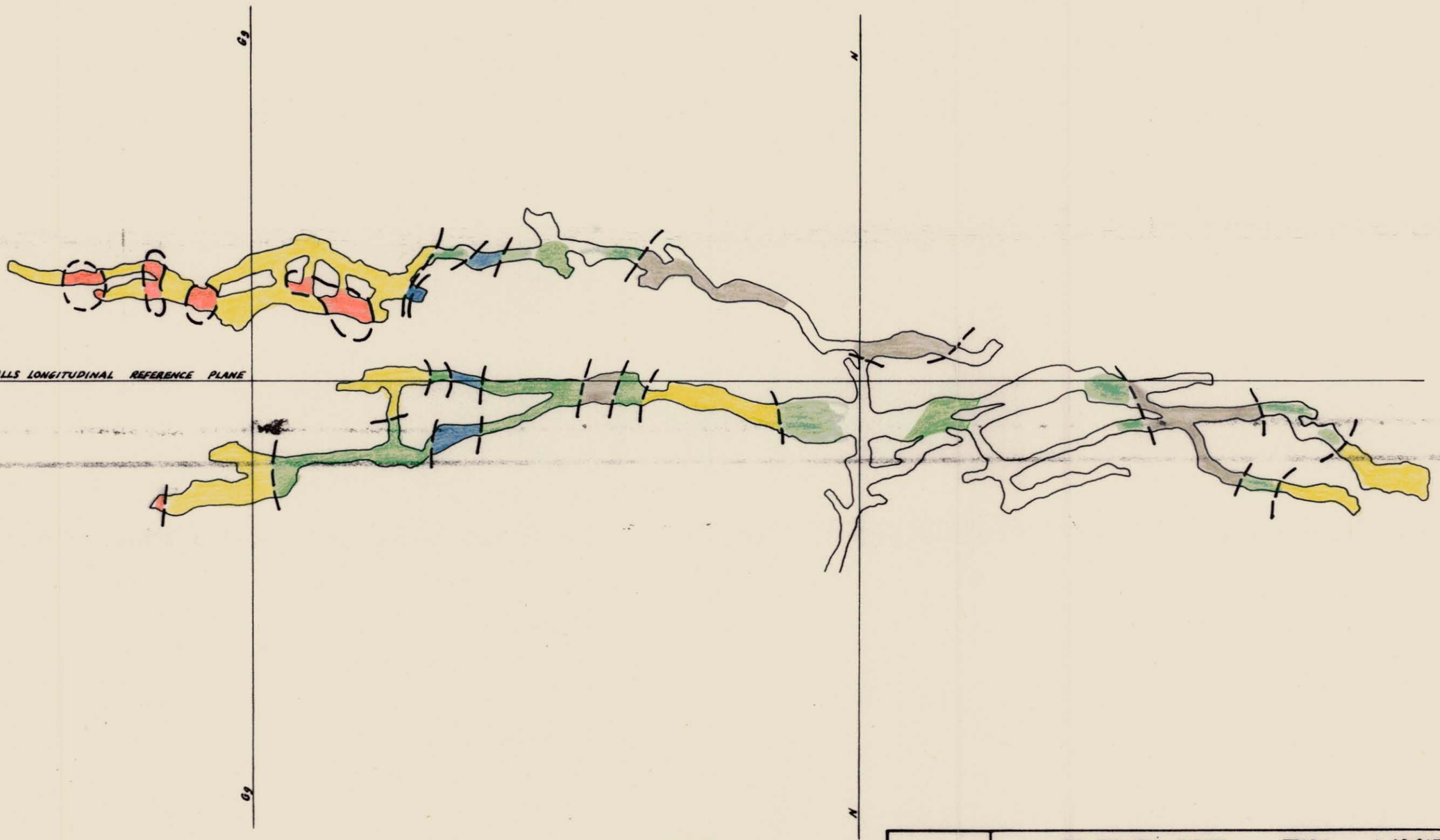
MC·FOL·001.

CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN

ZINC

DRAWN	Paul.
ORIGINATOR	E.V.D.
DATE	29·4·83
SCALE	1:2000
DRAWING No.	1



VALUES
- ≤ 1000 ppm
- > 1000 but ≤ 3000 ppm
- > 3000 but ≤ 6000 ppm
- > 6000 but ≤ 9000 ppm
- > 9000 ppm

MC-FIL-002.

0m 50m 100m

5 cm

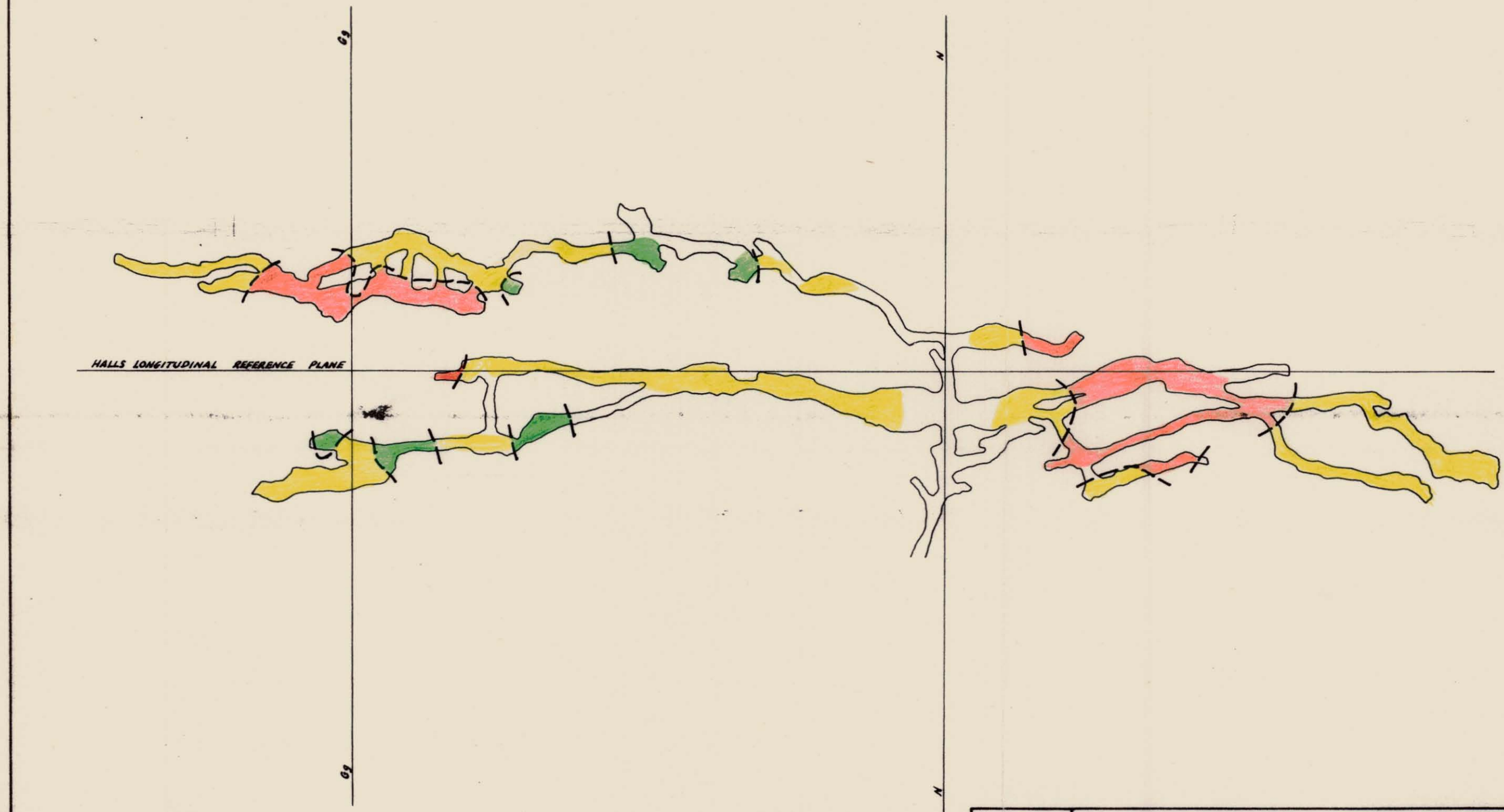
344

CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN

COPPER

DRAWN	Paul.
ORIGINATOR	E.V.D.
DATE	29-4-83
SCALE	1:2000
DRAWING No.	2

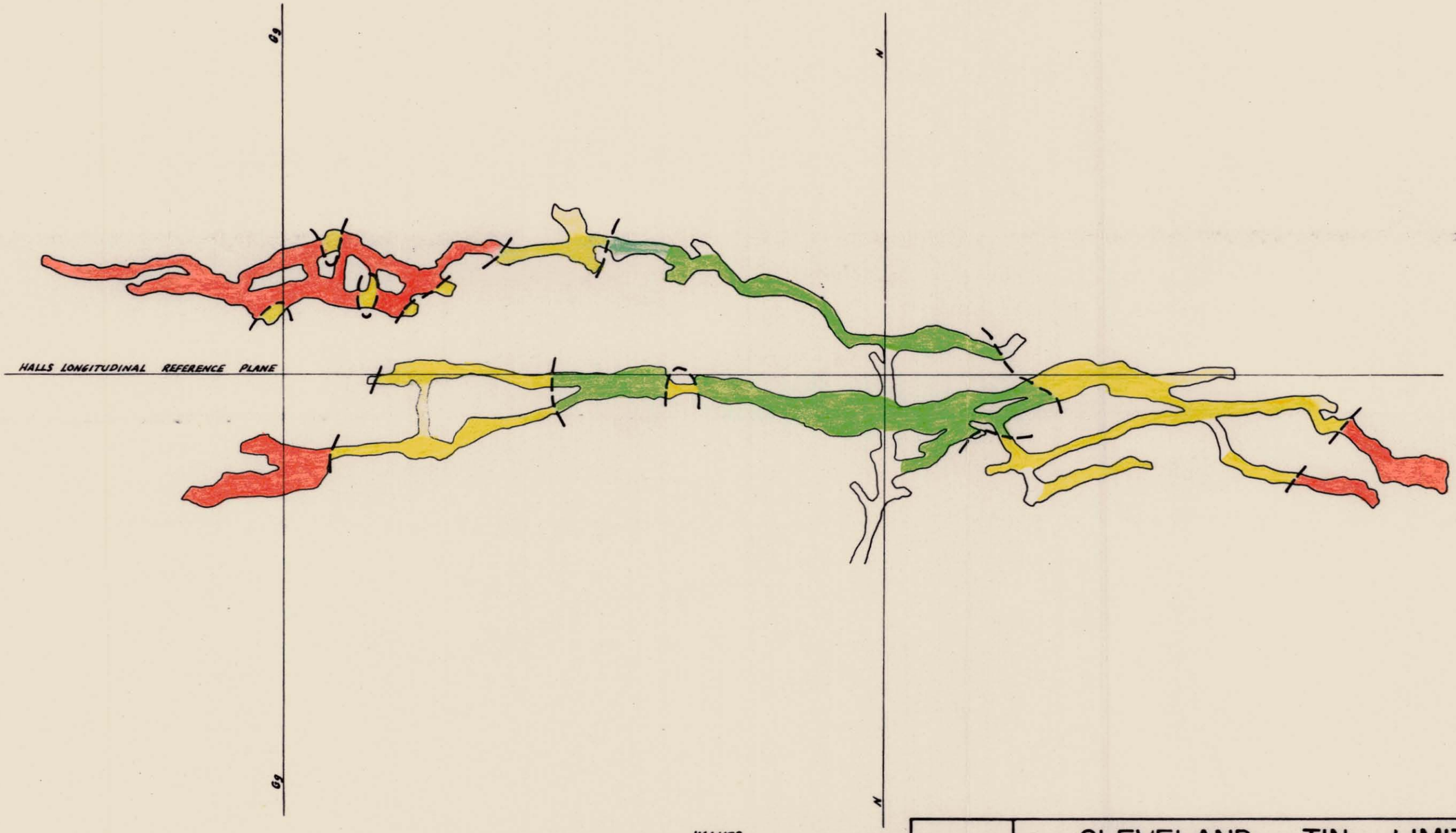


CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN

CHROMIUM

DRAWN	Paul.
ORIGINATOR	E.V.D.
DATE	29-4-83
SCALE	1:2000
DRAWING No.	3



VALUES
- ≤ 50ppm
- > 50 but ≤ 100ppm
- > 100ppm

0m 50m 100m

5 cm

346

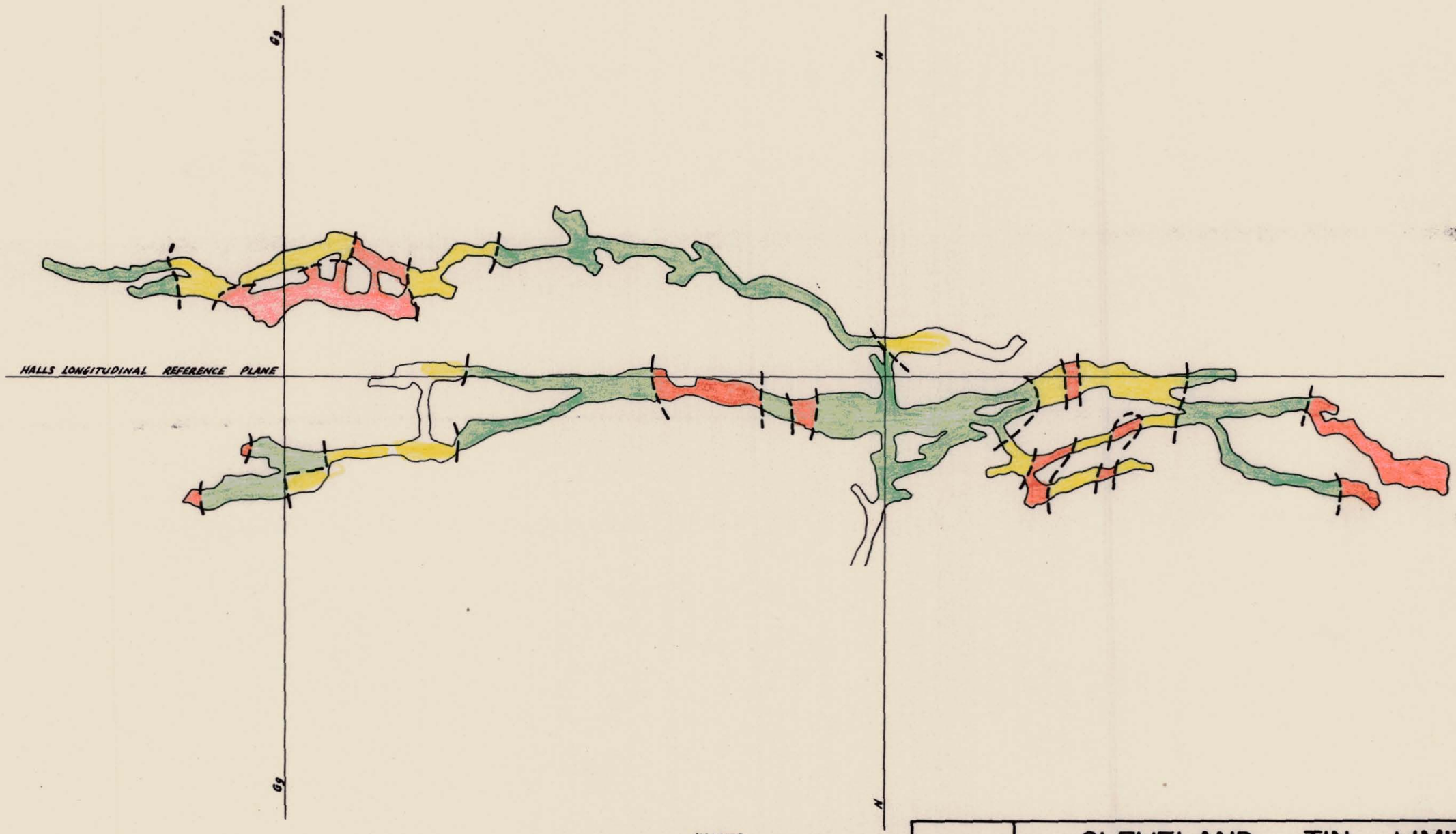
MC·FOL·004.

CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN
COBALT

DRAWN	Paul.
ORIGINATOR	E.V.D.
DATE	29·4·83
SCALE	1:2000
DRAWINC No.	4

347



VALUES

- ≤ 0·5%
- > 0·5 but ≤ 1·00%
- > 1·00 but ≤ 1·5%
- > 1·5%.

0m 50m 100m

5 cm

MC·FOL·005.

N

CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN

TOTAL TIN

DRAWN	Paul.
ORIGINATOR	E.V.D.
DATE	29·4·83
SCALE	1:2000
DRAWING No.	5

G3

N

HALLS LONGITUDINAL REFERENCE PLANE

G9

N

VALUES

- ≤ 25ppm
- > 25 but ≤ 50ppm
- > 50 but ≤ 100ppm
- > 100 but ≤ 200ppm
- > 200ppm

0m 50m 100m

5 cm

348

MC. FOL: 006.

CLEVELAND TIN LIMITED

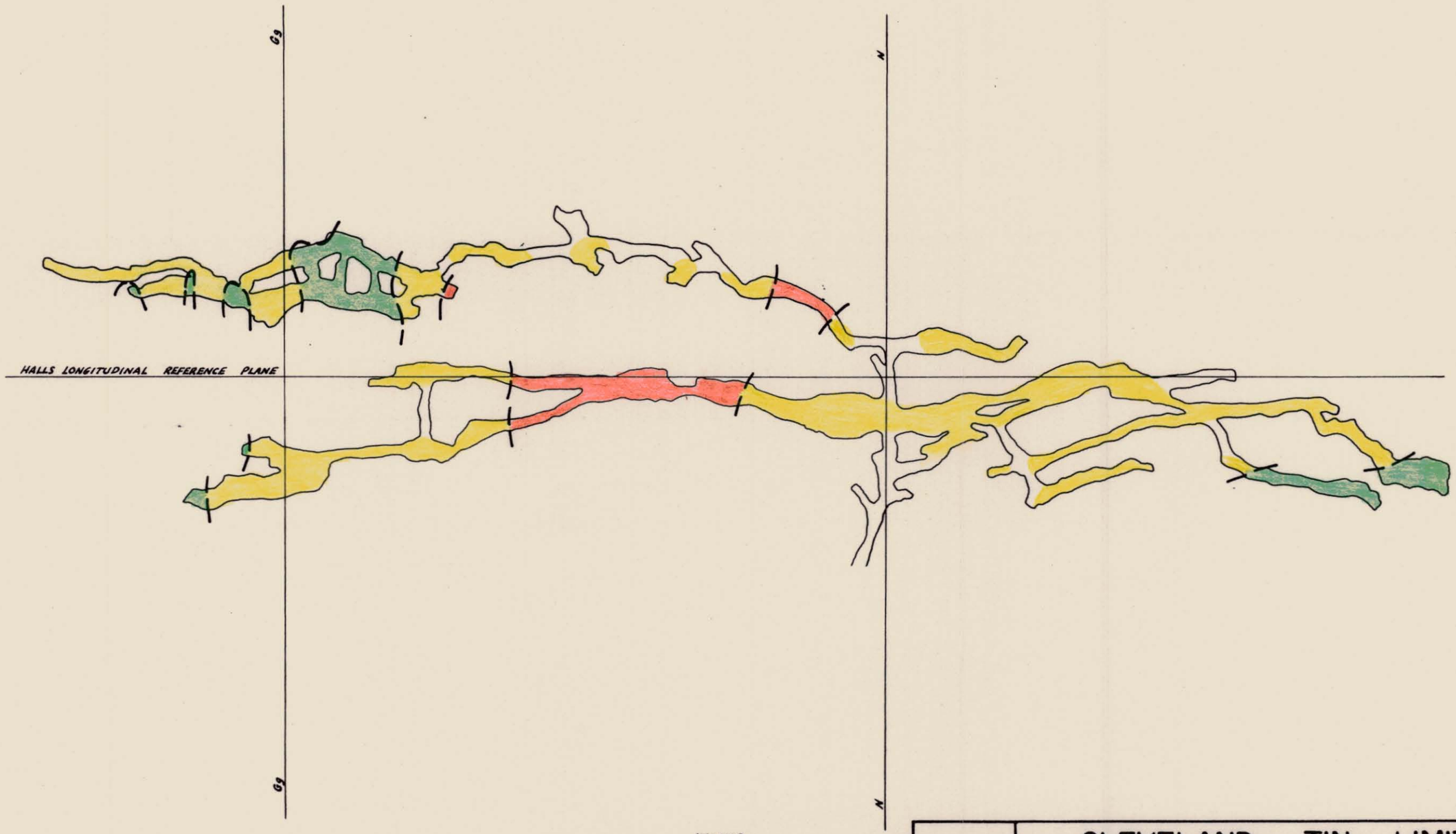
FOLEY ZONE

9 LEVEL PLAN

LEAD

DRAWN	Paul.
ORIGINATOR	E. V. D.
DATE	29·4·83
SCALE	1:2000
DRAWING No.	6

72 354



VALUES
- > 300 ppm
- 100-300 ppm
- < 100 ppm

0m 50m 100m

5 cm

MC-FAL-007.

CLEVELAND TIN LIMITED

FOLEY ZONE
9 LEVEL PLAN

BISMUTH

DRAWN	Bul.
ORIGINATOR	E.V.D.
DATE	29-4-83
SCALE	1:2000
DRAWING No.	7

349

72 355

SW

NE

Gg-SECTION

N-SECTION.

RL.1400m

SURFACE

9Level

LODE TERMINATION

0·5% Sn

LIMESTONE

RL 1200m

FAULT

WINDOW

FOLEY ZONE.
(In Footwall)

0·5% Sn

Sea Level.

RL 1000m

VALUES
- >400 ppm
- 400 — 4000 ppm
- 200 — 400 ppm
- < 200 ppm

32Level.

Gg.

QTZ. PORPHRY INTRUSIVE

0·3% WO3

LIMIT OF VEINS

N.

0m 100m 200m

5 cm

MC-FOL. 008.

350

CLEVELAND TIN LIMITED		
FOLEY ZONE LONGITUDINAL PROJ. on HALLS 'B' GENERALIZED ZINC DISTRIBUTION	DRAWN	Paul
	ORIGINATOR	E.V.D.
	DATE	29-4-83
	SCALE	1:2740
	DRAWING No.	8

72 356

SW

NE

G9-SECTION

N-SECTION

RL.1400m

RL.1400m

SURFACE

LODE TERMINATION

9Level

9Level

0·5% Sn

LIMESTONE

LIMESTONE

RL 1200m

RL.1200m

FAULT

WINDOW

FOLEY ZONE.
(In Footwall)

0·5% Sn

Sea Level.

RL.1000m

VALUES
< 25 ppm
25 – 200 ppm
> 200 ppm

32Level.

G9.

QTZ. PORPHYRY INTRUSIVE

0·3% WO3

LIMIT OF VEINS

N.

0m 100m 200m

5 cm

MC-FOL-009.

CLEVELAND TIN LIMITED		
FOLEY ZONE LONGITUDINAL PROJ. on HALLS 'B' GENERALIZED LEAD DISTRIBUTION	DRAWN	Paul
	ORIGINATOR	E.V.D.
	DATE	29-4-83
	SCALE	1:2740
	DRAWING No.	9

72 357

SW

NE

Gg - SECTION

N - SECTION.

RL. 1400m

RL. 1400m

SURFACE

9 Level

9 Level

LODE TERMINATION

0·5% Sn

LIMESTONE

LIMESTONE

RL 1200m

RL. 1200m

FAULT

WINDOW

FOLEY ZONE.
(In Footwall)

0·5% Sn

Sea Level.

RL 1000m

VALUES

< 100 ppm

100 — 300 ppm

> 300 ppm

5 cm

QTZ. PORPHYRY INTRUSIVE

0·3% WO3

LIMIT OF VEINS

Gg.

N.

32 Level.

0m 100m 200m

352

MC·FOL·010.

CLEVELAND TIN LIMITED

FOLEY ZONE

LONGITUDINAL PROJ. on HALLS 'B'

GENERALIZED BISMUTH DISTRIBUTION

DRAWN	Paul
ORIGINATOR	E.V.D.
DATE	29·4·83
SCALE	1:2740
DRAWINC No.	10

ULTRAMAFIC SEQUENCE

Gg SECTION

N SECTION

HALL'S REFERENCE PLANE

0·3% WO_3 LIMIT

CRESCENT SPUR MICA SANDSTONE

QTZ. PORPHYRY INTRUSIVE

HENRYS LODE

HENRYS

BATTERY REFERENCE PLANE.

HALLS FORMATION

'B' LENS

'B' LENS

'C' LENS

'D' LENS

'E' LENS

EN FAULT

Gg

N

DEEP CREEK VOLCANICS

5 cm

0m 100m 200m

N

MC. FOL. 011.

353

CLEVELAND TIN LIMITED

FOLEY ZONE

PLAN OF 32 LEVEL
RL. 850 m.

DRAWN	Paul
ORIGINATOR	E.V.D.
DATE	2-5-83
SCALE	1:2000
DRAWING No.	11

72 359

3006N

5000E

5100E

CRESCENT SPUR SANDSTONE
ULTRABASIC COMPLEX.

HENRY'S LENS

HALLS FORMATIONS

RL 1000m

RL 1000m

LIMIT OF SIGNIFICANT VEINS

INTERPRETED LIMIT OF QTZ. PORPHYRY

HALLS '8' LENS

RL 800m

RL 800m

BATTERY REFERENCE PLANE.

5 cm

3006N

5000E

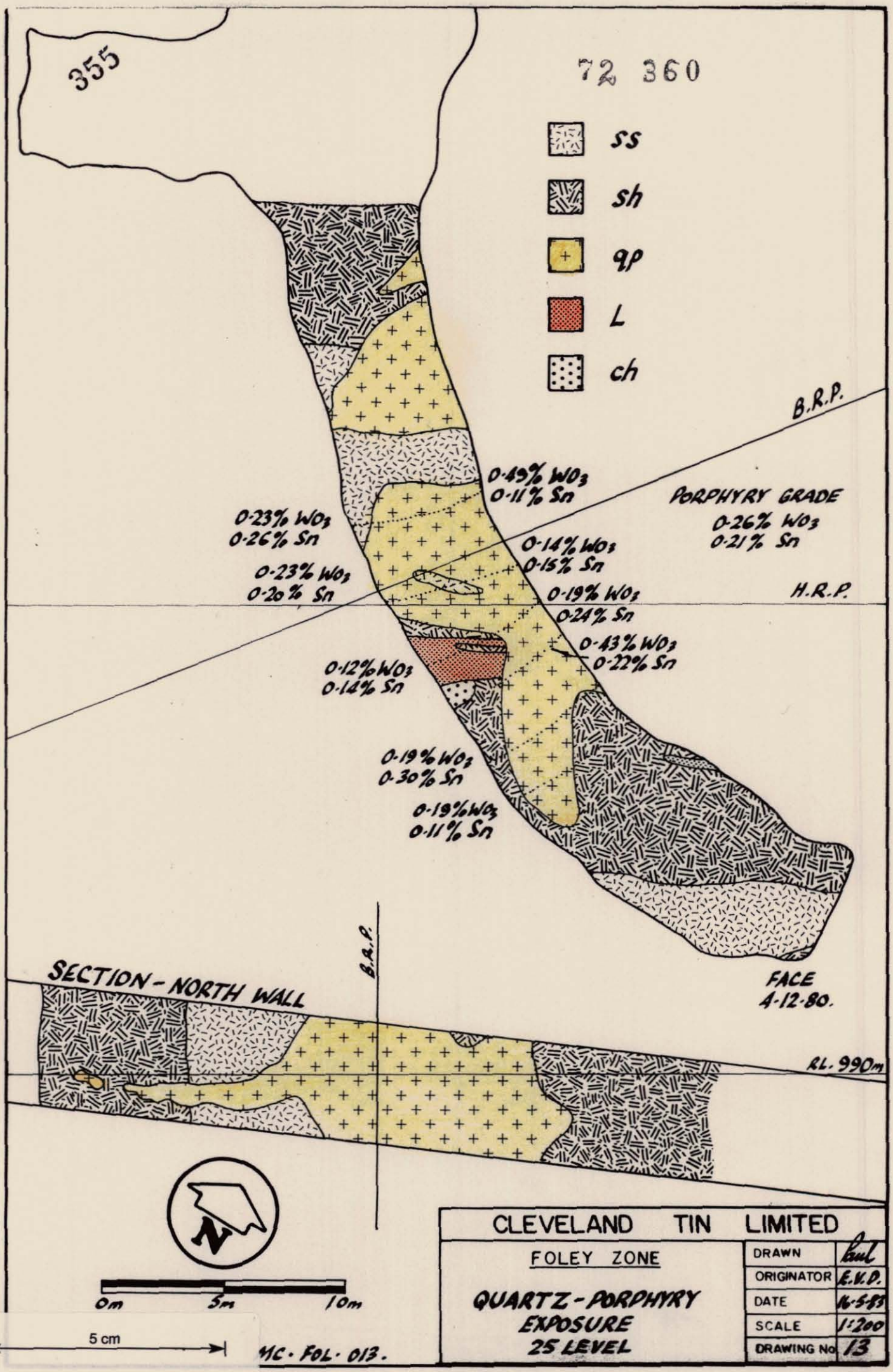
MC-FOL-012.

CLEVELAND TIN LIMITED

FOLEY ZONE

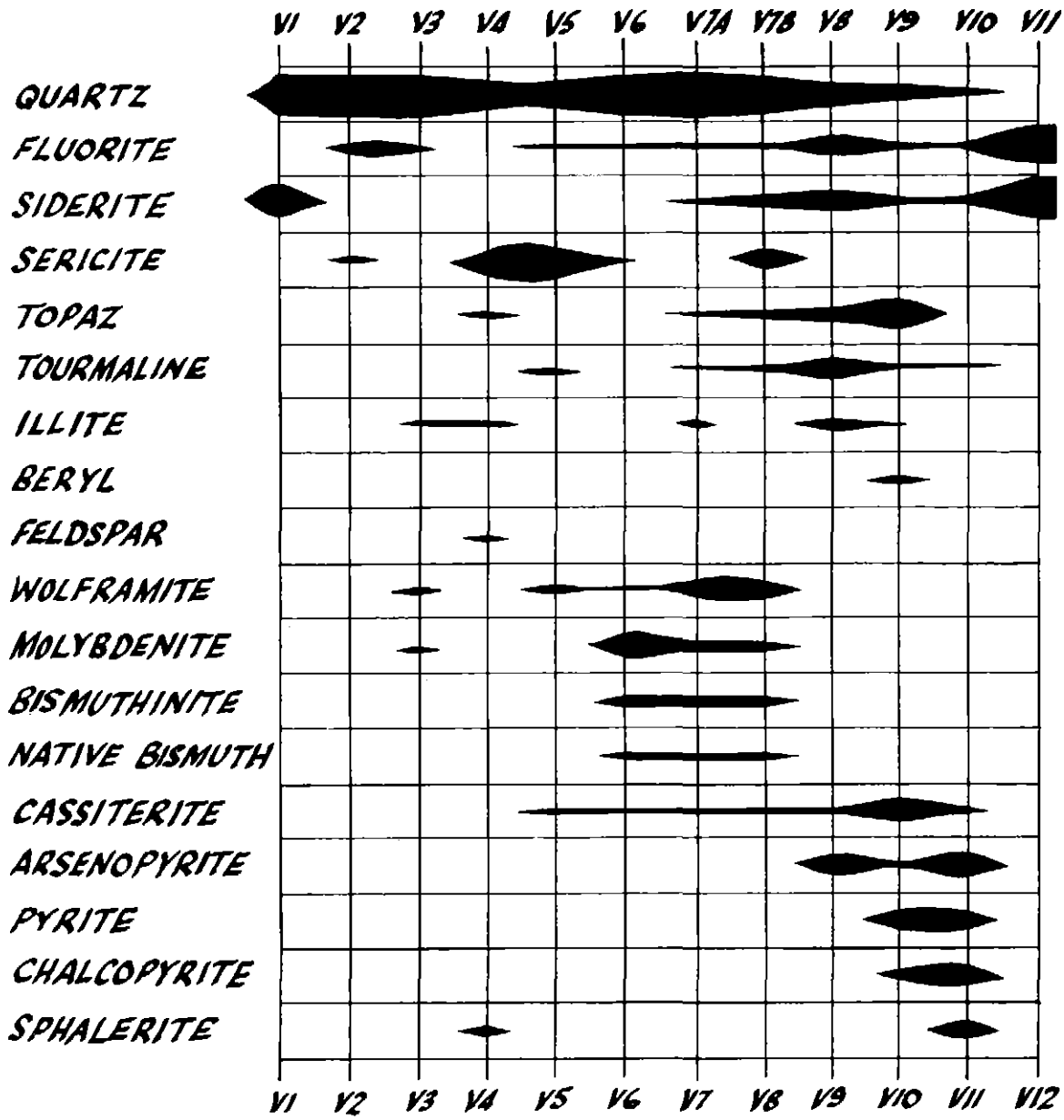
LONGITUDINAL PROJECTION OF QTZ. PORPHYRY INTRUSIVE

DRAWN	Paul
ORIGINATOR	E.V.D
DATE	17-5-83
SCALE	1:2000
DRAWING No	12


355
72 360
ss
sh
qp
L
ch
B.R.P.
0·49% WO3
0·11% Sn
PORPHYRY GRADE
0·26% WO3
0·21% Sn
0·23% WO3
0·26% Sn
0·14% WO3
0·15% Sn
0·23% WO3
0·20% Sn
0·19% WO3
0·24% Sn
H.R.P.
0·43% WO3
0·22% Sn
0·12% WO3
0·14% Sn
0·19% WO3
0·30% Sn
0·19% WO3
0·11% Sn
FACE
4-12-80.
B.A.P.
SECTION - NORTH WALL
RL. 990m
N
0m
5m
10m
5 cm
MC · FOL · 013.
CLEVELAND TIN LIMITED
FOLEY ZONE
QUARTZ - PORPHYRY
EXPOSURE
25 LEVEL
DRAWN
ORIGINATOR E.V.D.
DATE 14-5-83
SCALE 1:200
DRAWING No 13

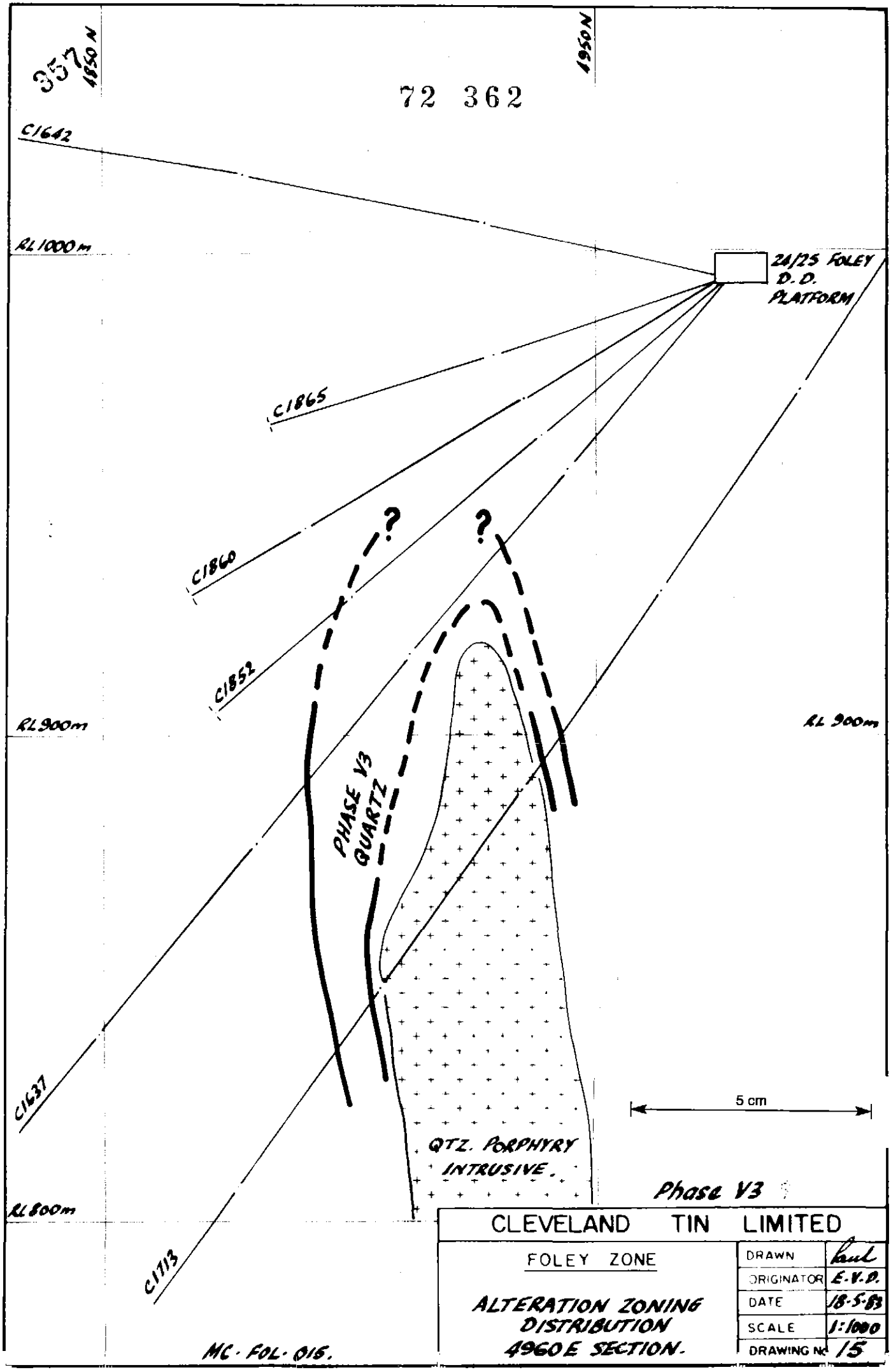
356

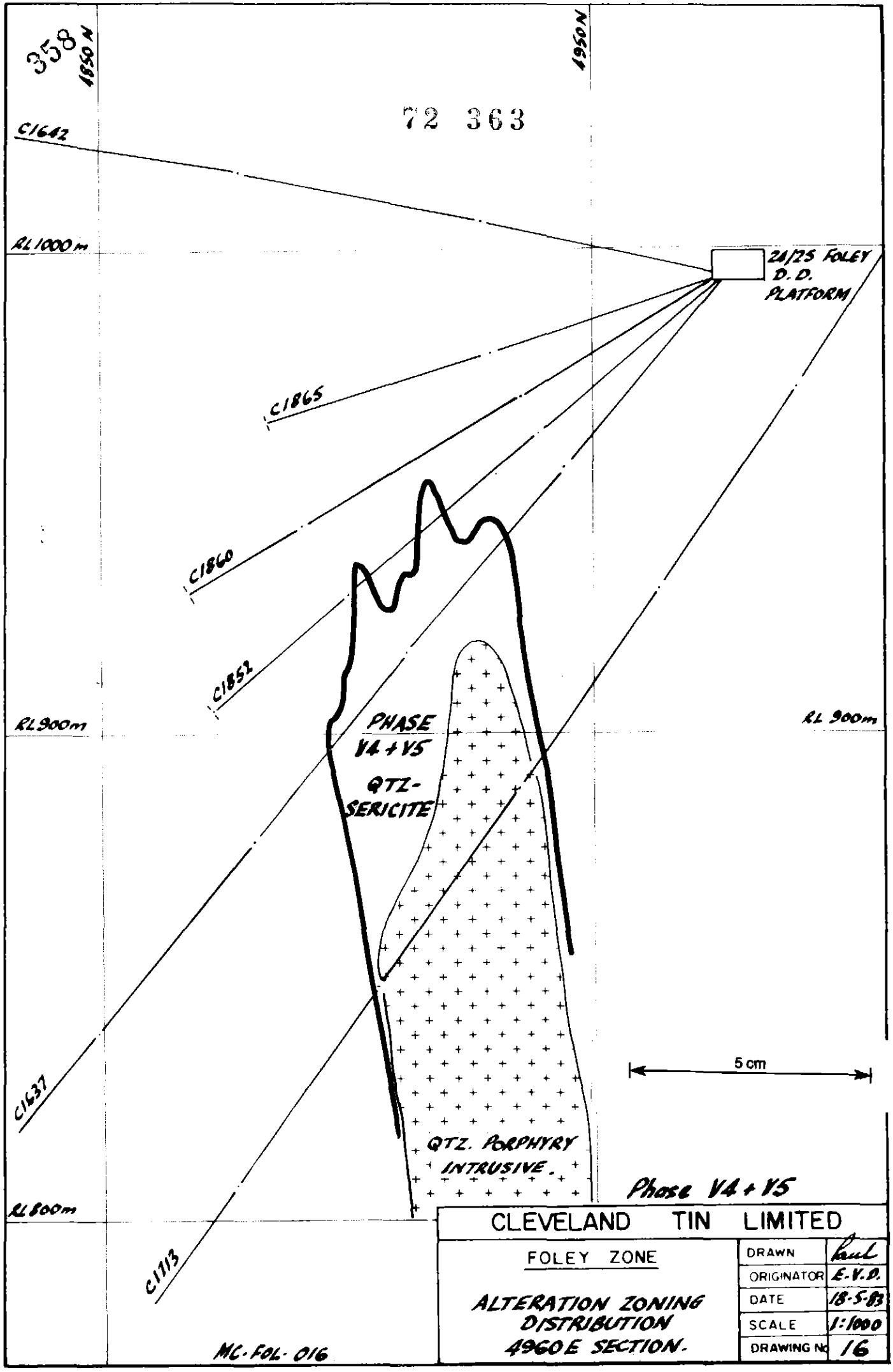
72 361

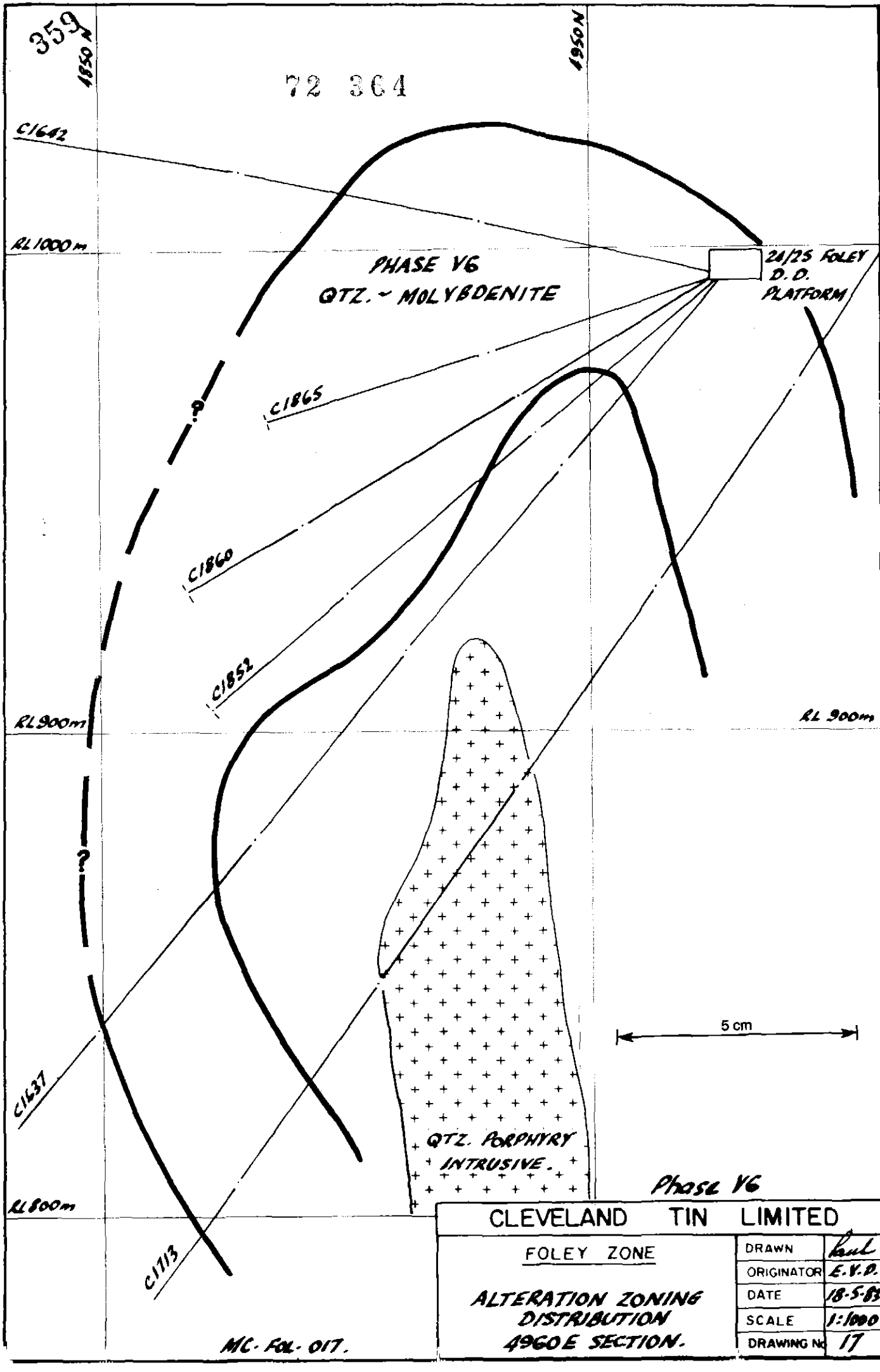


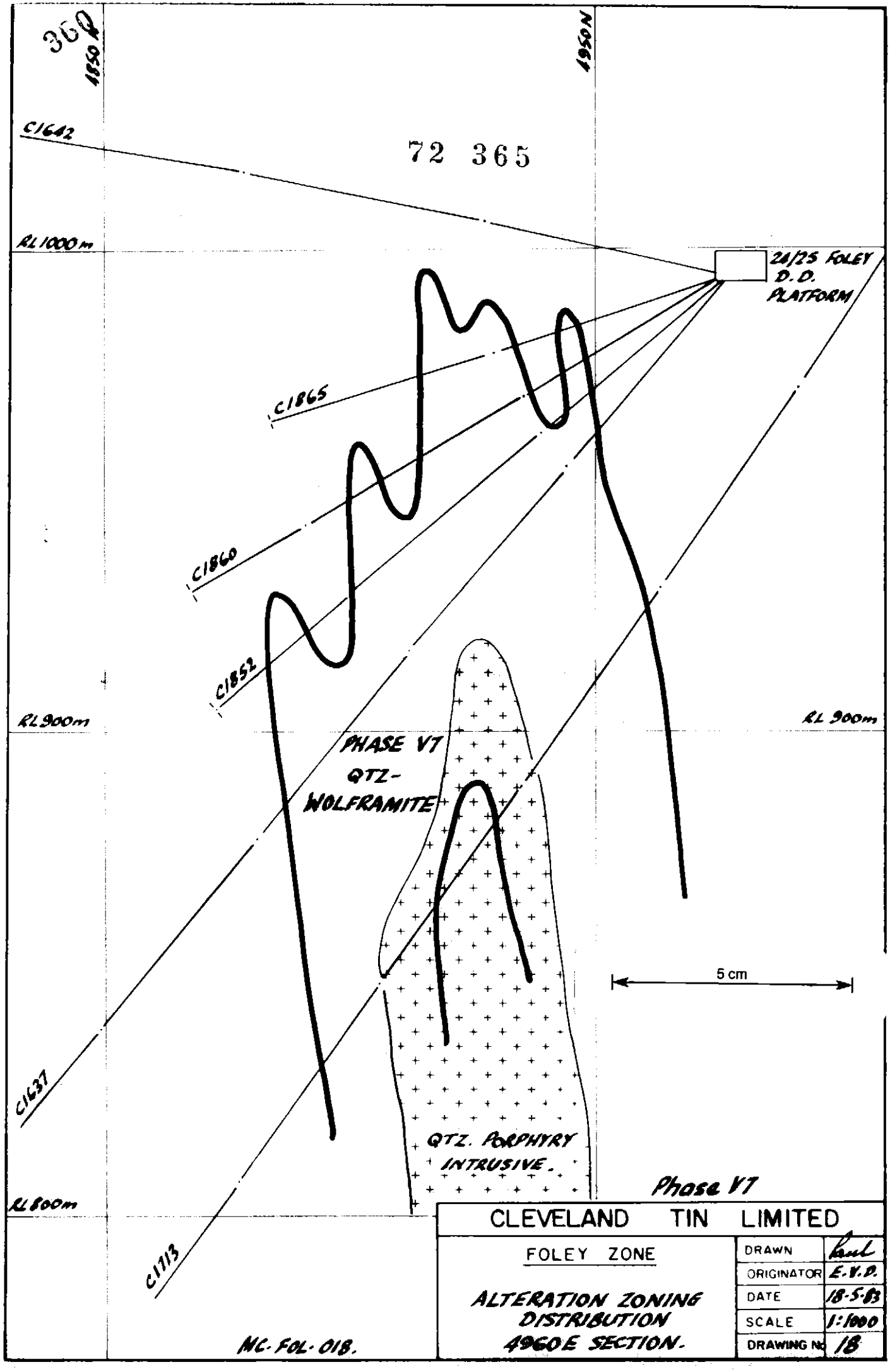
CLEVELAND TIN LIMITED		
FOLEY ZONE PARAGENETIC MINERAL SEQUENCE	DRAWN	Rml
	ORIGINATOR	E.V.D.
	DATE	20-6-83
	SCALE	
	DRAWING No	14

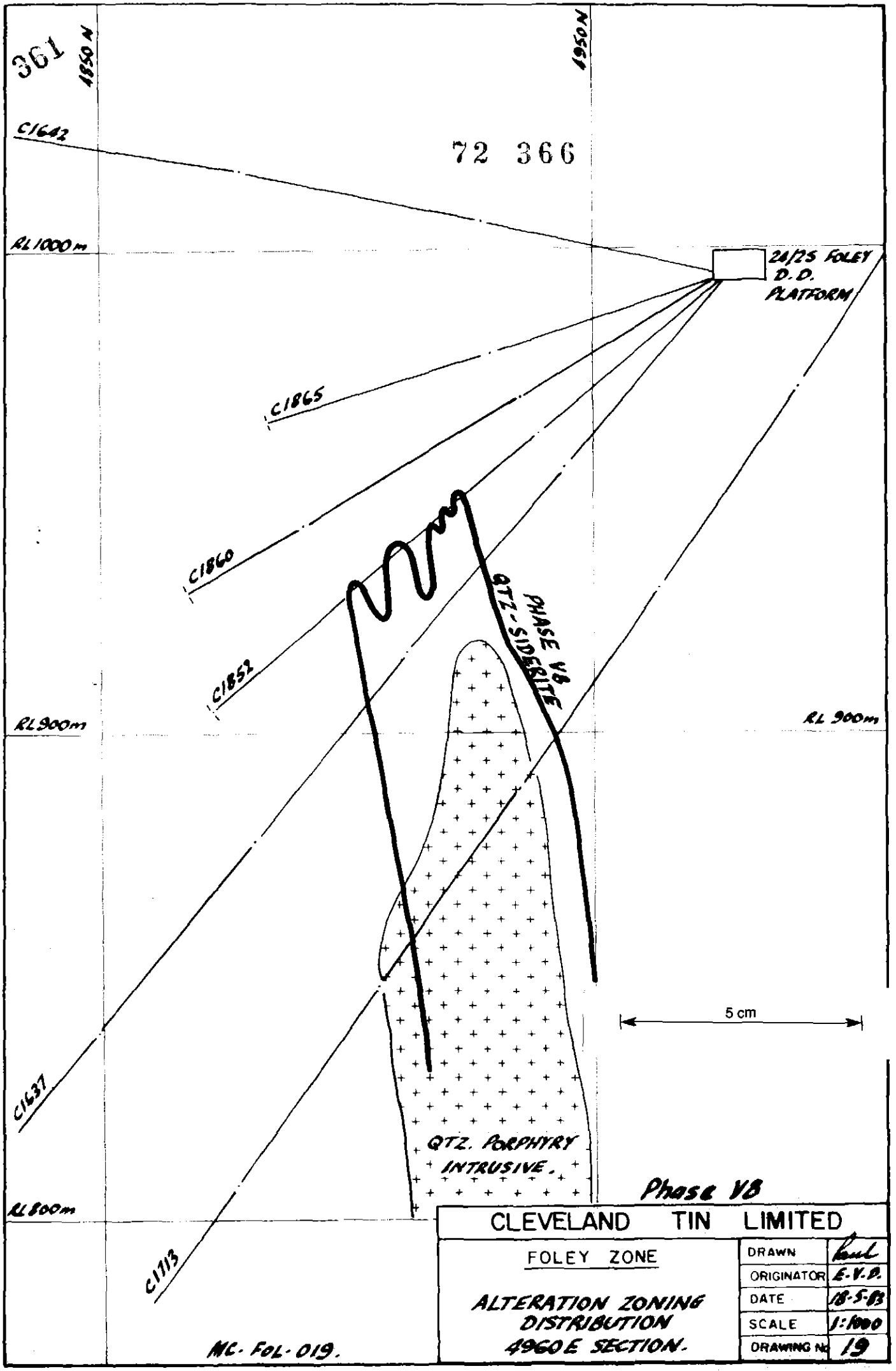
MC-FOL-014.


357
1850 N
1950N
72 362
C1642
RL 1000m
24/25 FOLEY
D.D.
PLATFORM
C1865
C1860
C1852
?
?
RL 900m
RL 900m
PHASE V3
QUARTZ
C1637
5 cm
QTZ. PORPHYRY
INTRUSIVE.
Phase V3
RL 800m
C1113
CLEVELAND TIN LIMITED
FOLEY ZONE
ALTERATION ZONING
DISTRIBUTION
4960E SECTION.
DRAWN
ORIGINATOR
DATE
SCALE
DRAWING No
Paul
E.V.D.
18-5-83
1:1000
15
MC-FOL-016.


358
1850 N
1950N
72 363
C1642
RL 1000m
21/25 FOLEY
D.D.
PLATFORM
C1865
C1860
C1852
RL 900m
RL 900m
PHASE
V4 + V5
QTZ-
SERICITE
5 cm
C1637
QTZ. PORPHYRY
INTRUSIVE.
Phase V4 + V5
RL 800m
C1113
MC-FOL-016
CLEVELAND TIN LIMITED
FOLEY ZONE
ALTERATION ZONING
DISTRIBUTION
4960E SECTION.
DRAWN
ORIGINATOR E.V.D.
DATE 18-5-83
SCALE 1:1000
DRAWING No 16


359
1850 N
1950 N
72 364
C1642
RL 1000m
PHASE V6
QTZ. ~ MOLYBDENITE
24/25 FOLEY
D.D.
PLATFORM
C1865
C1860
C1852
RL 900m
RL 900m
5 cm
C1637
QTZ. PORPHYRY
INTRUSIVE.
Phase V6
RL 800m
C1713
MC-FOL-017.
CLEVELAND TIN LIMITED
FOLEY ZONE
ALTERATION ZONING
DISTRIBUTION
4960E SECTION.
DRAWN Paul
ORIGINATOR E.V.D.
DATE 18-5-83
SCALE 1:1000
DRAWING No 17


360
1850 N
1950 N
72 365
C1642
RL 1000m
24/25 FOLEY
D.D.
PLATFORM
C1865
C1860
C1852
RL 900m
RL 900m
PHASE VT
QTZ-
WOLFRAMITE
5 cm
C1637
QTZ. PORPHYRY
INTRUSIVE.
Phase VT
RL 800m
C1113
MC-FOL-018.
CLEVELAND TIN LIMITED
FOLEY ZONE
ALTERATION ZONING
DISTRIBUTION
4960E SECTION.
DRAWN
ORIGINATOR E.V.D.
DATE 18-5-83
SCALE 1:1000
DRAWING No 18

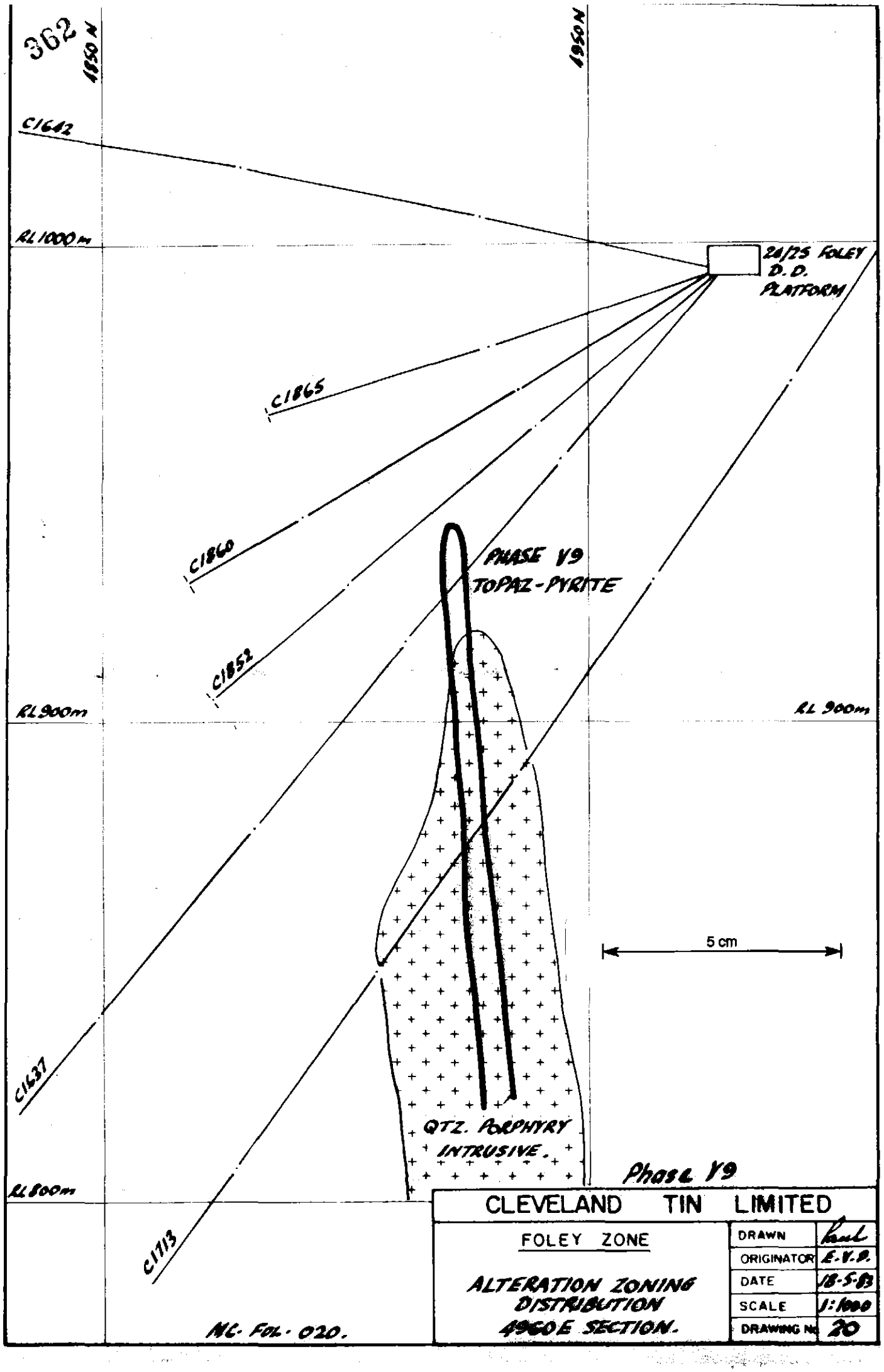


CLEVELAND TIN LIMITED

FOLEY ZONE

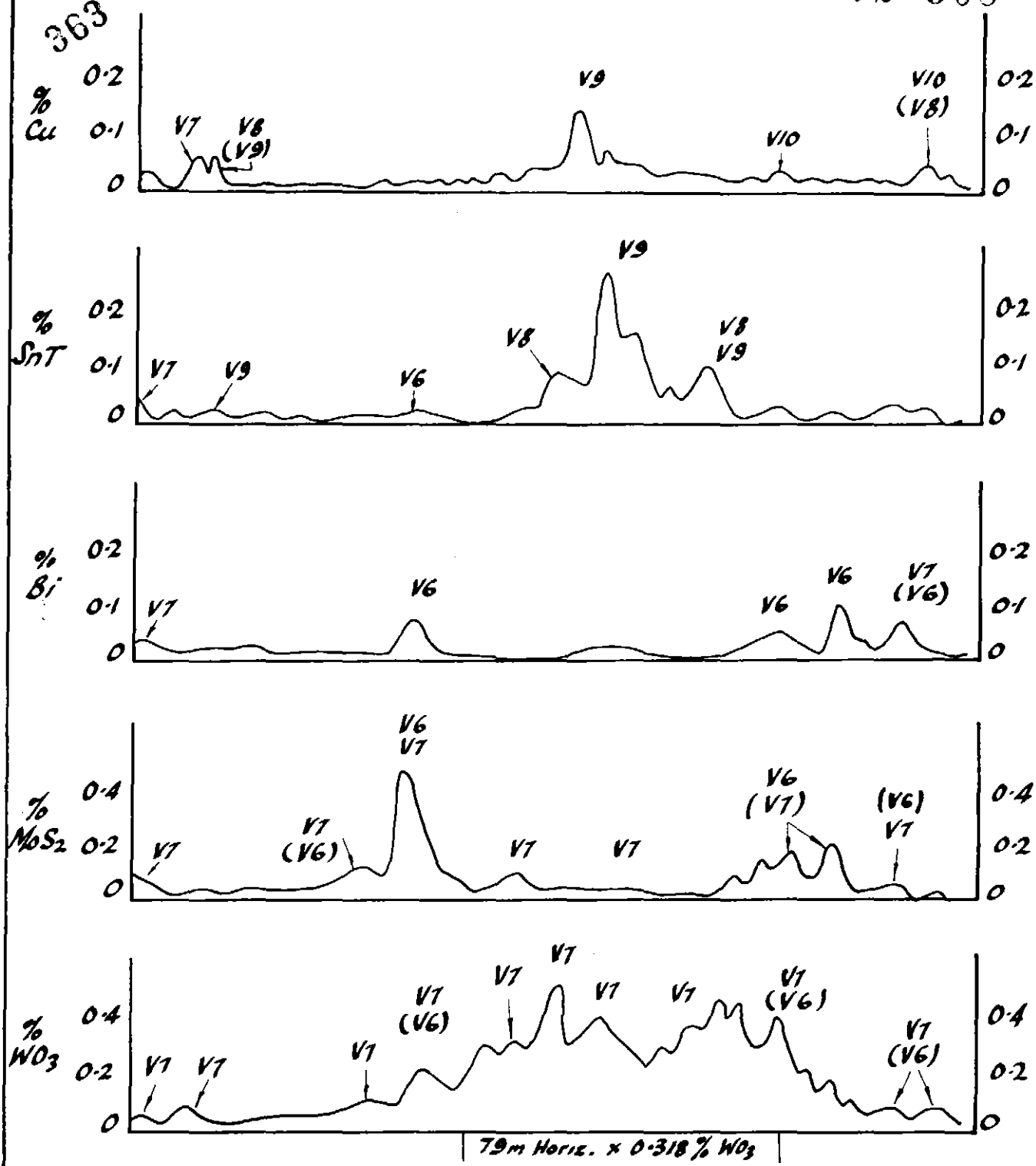
ALTERATION ZONING DISTRIBUTION 4960E SECTION.

DRAWN	Paul
ORIGINATOR	E.V.D.
DATE	18-5-83
SCALE	1:1000
DRAWING No	19


362
1850 N
1950 N
C1642
RL 1000m
24/25 FOLEY
D.D.
PLATFORM
C1865
C1860
C1852
PHASE V9
TOPAZ-PYRITE
RL 900m
RL 900m
5 cm
C1637
QTZ. PORPHYRY
INTRUSIVE.
Phase V9
RL 800m
C1713
CLEVELAND TIN LIMITED
FOLEY ZONE
ALTERATION ZONING
DISTRIBUTION
4960E SECTION.
DRAWN
ORIGINATOR E.V.D.
DATE 18-5-83
SCALE 1:1000
DRAWING No 20
MC-FOL-020.

72 368

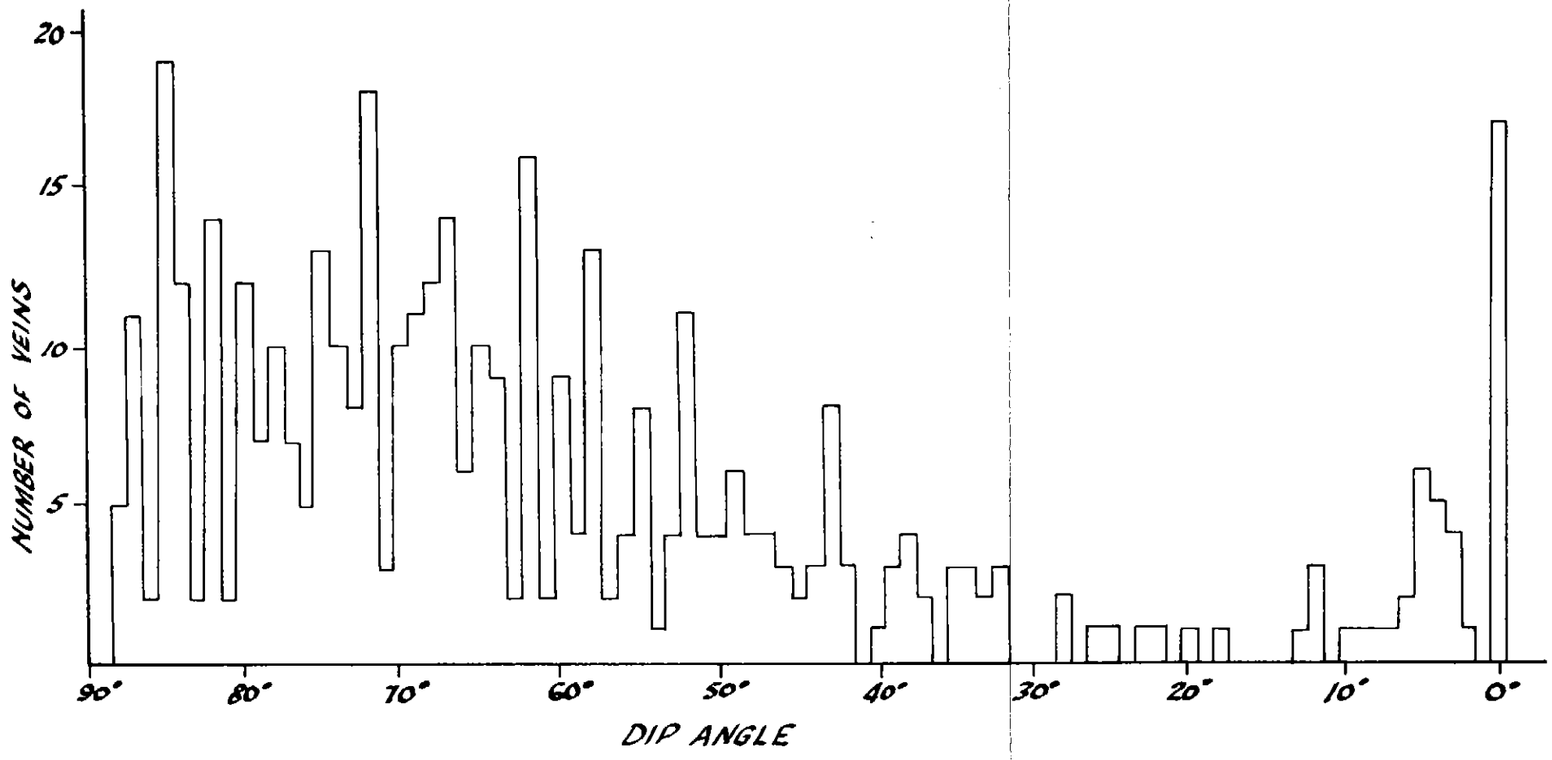
363



MAJOR CONTRIBUTIONS from SPECIFIC VEIN PHASE ~ V7
MINOR " " " " " ~ (V7)

CLEVELAND TIN LIMITED		
FOLEY ZONE METAL ZONING D.D.H. C1713.	DRAWN	Rud
	ORIGINATOR	L.V.D.
	DATE	10-5-84
	SCALE	
	DRAWING No	21

MC-FOL.-021.



D.D.H. C1615 (VERTICAL)

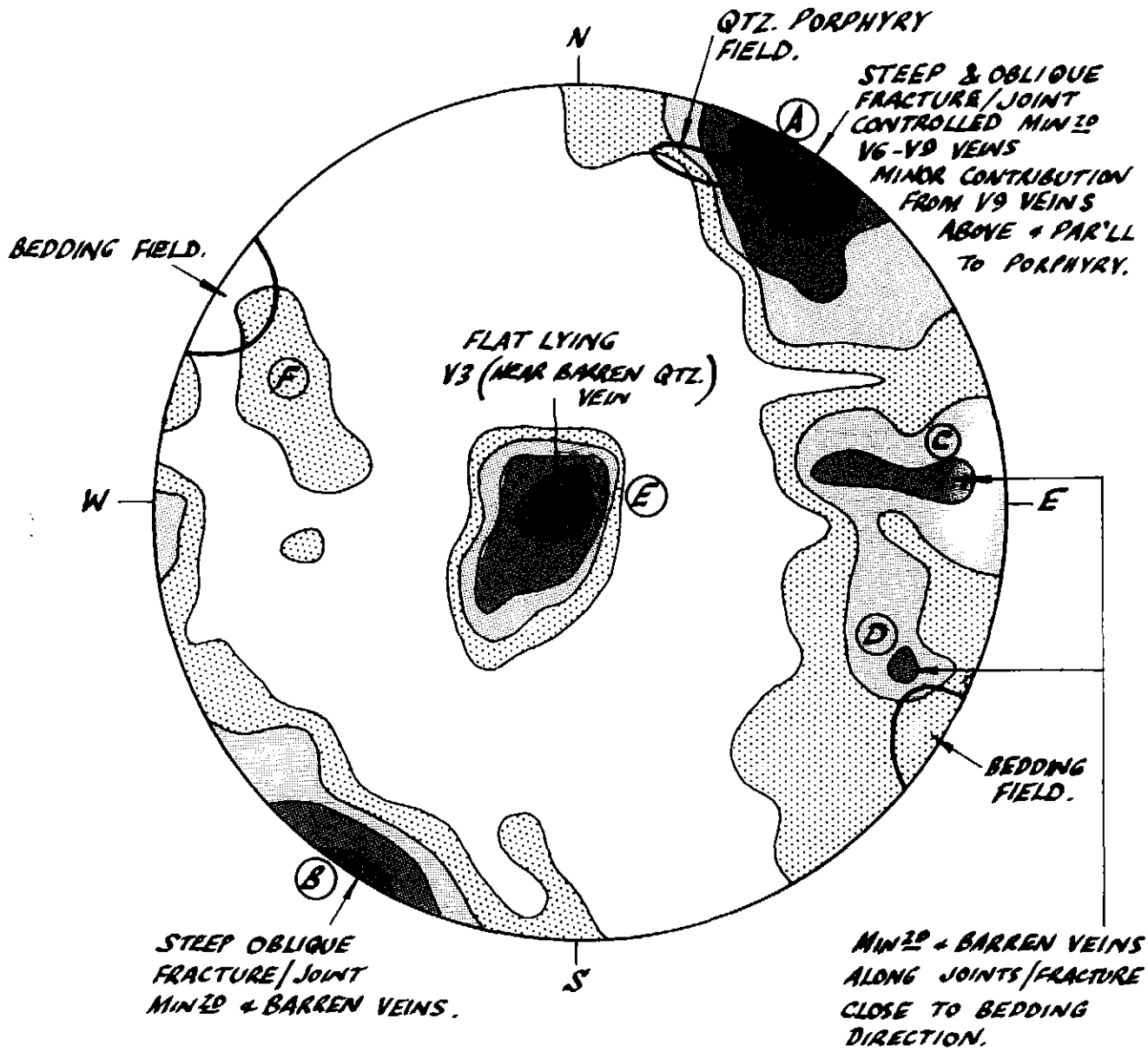
CLEVELAND TIN LIMITED		
FOLEY ZONE NUMBER OF VEINS - TRUE DIP DISTRIBUTION D.D.H. C1615	DRAWN	Paul
	ORIGINATOR	E.V.D.
	DATE	19-5-83
	SCALE	
	DRAWING No	22

MC. FOL-022.

TOC

365

72 370



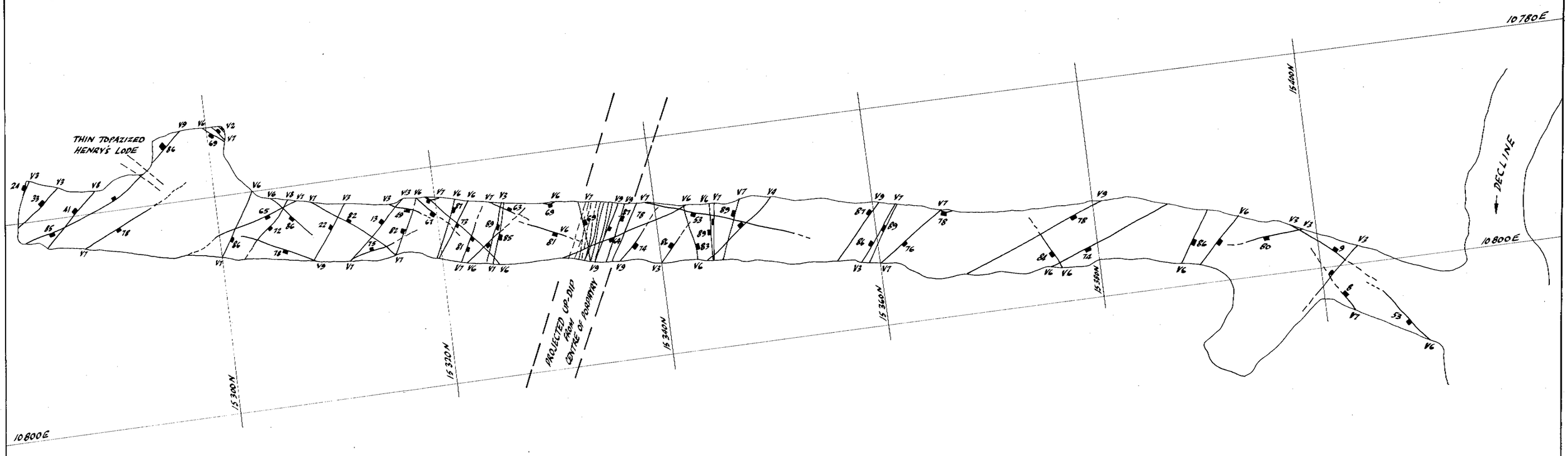
POLES on UPPER HEM. of WULFF NET.

CLEVELAND TIN LIMITED		
FOLEY ZONE VEIN ORIENTATIONS 17, 21 and 20-22 LEVELS 128 VEINS	DRAWN	Paul
	ORIGINATOR	E.V.D.
	DATE	25-83
	SCALE	
	DRAWING No	23

MC. FOL. 023.

366

72 371



N.B. ~ COUNTRY-ROCK IS DOMINANTLY S/STONE WITH MINOR SHALE AND TINLODE (HENRY'S)

~ VEINS AT WAIST HEIGHT.

~ VEIN DIP & VEIN PHASE SHOWN

5 cm

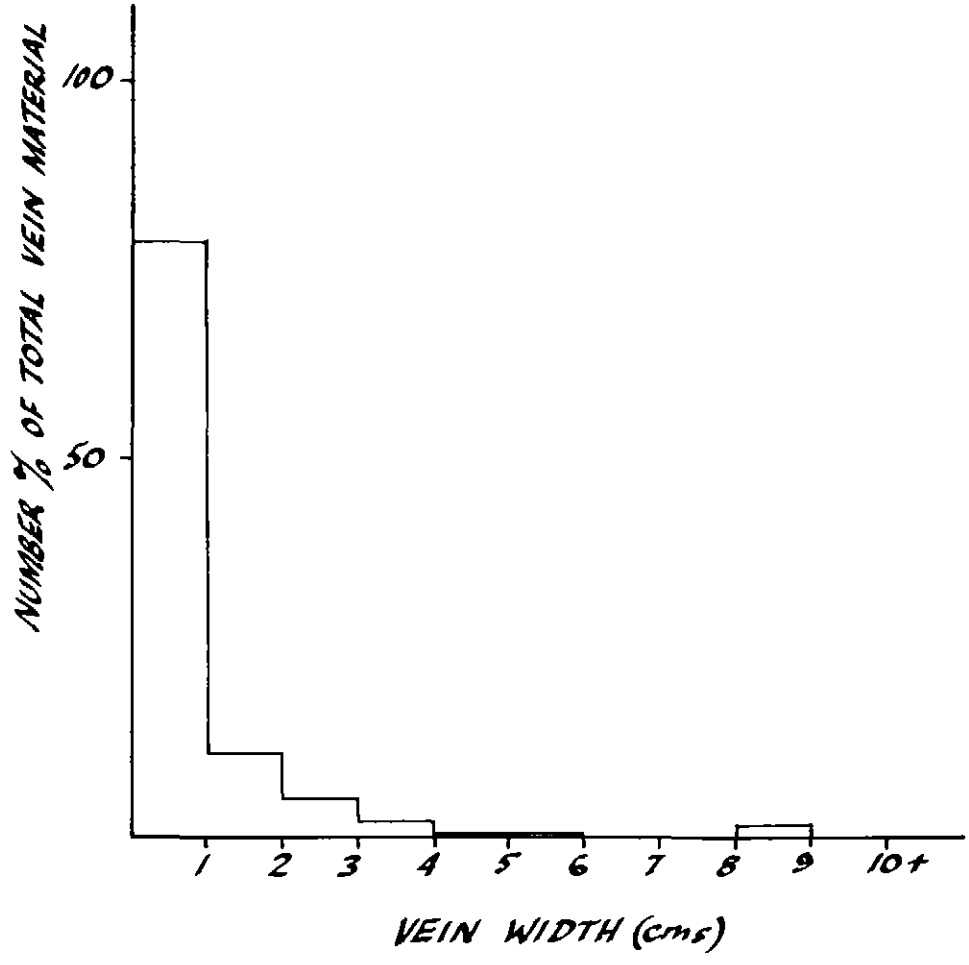
0m 5 10 15 20m

MC. FOL. 024.

CLEVELAND TIN LIMITED		
FOLEY ZONE	DRAWN	Paul
	ORIGINATOR	E.V.D.
VEIN MAPPING PLAN	DATE	16.5.83
21 LEVEL BATTERY ACCESS DRIVE.	SCALE	1:200
	DRAWING No.	24

367

72 372



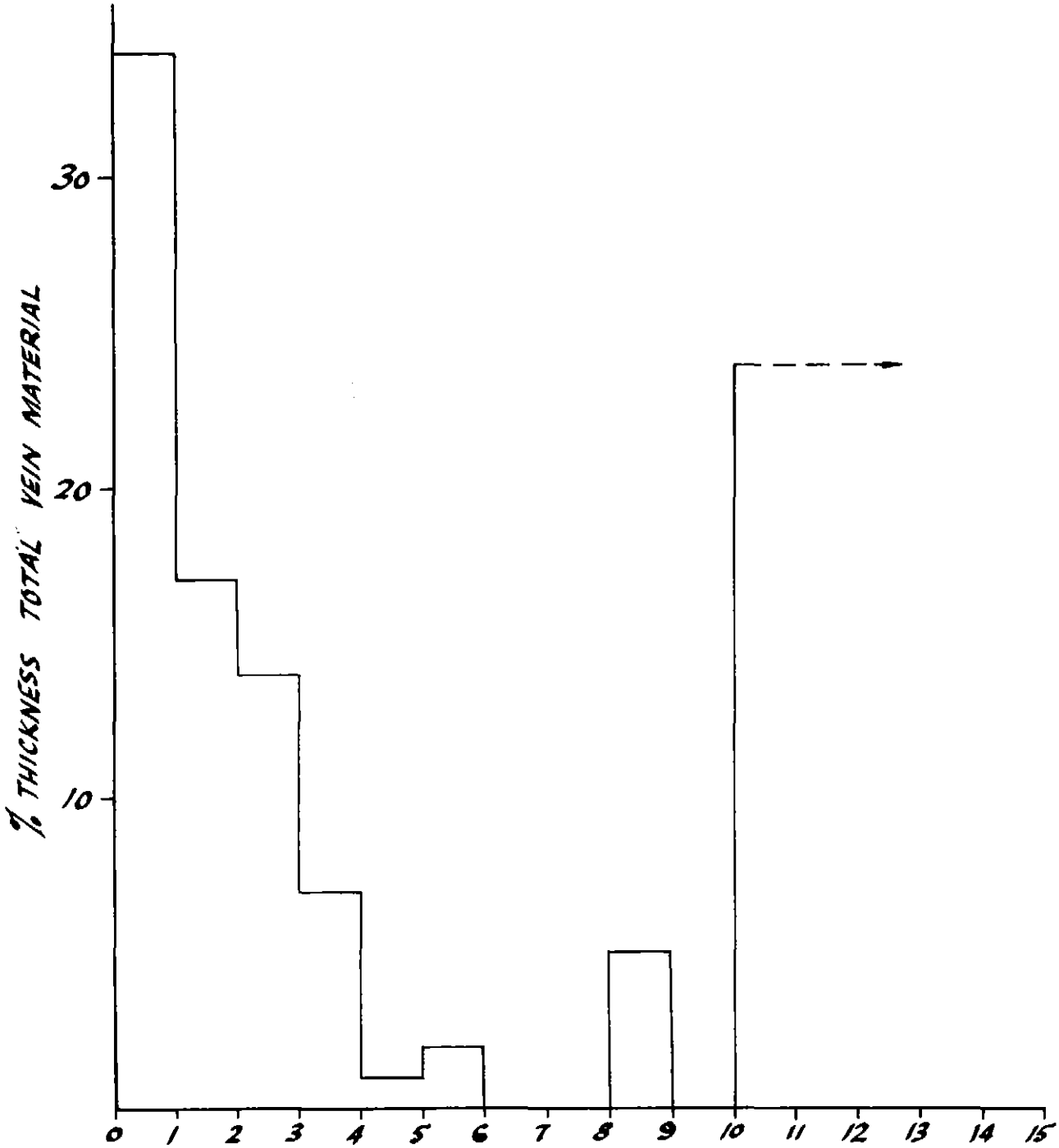
D.D.H. C1615, 423m, TOTAL 421 VEINS = 100%.

CLEVELAND TIN LIMITED		
FOLEY ZONE	DRAWN	Paul
	ORIGINATOR	E.V.D.
VEIN NUMBER DISTRIBUTION ~ all veins ~ D.D.H. C1615	DATE	17-5-83
	SCALE	
	DRAWING No	25

MC-FOL-025.

368

72 373



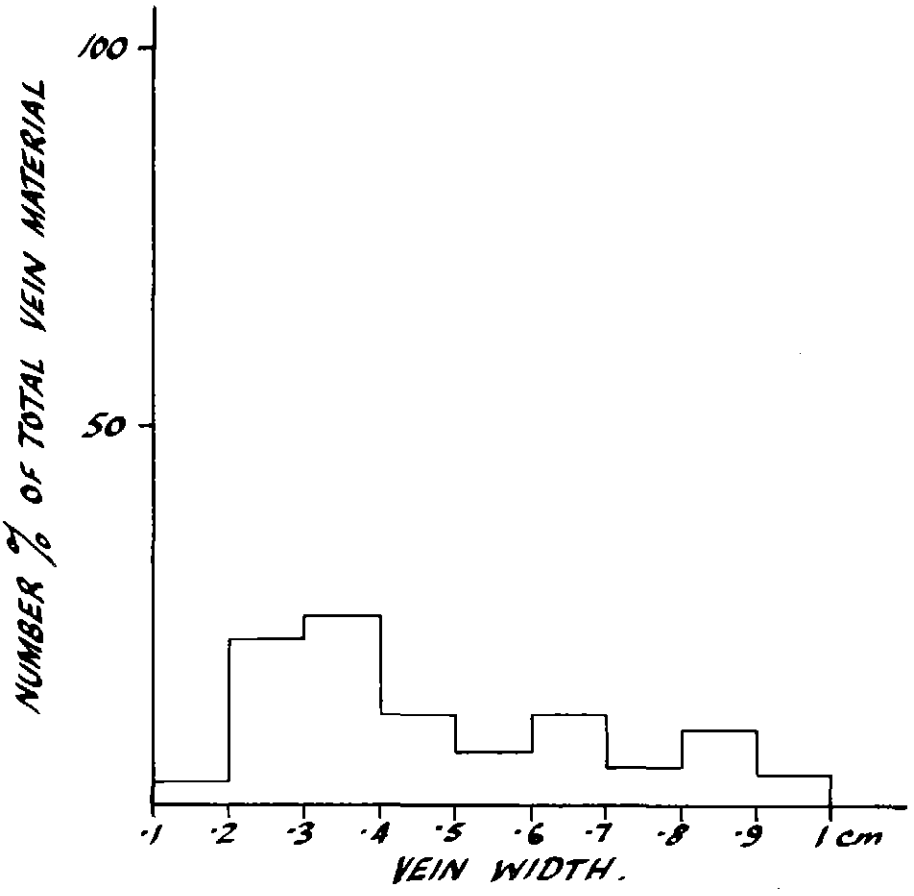
D.D.H. C1615, 423m, 421 VEINS

CLEVELAND TIN LIMITED		
FOLEY ZONE	DRAWN	[illegible]
	ORIGINATOR	E.V.D.
VEIN THICKNESS DISTRIBUTION - greater than 1mm. - D.D.H. C1615	DATE	17-5-83
	SCALE	
	DRAWING No	26

MC-FOL-026

369

72 374



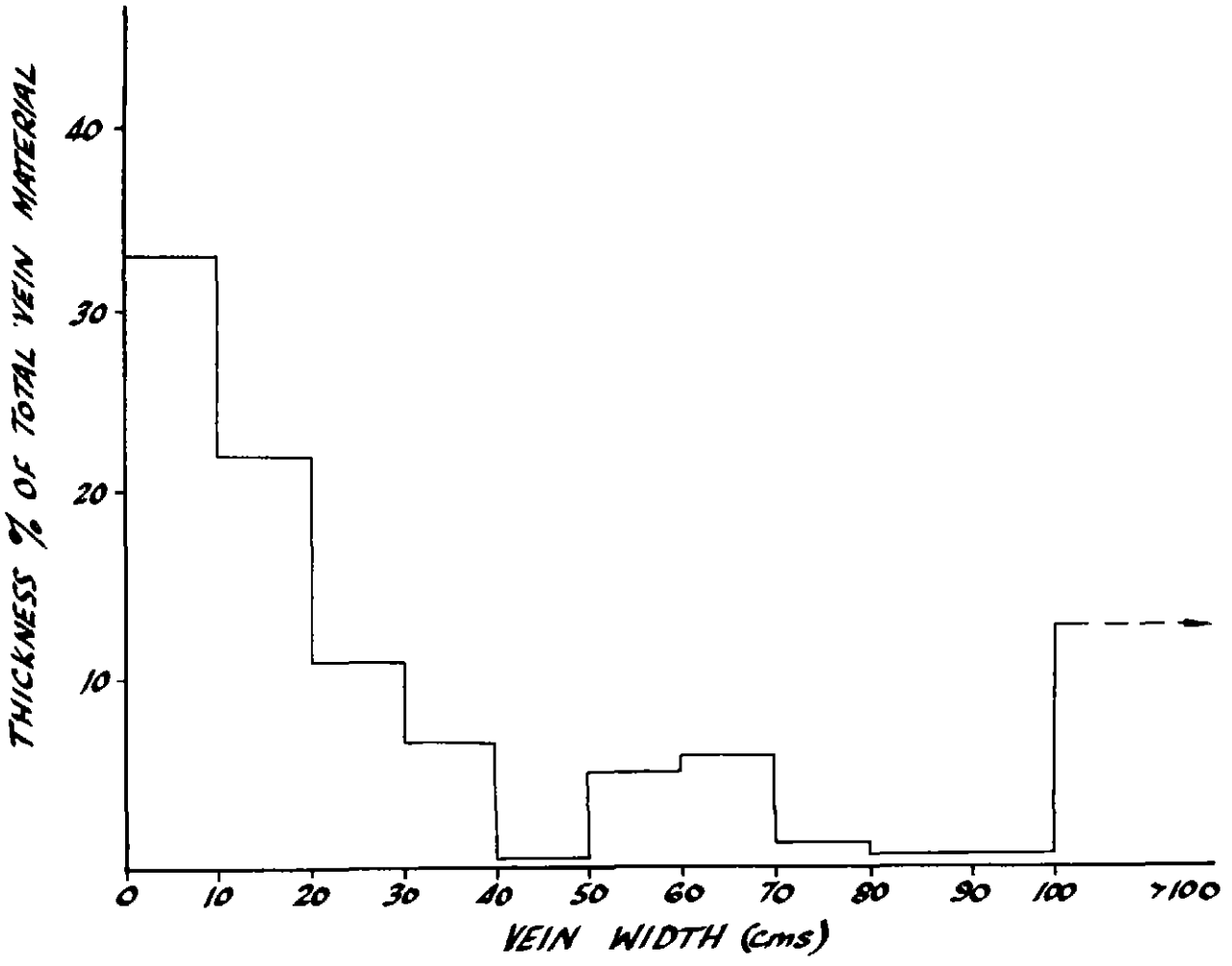
D.D.H. C1615 , 423m , TOTAL 337 VEINS = 100%.

CLEVELAND TIN LIMITED		
FOLEY ZONE	DRAWN	R.L
	ORIGINATOR	E.K.D.
VEIN NUMBER DISTRIBUTION less than 1cm - greater than 1cm D.D.H. C1615	DATE	11-5-83
	SCALE	
	DRAWING No.	27

MC-FOL-021.

370

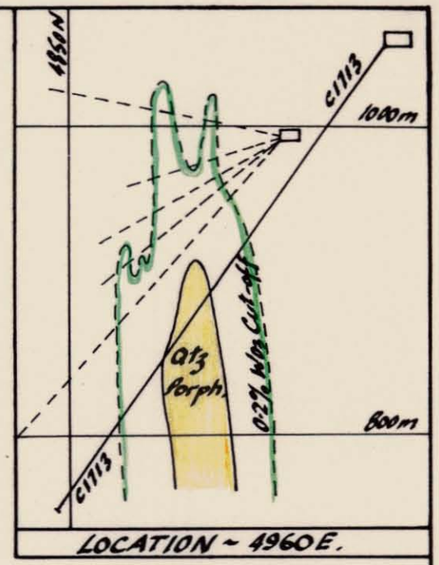
72 S75

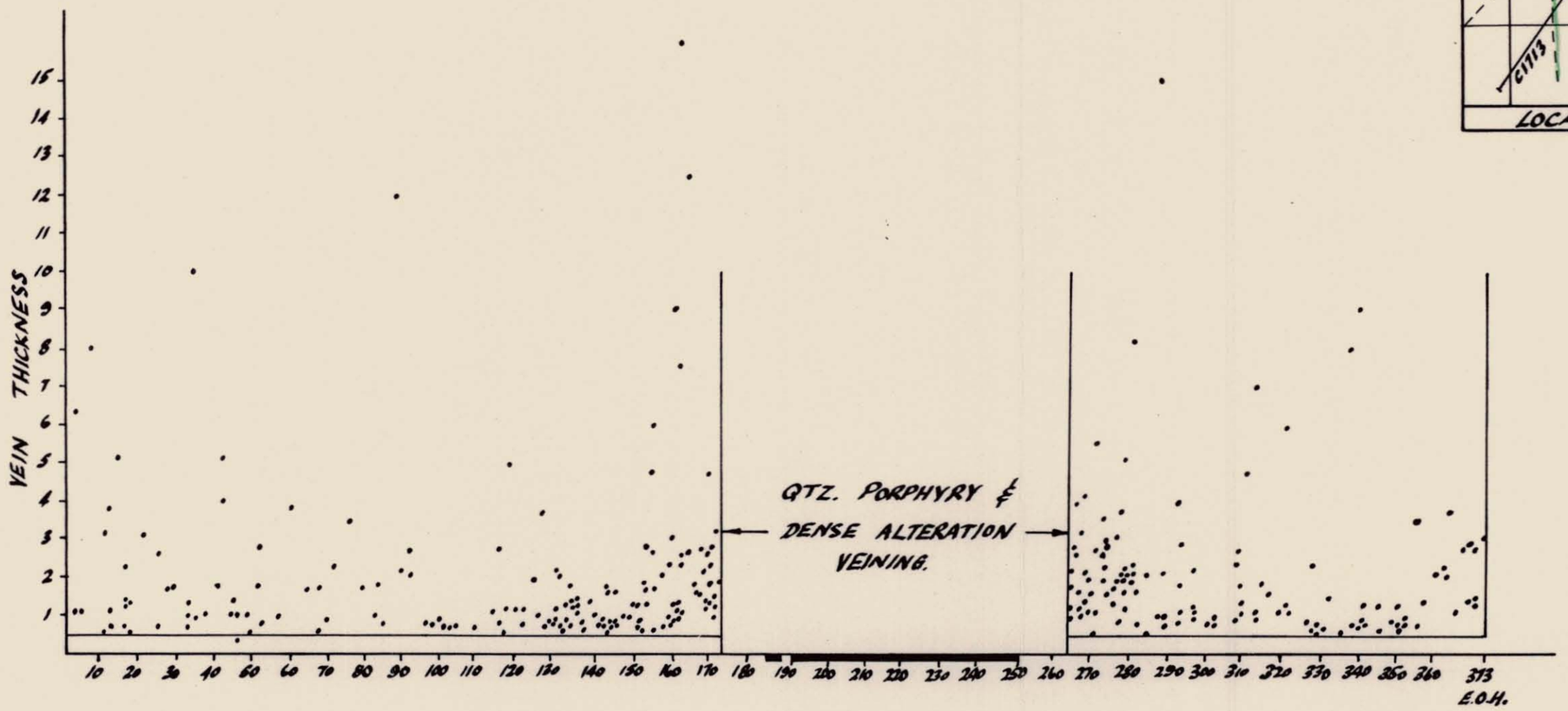


D.D.H. C1608, 0-85m

CLEVELAND TIN LIMITED		
FOLEY ZONE VEIN SIZE DISTRIBUTION D.D.H. C1608	DRAWN	R.L
	ORIGINATOR	E.V.D.
	DATE	14-5-73
	SCALE	
	DRAWING No	28

MC-FOL-028.





DISTANCE DOWN D.D.H. C1713.

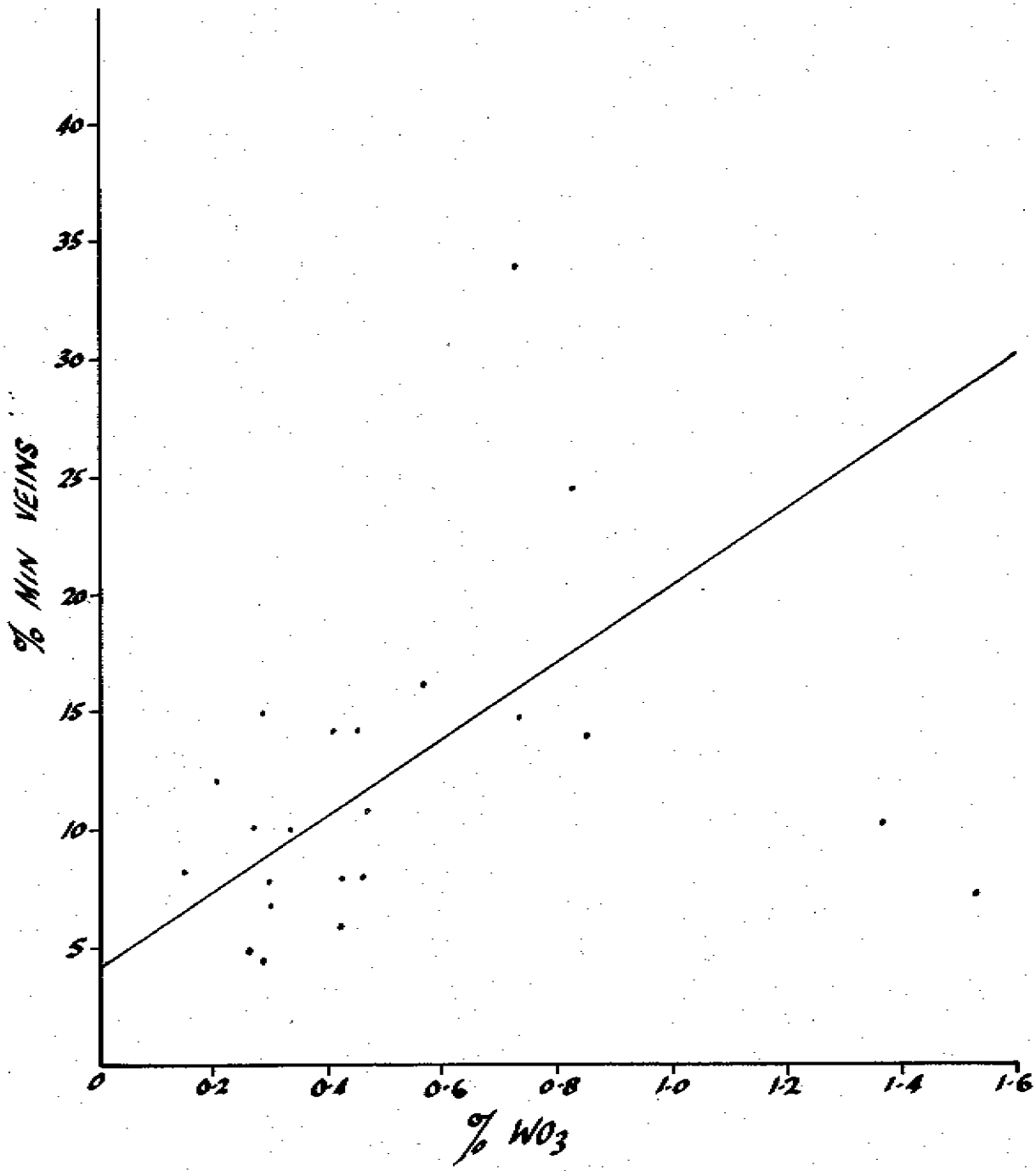
CLEVELAND TIN LIMITED		
FOLEY ZONE VEIN SIZE DISTRIBUTION D.D.H. C1713.	DRAWN	Paul
	ORIGINATOR	E.V.D.
	DATE	4-5-83
	SCALE	
	DRAWING No	29

371

MC-FOL-029.

372

72 377



CLEVELAND TIN LIMITED		
FOLEY ZONE	DRAWN	Paul
	ORIGINATOR	E.W.D.
MIN. VEIN DENSITY Vs ASSAYS D.D.H. C1754.	DATE	17-5-83
	SCALE	
	DRAWING No.	30

MC-FOL-030.

72 378

SW

NE

Gg-SECTION

N-SECTION

RL.1400m

SURFACE

9Level

LODE TERMINATION

Qtz-Tm-Po-Py

Qtz-Po-Py-Sider.

Qtz-Chl-Po

Qtz-Tm-Chl-Sider-Py-Po 0·5% Sn

LIMESTONE

RL 1200m

Qtz-Tm-Sider.-Po-Py-Flr.

Qtz-Tm-Chl-Po

Chl-Qtz-Po

FAULT WINDOW

FOLEY ZONE.
(In Footwall)

Chl-Amphib-Po-Qtz

0·5% Sn

Sea Level.

RL 1000m

Amphib-Qtz-Po-Mag
-Biotite-Flr.

Amphib-Po-Qtz-Mag

QTZ. PORPHRY INTRUSIVE

0·3% WO3

LIMIT OF VEINS

Gg.

N.

32Level.

KEY

Qtz - Quartz
Tm. - Tourmaline
Chl. - Chlorite
Sider. - Siderite
Amphib - Amphibole
Po. - Pyrrhotite
Py. - Pyrite
Flr. - Flourite

0m 100m 200m

5 cm

MC. FOL. 031.

373

CLEVELAND TIN LIMITED

FOLEY ZONE

LONG' PROJECTION - HALLS B

GENERAL MINERALOGY

DRAWN	Paul
ORIGINATOR	E.V.D.
DATE	29·4·83
SCALE	1:2740
DRAWING No.	31

72 379

RL 950m

RL 900m

RL 850m

Ga

4982

C1627

10m (6m Horiz)
0.32% WO3
0.11% Sn

PROJECTED
QTZ - ARSENY

PROJECTED DOWN DIP
CONTINUATION OF QTZ. PORPHYRY.

4982 N

C1634

7.5m (2.5m Horiz)
0.19% WO3
0.04% Sn

Gb

4963

4963 N

Gc

4945

22.5m (14m Horiz)
0.41% WO3
0.03% Sn

PROJECTED INTERSECTION OF LODE
0.4% WO3 CUT-OFF

4945 N

C1608

C1611

Gd

4927N

47.5m (13m Horiz)
0.38% WO3
0.07% Sn

4927 N

PROJECTED INTERSECTION OF LODE
0.2% WO3 CUT-OFF

Ge

4909N

4909 N

RL 850m

Gf

4890N

0687

374

RL 950m

RL 900m

MC-FOL-032.

CLEVELAND TIN LIMITED

FOLEY ZONE

LONGITUDINAL PROJECTION OF HENRY'S LODE WITH D.D.H. INTERSECTIONS

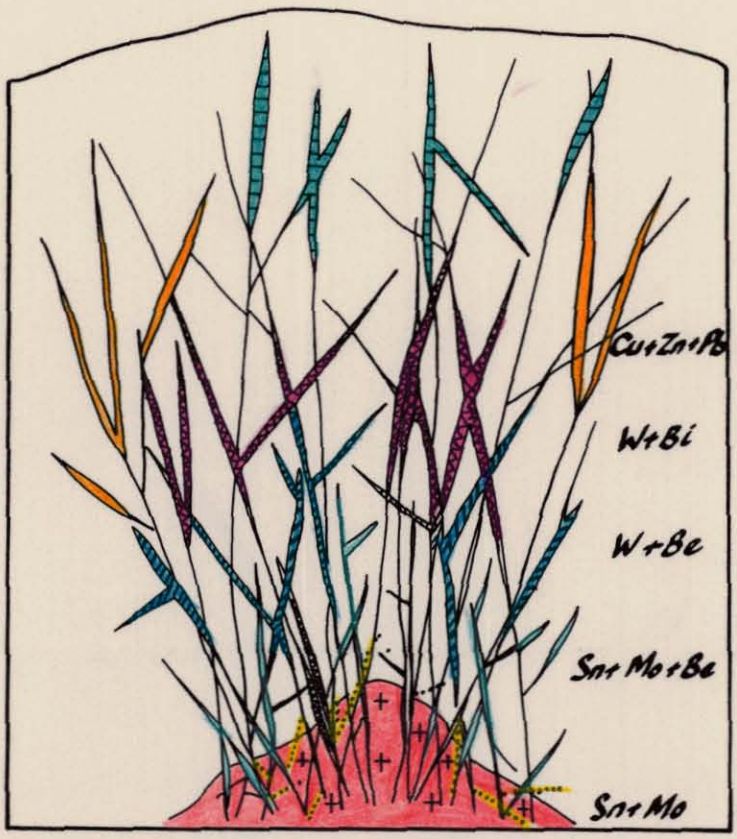
DRAWN	Paul
ORIGINATOR	E.V.D.
DATE	17-5-83
SCALE	
DRAWING No	32

375

72 380

VEIN STOCKWORK~KAZAKHSTAN DEPOSIT, U.S.S.R.

(after G.N. SHCHERBA)



GRANITES

QTZ. VEINLETS

ORE-BEARING QTZ-FELDSPAR V'LETS.

QTZ-MOLYBDENITE V'LETS, VUGGY

QTZ-WOLFRAMITE V'LETS, VUGGY

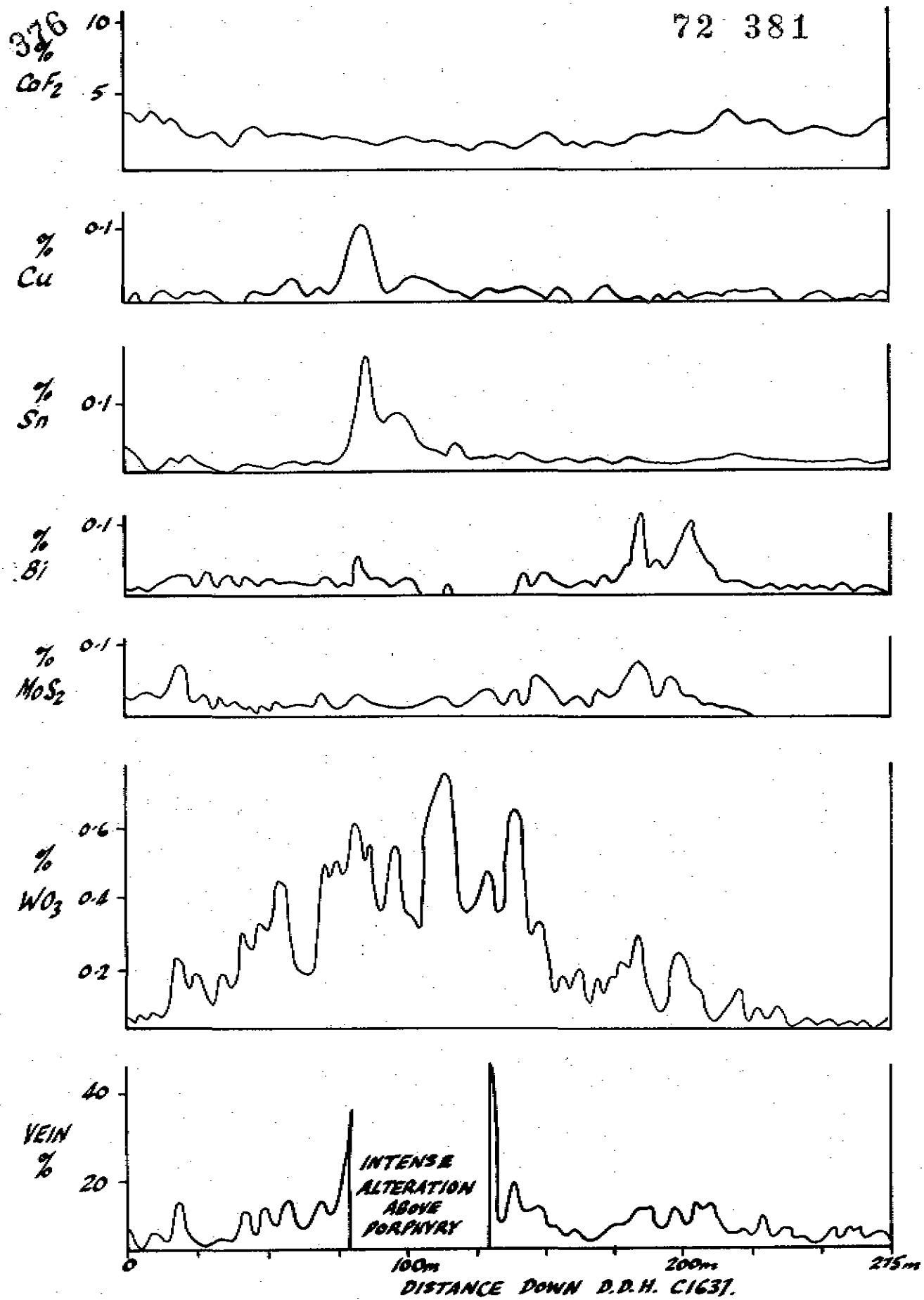
QTZ-SULFIDE VEINLETS

QTZ VEINLETS, COLUMNAR (TYPE I) AND VUGGY; CARBONATE, ZEOLITE (VEINLETS); FORMED AFTER DEPOSITION OF ORES.

CLEVELAND TIN LIMITED		
FOLEY ZONE VEIN STOCKWORK	DRAWN	Paul
	ORIGINATOR	E.Y.D.
	DATE	19-5-83
	SCALE	
	DRAWING No	33

MC-FOL-033.

72 381



CLEVELAND TIN LIMITED

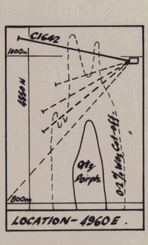
FOLEY ZONE

ASSAY PROFILE
D.D.H. C1637.

DRAWN	[illegible]
ORIGINATOR	E.V.D.
DATE	11-5-83
SCALE	
DRAWING No	34

MC-FOL-034.





CLEVELAND TIN LIMITED

FOLEY ZONE

ELEMENTAL DISTRIBUTION

D.D.H. C1642.

DRAWN	
ORIGINATOR	E.I.P.
DATE	19-5-83.
SCALE	
DRAWING No.	35

M.C. No. 115.

72 382

72 383

SW

NE

G9-SECTION

N-SECTION

RL 1400m

SURFACE

9Level

LODE TERMINATION

100ppm Bi

300ppm Bi

0·5% Sn

LIMESTONE

RL 1200m

FAULT

WINDOW

Sea Level

RL 1000m

FOLEY ZONE
~ Projected at Henry's Lode position ~

BROWN BIOTITE

HENRY'S KHAKI + GREEN BIOTITE

KHAKI + GREEN BIOTITE ZONE (HALLS)

RL 900m

32 Level

RL 800m

BROWN BIOTITE ZONE (HALLS)

C969

C1633

65m x 0·19% WO3

RL 600m

NUMBERS, eg (3) ~ AS PER TEXT.

5 cm

G9 SECTION

MC-FOL-036.

CLEVELAND TIN LIMITED	
FOLEY ZONE LONGITUDINAL PROJECTION HALLS 'B' EXPLORATION TARGET.	DRAWN: Paul ORIGINATOR: E.V.D. DATE: 20-5-83 SCALE: APPROX 1:2500 DRAWING No: 36



PLATE 2. Topazized quartz porphyry apophyses (outlined in red) within shale and sandstone in 25 level decline. Distance between yellow marks - 1 metre.

72 385

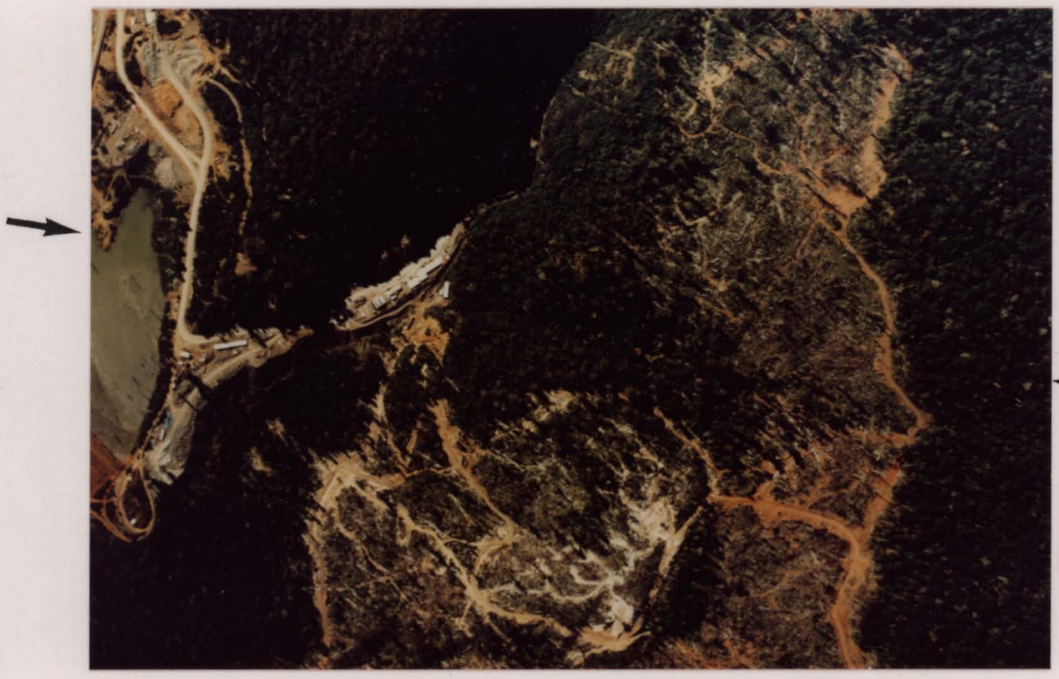


PLATE 3. Aerial photograph above mine working showing east-west trending Foley lineament.

382

12 387



PLATE 4. Remnant zoned feldspar in sericitized quartz porphyry. Dark spots are tourmaline. DDH C1615 - 189.3 m. Scale in cms.

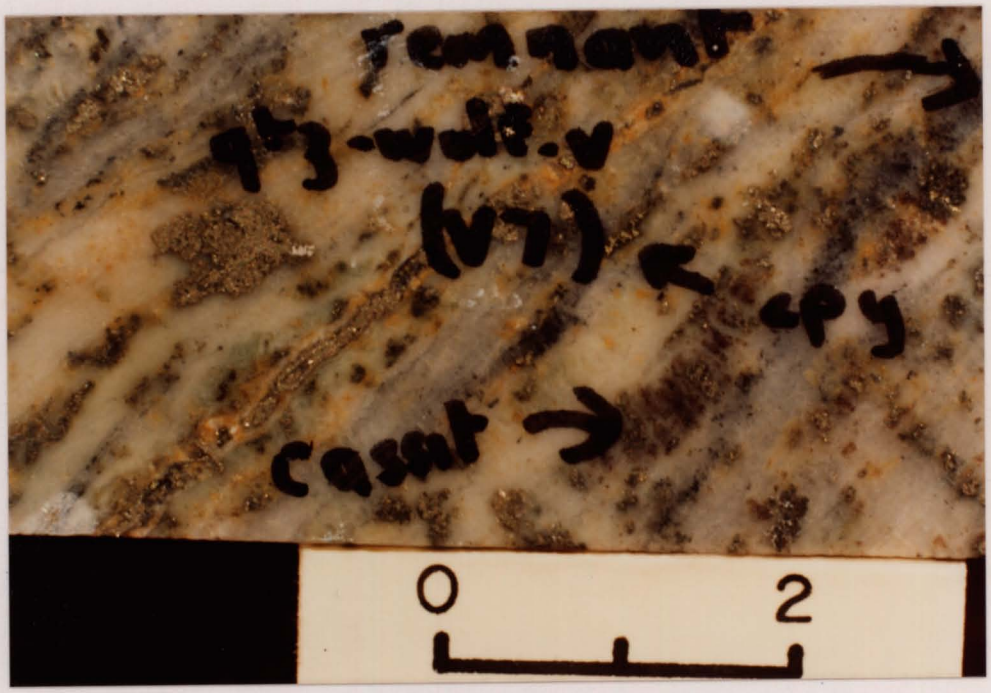


PLATE 5. Topazized, pyrite-cassiterite bearing quartz-porphyry. DDH C1713 - 209.6 m. Scale in cms.

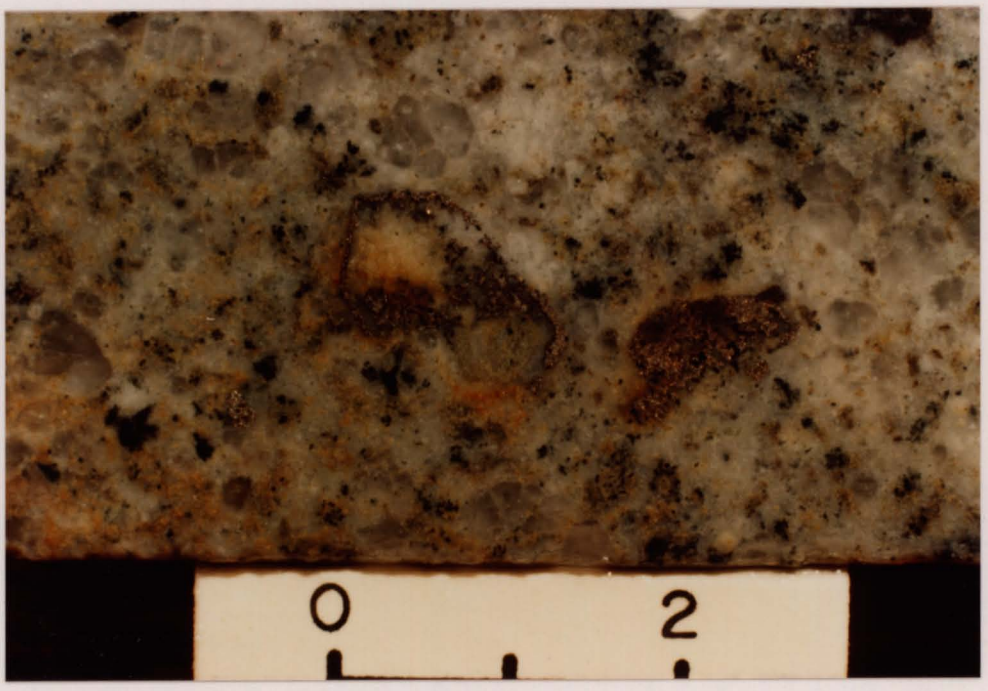


PLATE 6. Topazized quartz porphyry with pyrite 'ghost' after original f eldspar. DDH C1615 - 247.9 m. Scale in cms.

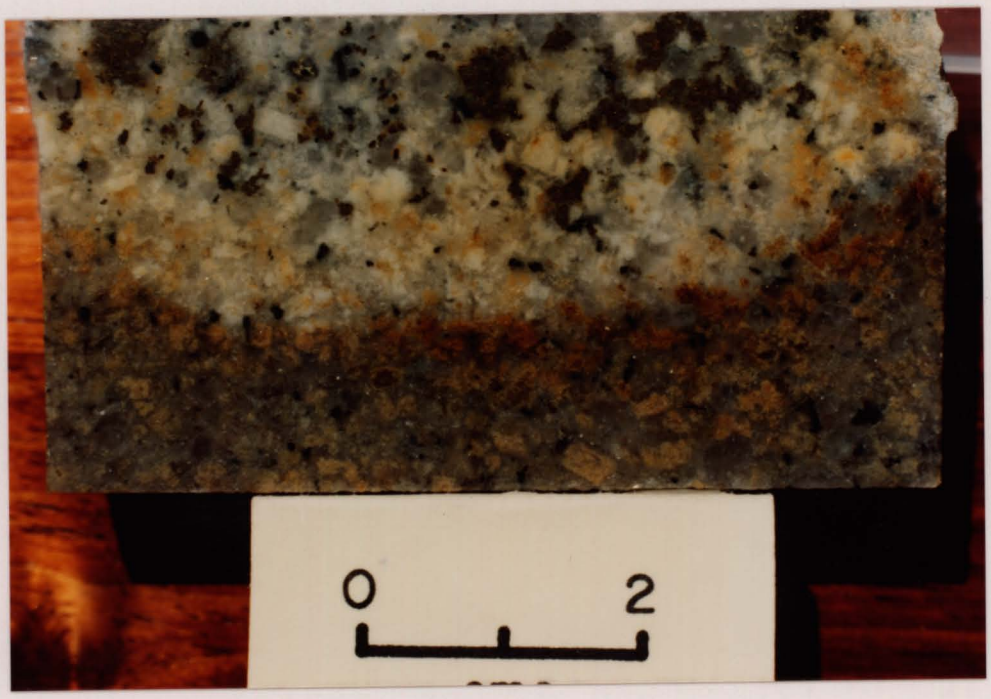


PLATE 7. Topaz-pyrite altered porphyry (top) with grey sericite alteration (below). Relict F eldspars (brown) are replaced by siderite. DDH C1615 - 208.8 m.



PLATE 8. Sericite-illite altered (greisenized) sandstone cut by later quartz veins. DDH C1713 - 195.6m. Scale in cms.



PLATE 9. Grey sericite alteration and yellow illite alteration contact in quartz porphry. Fine dark spots are wolframite and sphalerite. DDH C1713 - 227.5 m.

385

72 330

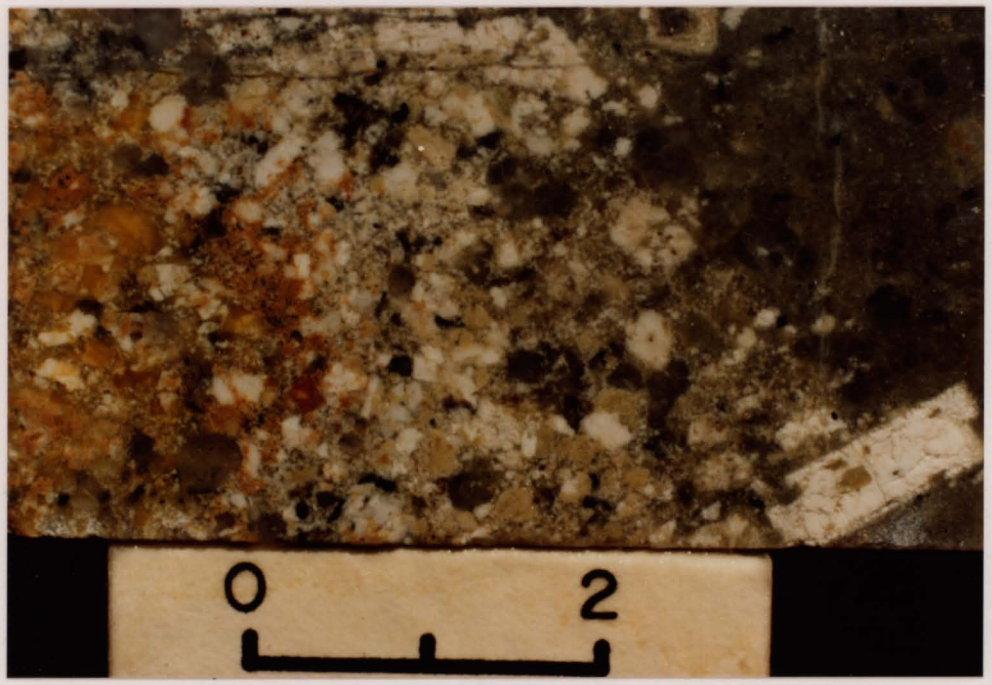


PLATE 10. Yellow illite alteration (left) with Kaolinite alteration (centre) and sericite alteration (right) in quartz porphyry. DDH. C1633 - 542.8m. Scale in cms.

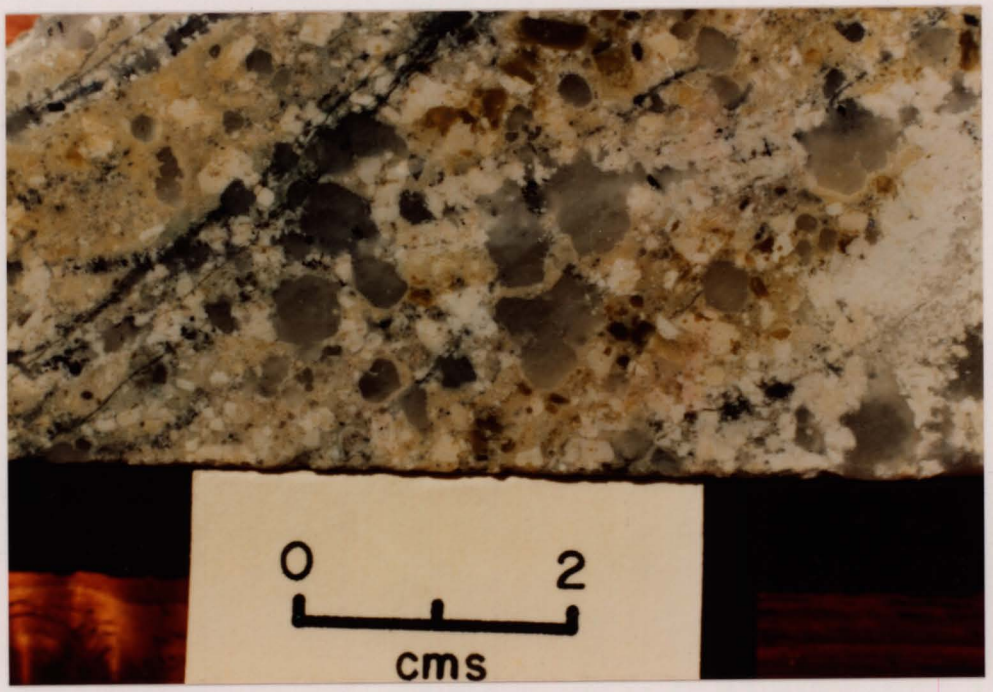


PLATE 11. Kaolinite altered quartz porphyry DDH C1713 - 201.8

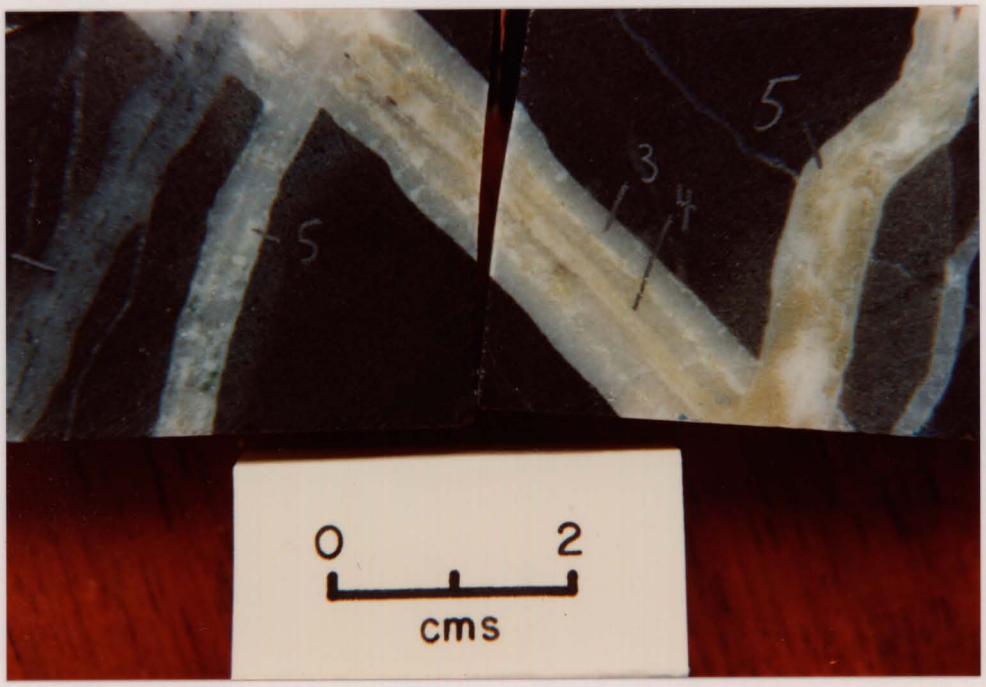


PLATE 12. Multi-pulse illite altered sericite veins (V3, V4) cut by later sericite-quartz veins (V5) - DDH C1634 - 106.6 m.

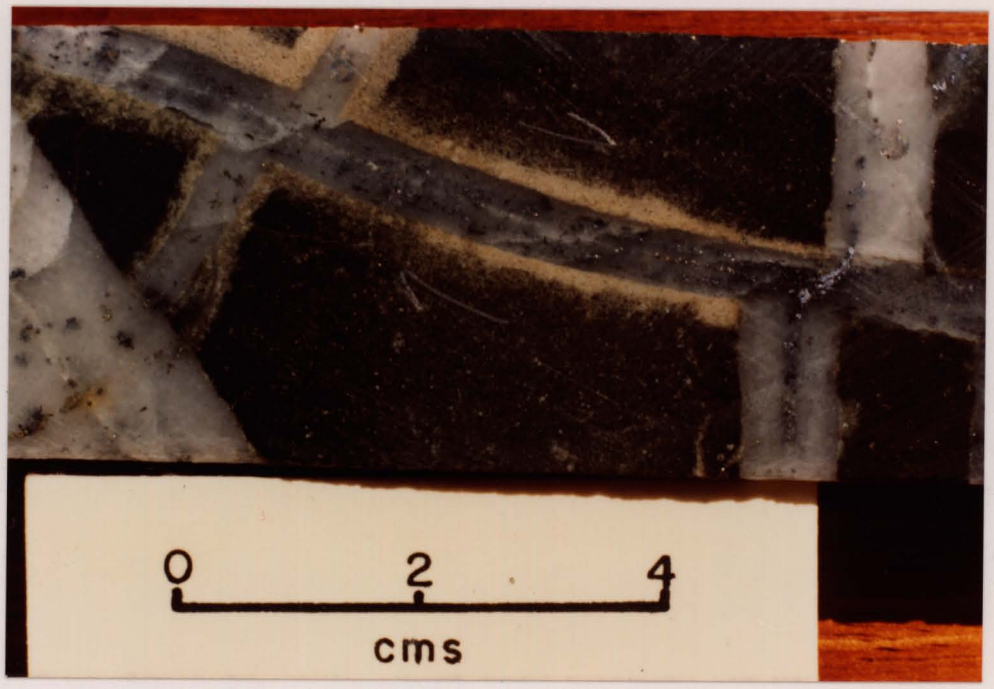


PLATE 13. Cross-cutting veins. Sub- horizontal multi-pulse mineralized vein (V7) cutting earlier near vertical compounded quartz veins (V3 and V6) DDH. C1754-170.4m.

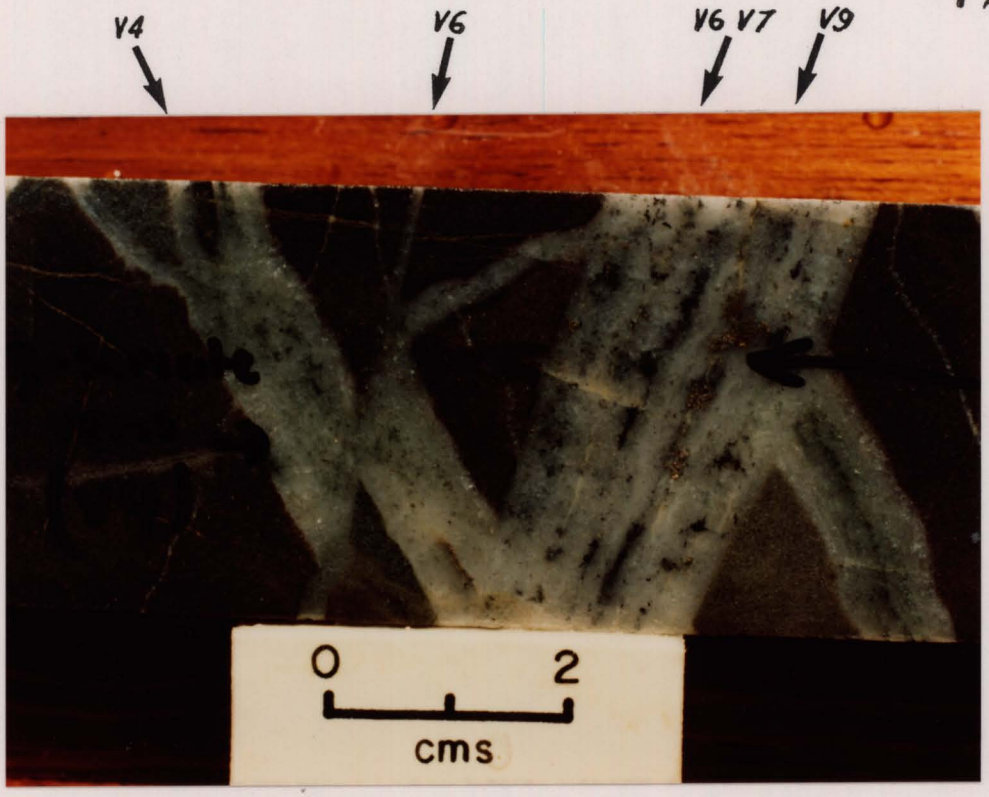


PLATE 14. Composite quartz veins with phases V6, V7 and V9 (vertical - right side) cutting earlier quartz sericite veins V4.
DDH C1634 - 159.8 m.

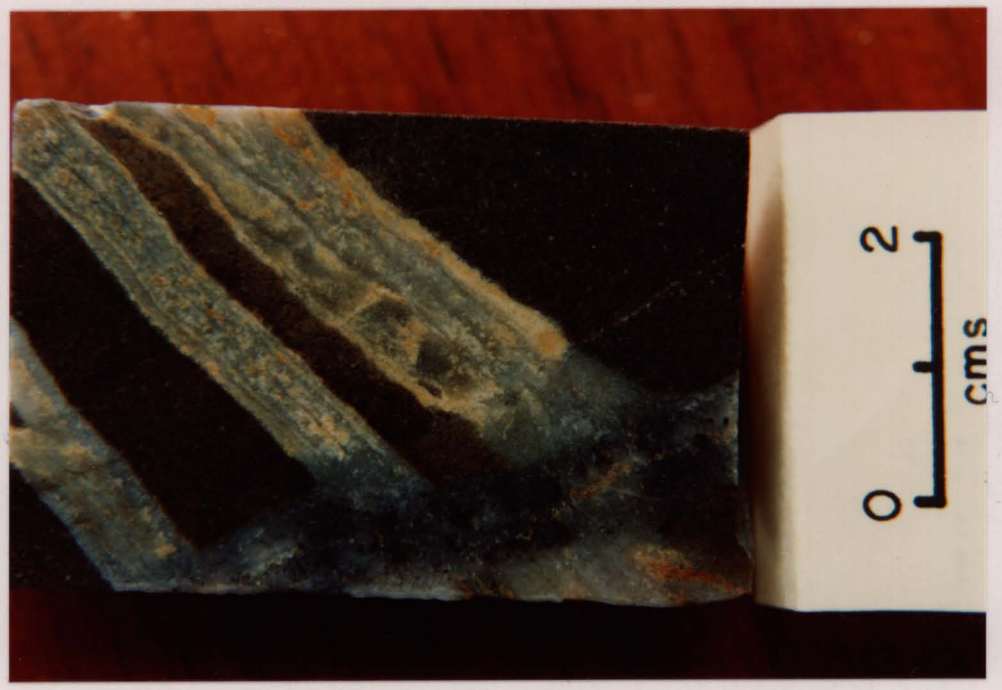


PLATE 15. Localized siderite replacement of multi-pulse quartz-sericite veins (V4). Mineralized quartz vein (V7) at bottom.
DDH C1634 - 138.8 m.



PLATE 16. Wolframite bearing quartz vein (V7). Note molybdenite selvage on vein contact. Illite-flourite in centre of vein. 21 Battery Access Drive. East side - wall. Geol. pick head for scale.

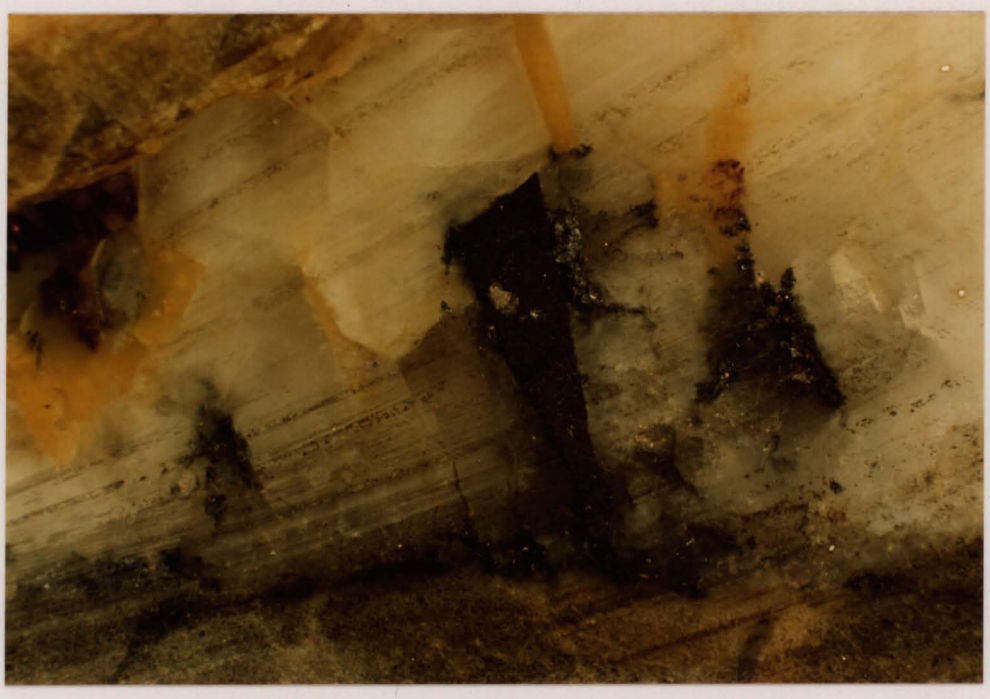


PLATE 17. Wolframite blade with inclusions of bismuthinite and native bismuth. Minor molybdenite against wolframite. Quartz with yellow interstitial illite. Blade is approx. 14 mm long. DDH C1634 - 145.4 m.

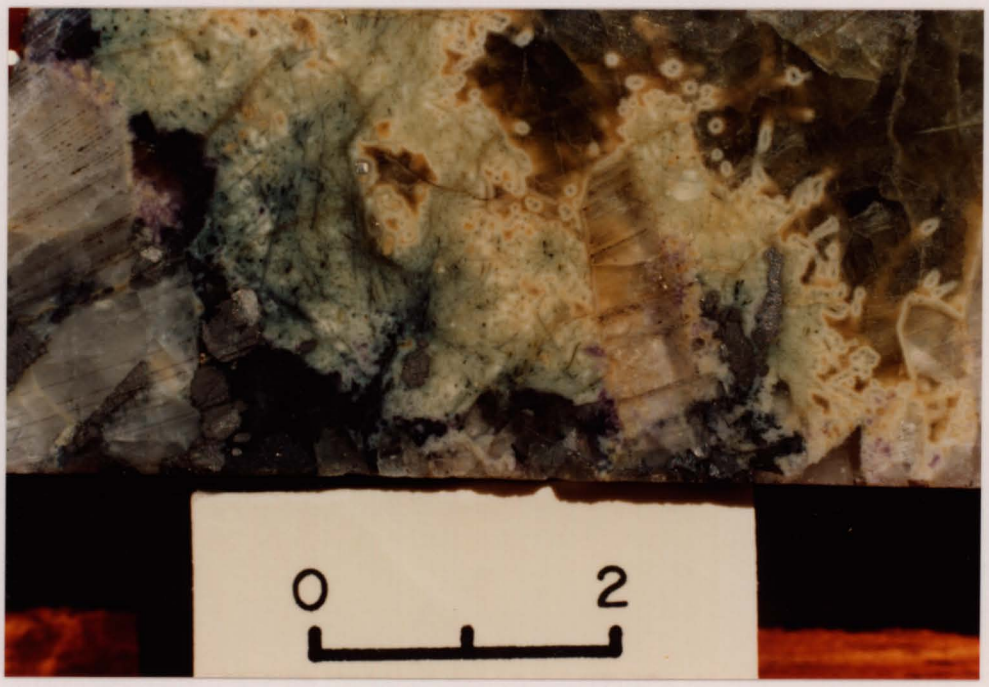


PLATE 18. Quartz vein with late brown siderite (top right) and pale yellow illite (top left) with fine needles of tourmaline. Grey arsenopyrite and purple flourite (bottom left). DDH C1634 - 143.4 m.

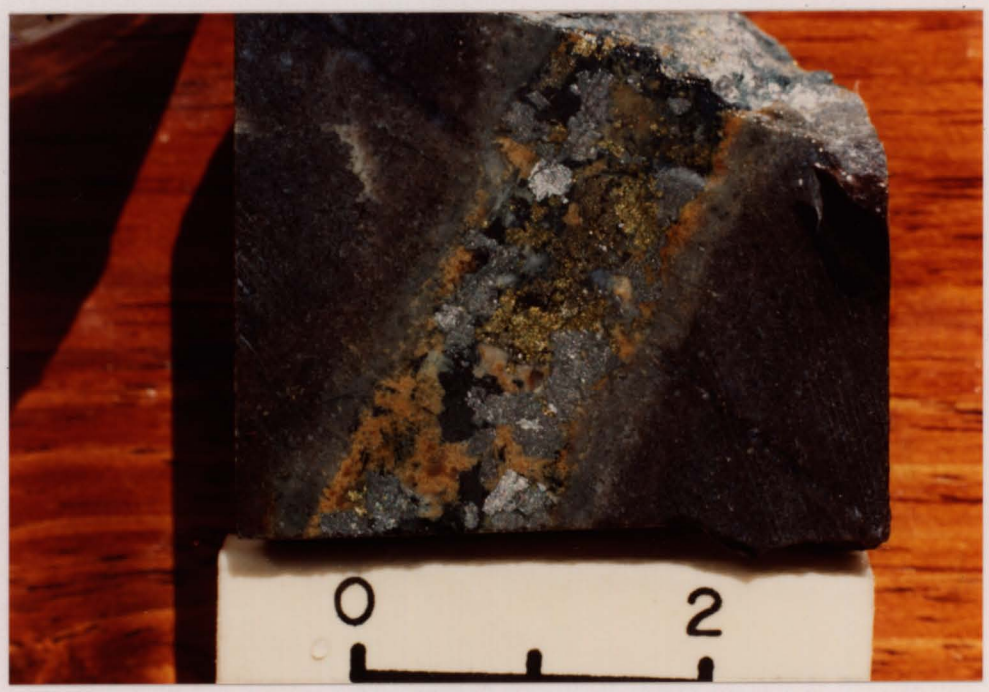


PLATE 19. Arsenopyrite-pyrite-tourmaline vein (V8) with silicified cont acts against weakly biotite altered sandstone. DDH C1637 - 60.5 m. Scale in cms.

390

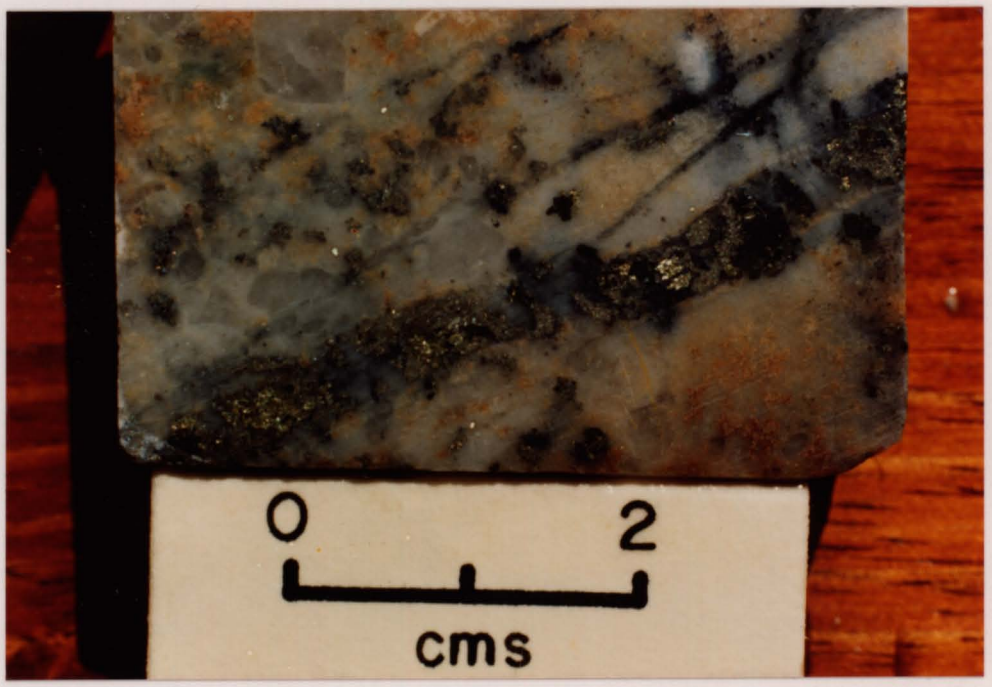


PLATE 20. Pyrite-quartz-chalcopyrite-spalerite vein (V8) in topaz altered mineralized quartz porphyry. DDH C1634 - 108.9 m.

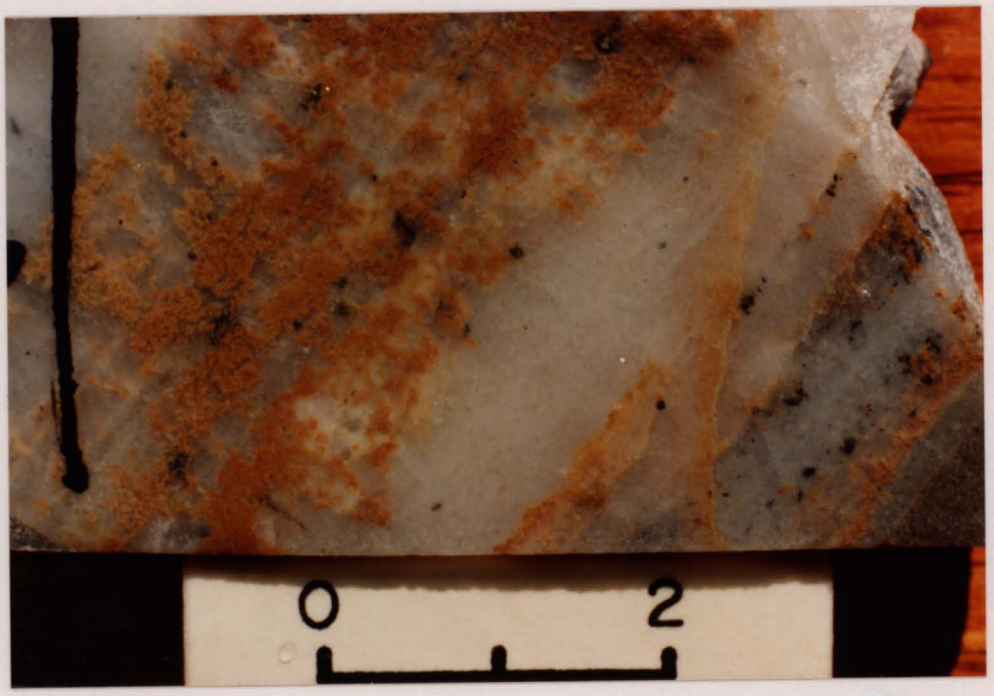


PLATE 21. Brown siderite replacement after earlier multiple sericite and quartz veins DDH C1637-94.0 m. Scale in cms.



PLATE 39. 15mm to 65 mm particle size "accept" from photometric sorter. Scale is 30 cms. long.

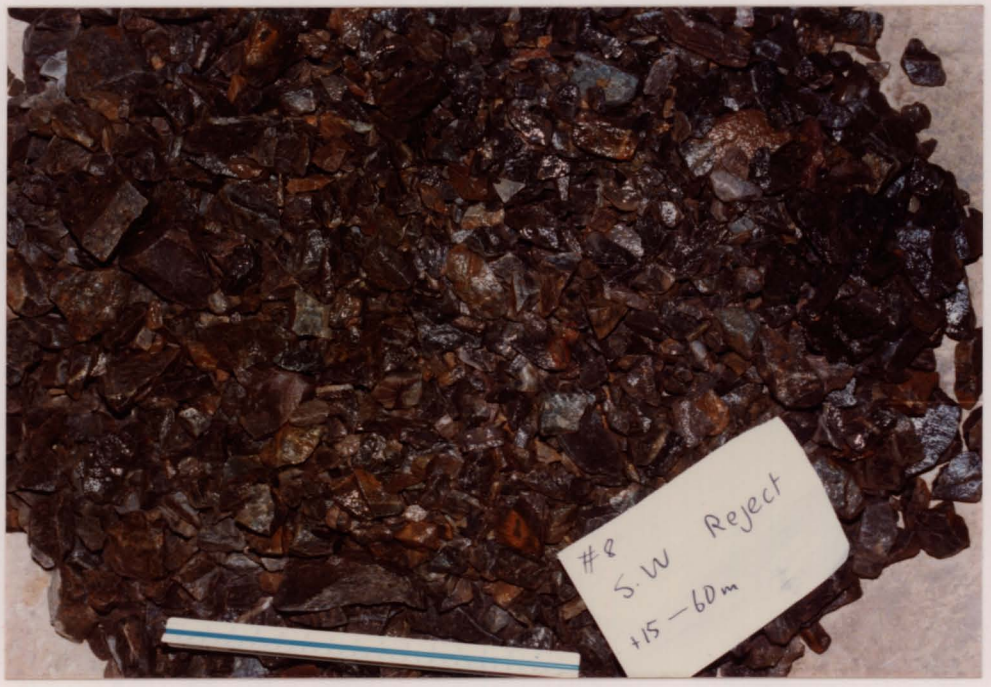


PLATE 40. 15 mm to 65 mm particle size "reject" from photometric sorter. Scale is 30 cms. long.



PLATE 22. Quartz - topaz - pyrite vein (V9) 21 Battery Access Drive East side-wall.



PLATE 23. Numerous very thin late quartz - topaz - pyrite veinlets (V9) Veinlets form directly up-dip from porphyry 60 m. below. 21 Battery Access Drive. West side-wall.



PLATE 24. Dense compound veining (bottom half of tray).
DDH 1637 - 81 m. Scale is 16 cms long.

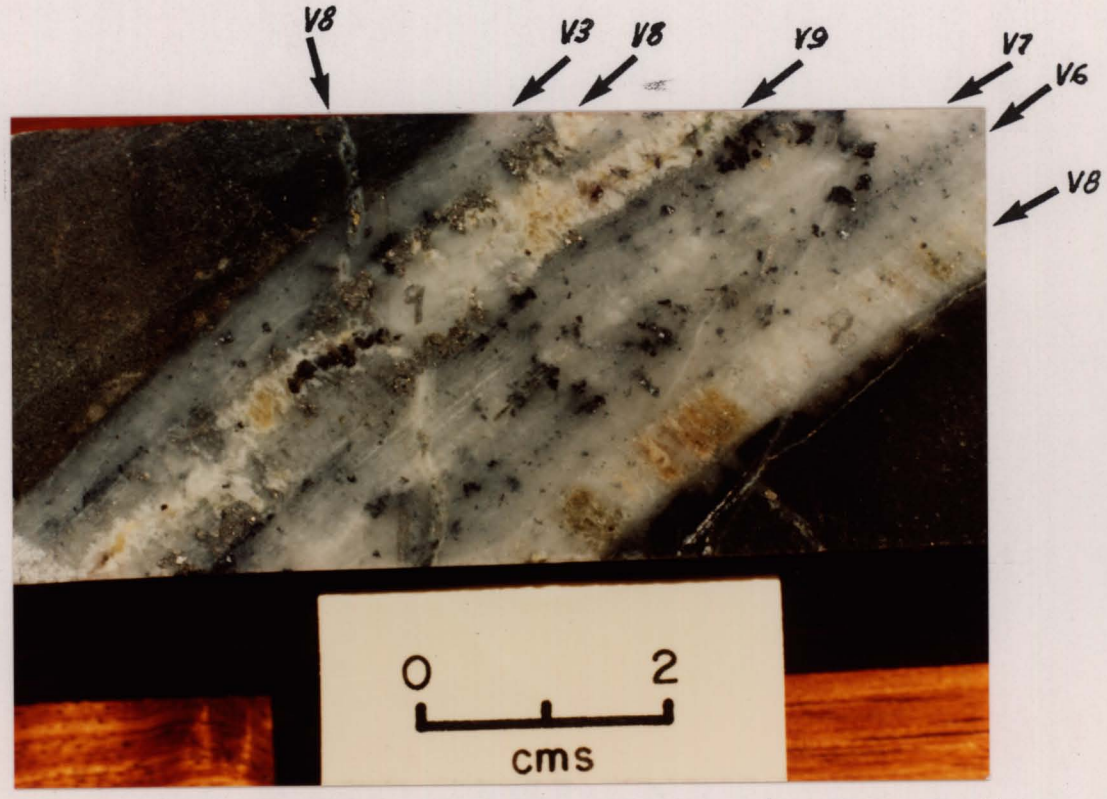


PLATE 25. Multiple invasions of several vein phases (V3,V6,V7,V8,V9) producing one apparent vein. DDH 1803 - 102.7 m.



PLATE 26. Well mineralized zone. Dark spots in quartz veins are wolframite. DDH C1754 O 148 m. Scale is 16 cms. long.

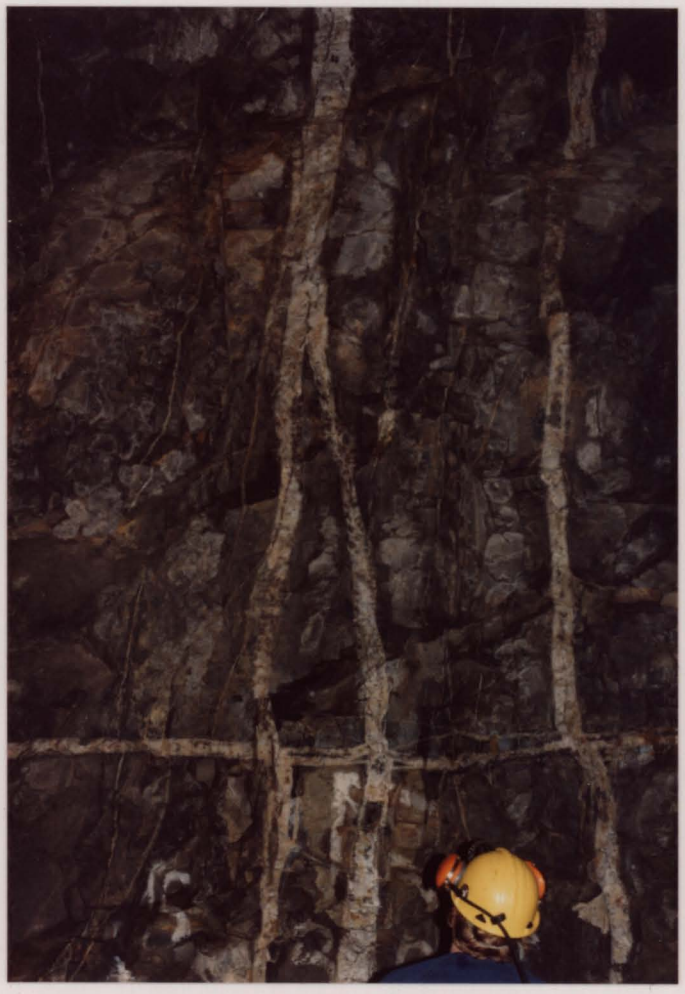


PLATE 27. Stage V6 and V7 mineralized veins (vertical) forming composite (side by side) single vein at top. Early stage V3 vein horizontally. 21 Battery Access Drive. West side-wall.



PLATE 28. Highly irregular gashing and "stoping" by flat quartz veins. 21 Battery Access Drive Loading Bay.



PLATE 29. Early stage V3 vein tension gash type junction. Higher vein on right side indicates possibly porphyry centre to the right. 21 Battery Access Drive. East side-wall.

V7 V9

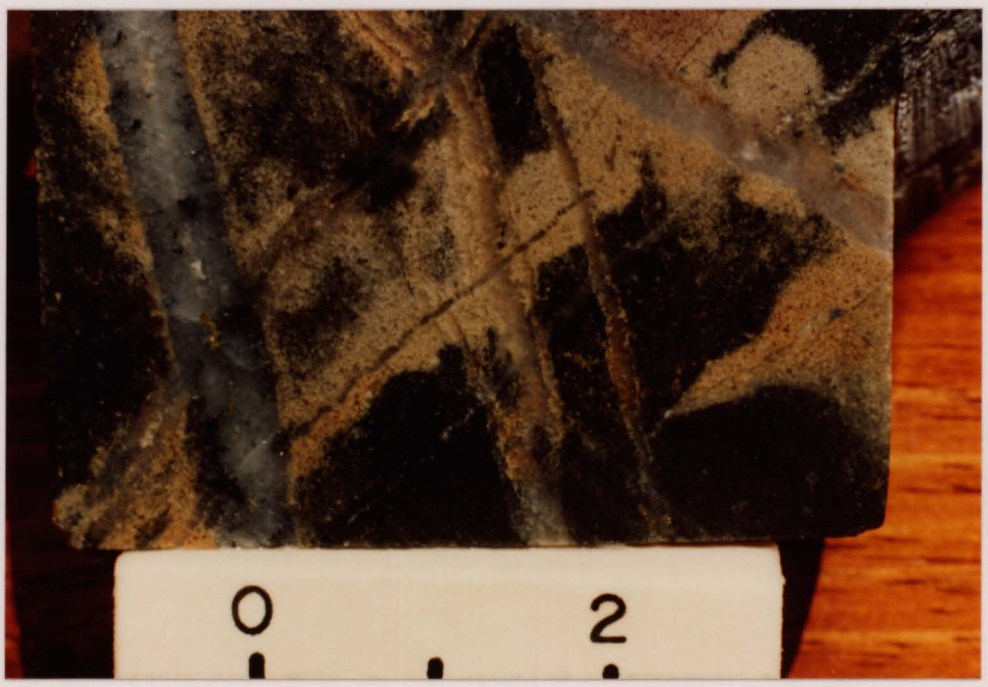


PLATE 30. Siderite - sericite bleached sandstone with dark grey tourmaline alteration. Mineralized vein (V7) with topaz-pyrite centre (V9) on left. DDH C1754 - 146.5 m. Scale in cms.

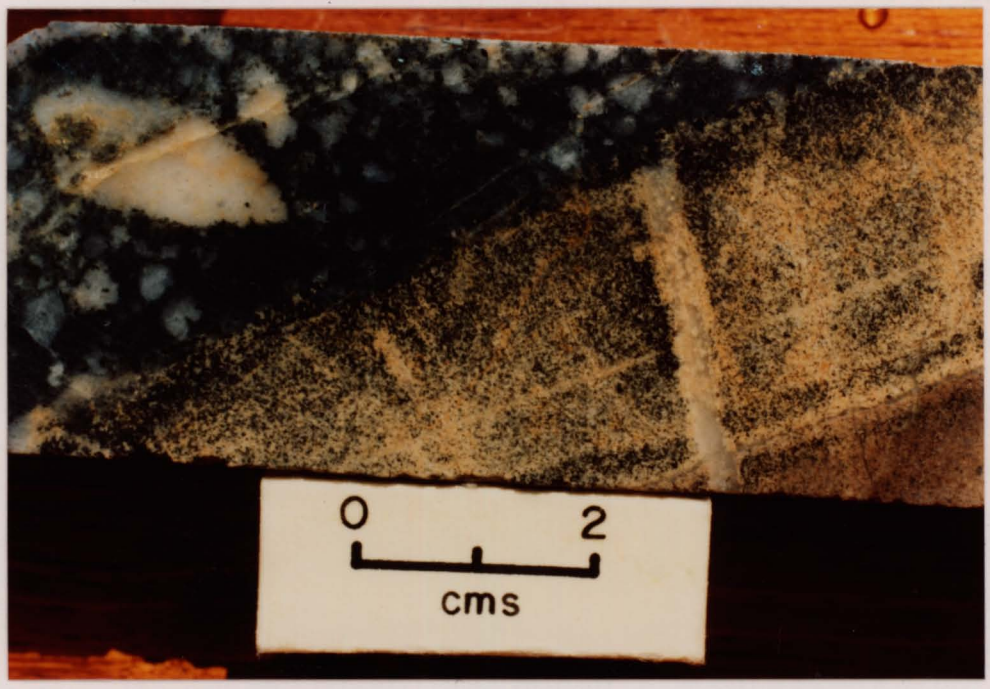


PLATE 31. Intense tourmaline altered quartz porphyry (top-left) against bleached (siderite, sericite, clay altered) sandstone DDH C1633 - 496.9 m.



PLATE 32. Interconnecting flat near barren quartz veins (V3). Note dark tourmaline alteration adjacent vein in bleached sandstones. 21 Battery Access Drive. West side-wall.



PLATE 33. Siderite, sericite, clay altered (bleached) sandstone surrounded by brown biotite altered sandstone.
21 Battery Access Drive. East side-wall. 1 m between white paint marks.

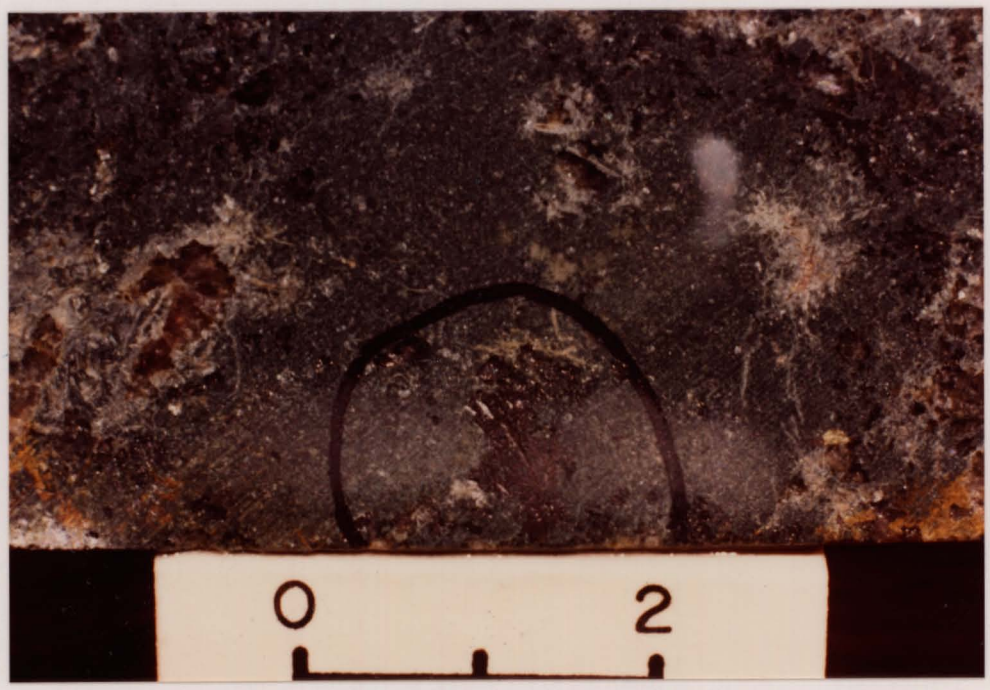


PLATE 34. Wolframite clot (circled) in green biotite - fluorite - sellaite altered Henry's lode. DDH C1754 - 61.1 m.

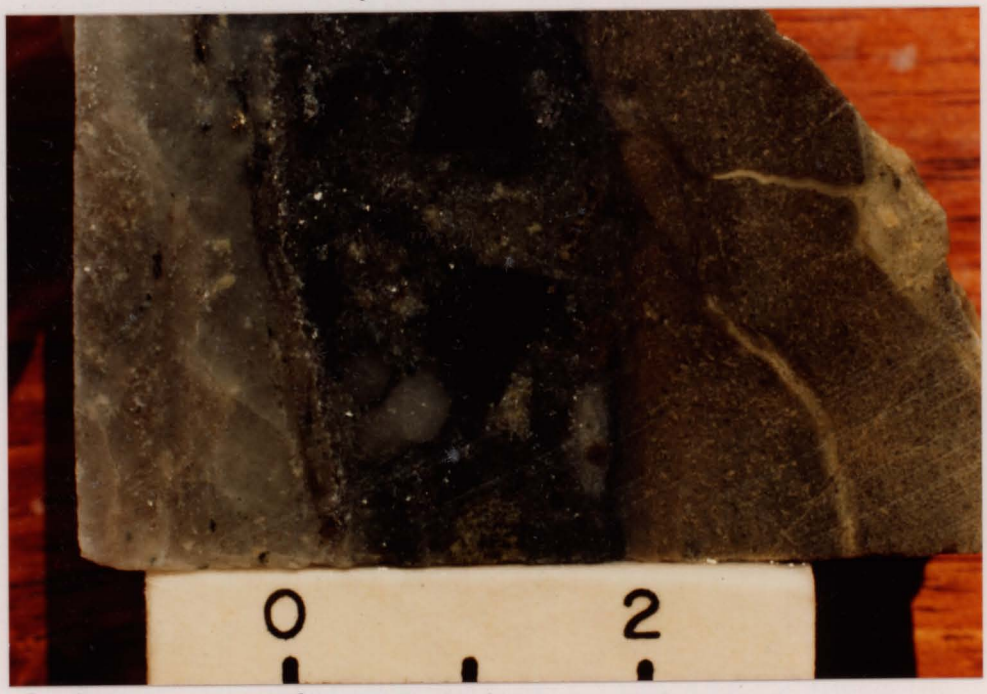


PLATE 35. Sericite - tourmaline matrix breccia with quartz, country rock fragments. Sericitized porphyry on extreme left. Sandstone on right. DDH C1741 - 99.1 m. Scale in cms.

401



PLATE 36. Very late stage pyrite - marcasite vughy breccia.
DDH C1811 - 90.1 m.

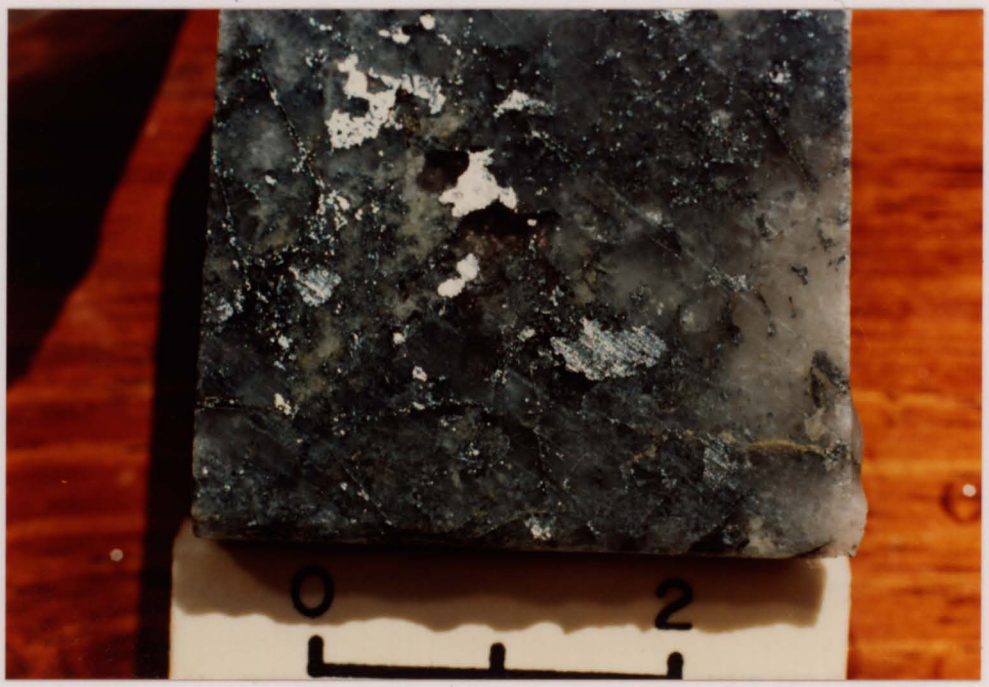


PLATE 37. Native bismuth (white) and bismuthinite (grey) in quartz-sellaite altered tin lode (Henry's) DDH C1842 - 42.9 m.
Scale in cms.



PLATE 38. Heavily topazized Henry's lode (left) against topaz-flourite vein V9 (right). 21 Battery Access Drive. West side-wall.



PLATE 39. 15mm to 65 mm particle size "accept" from photometric sorter. Scale is 30 cms. long.

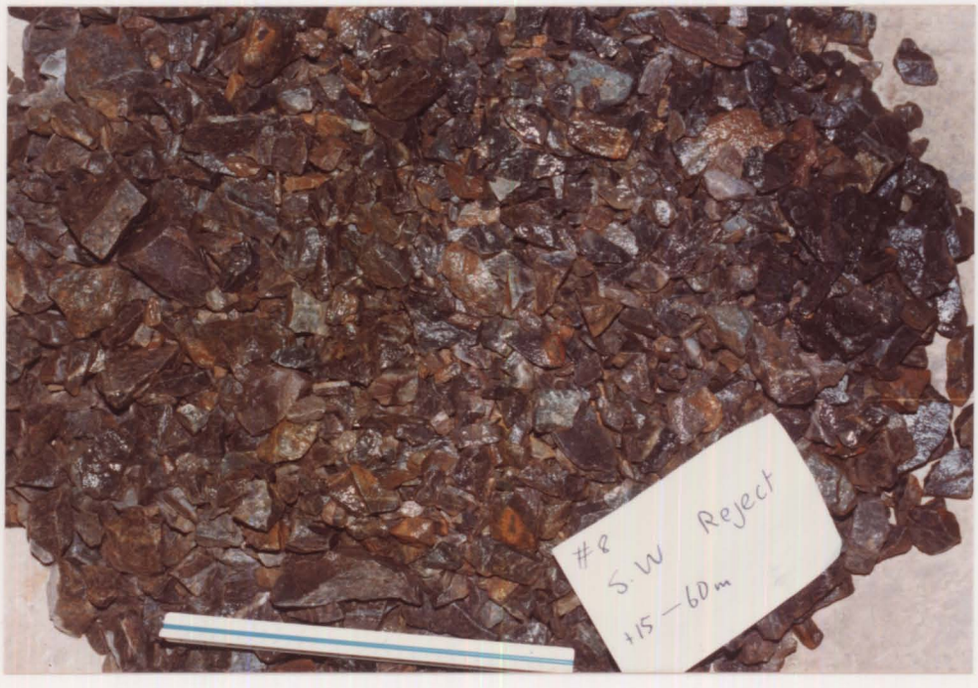
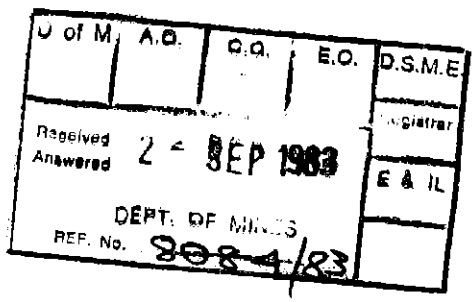


PLATE 40. 15 mm to 65 mm particle size "reject" from photometric sorter. Scale is 30 cms. long.

72 469



GEOLOGICAL ASSESSMENT

OF THE FOLEY ZONE MINERALIZATION

AT CLEVELAND MINE, TASMANIA.

PLANS AND SECTIONS

CONTENTS

1.	4880 E	SECTION	1:500		
2.	4920 E	"	"		
3.	4960 E	"	"		
4.	5000 E	"	"		
5.	5040 E	"	"		
6.	5080 E	"	"		
7.	5120 E	"	"		
8.	4960 E	"	"	WO_3 ASSAY	PROFILE
9.	"	"	"	MoS_2 "	"
10.	"	"	"	BI "	"
11.	"	"	"	SNT "	"
12.	"	"	"	CU "	"
13.	LONGIT.	PROJ.	"		
14.	PLAN	PROJ.	"		
15.	"	26 LEVEL	R.L. 970		
16.	"	27 "	R.L. 950		
17.	"	28 "	R.L. 930		
18.	"	29 "	R.L. 910		
19.	"	30 "	R.L. 890		

RL 650m
RL 700m
RL 750m
RL 800m
RL 850m
RL 900m
RL 950m
RL 1000m
RL 1050m

4800N
4850N
4900N
4950N
5000N
5050N

C1485
C1485
C1869
C1869
C1570
C1570
10.2% W03 CUT-OFF
5m x 0.335% WO3

5cm

72 411

	CLEVELAND TIN LTD			
	FOLEY ZONE 4880 E SECTION			DRAWING N° MC-FOL-001
DATE 10-5-83	DRAWN P.V.	TRACED P.V.	SCALE 1:500	SHEET

83-2028 6490

RL 650m
RL 700m
RL 750m
RL 800m
RL 850m
RL 900m
RL 950m
RL 1000m
RL 1050m

4800 N
4850 N
4900 N
4950 N
5000 N
5050 N

C1485
C1570
C1826
C1833
C1840
C1869

10m x 0·396 WO3
50m x 0·24% WO3
95m x 0·230 % WO3
5m x 0·289% WO3
5m x 0·378% WO3
102% WO3 CUT-OFF

	CLEVELAND TIN LTD		
	FOLEY ZONE 4920 E SECTION	DRAWING N°	MC-FOL-002
	5 cm 83-1028		
DATE 10·5·83	DRAWN P.V.	TRACED P.V.	SCALE 1:500	SHEET

72 412

C401

RL 650 RL 700 RL 750 RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

4800 N 4850 N 4900 N 4950 N 5000 N 5050 N

0·2% WO3 CUT-OFF

0·4% WO3 CUT-OFF

0·4% WO3 CUT-OFF

137·5m x 0·38 % WO3

55m 0·294% WO3

35m 0·268% WO3

15 m x 0·290% WO3

40 m x 0·475 % WO3

0·2% WO3

5m x 0·678 % WO3

12·5m x 0·296 % WO3

5m x 0·35 % WO3

72 413

	CLEVELAND TIN LTD				
	FOLEY ZONE 4960 E SECTION 83-2028				DRAWING N° MC-FOL-003
5 cm					
DATE 11·5·83	DRAWN K.T.	TRACED K.T.	SCALE 1:500	SHEET	

6402

RL 650 RL 700 RL 750 RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

4800 N
4850 N
4900 N
4950 N
5000 N
5050 N

C1739 E4 172m
C1811 W8 139m
C1832 E4 147m
C1842 E4 125m
C1834 E4 125m
C1811 E8 145m
C1741 E8 100m

02% WO3 CUT-OFF
0·4% WO3 CUT-OFF
0·4% WO3 CUT-OFF
02% WO3 CUT-OFF

92·5m x 0·279% WO3
77·5m x 0·382% WO3
37·5m x 0·360% WO3
25m x 0·270% WO3
45m x 0·217% WO3
5m x 0·305% WO3

C1842, E17
C1832, E17
C1811, E15
C1730, E15
C1741, E15

72 414

5 cm

	CLEVELAND TIN LTD	
	FOLEY ZONE 5000E SECTION 83-2028	DRAWING N° MC-FOL-004
DATE 11·5·83	DRAWN K.T. TRACED K.T. SCALE 1:500	SHEET 6403

RL 650
RL 700
RL 750
RL 800
RL 850
RL 900
RL 950
RL 1000
RL 1050

4800 N
4850 N
4900 N
4950 N
5000 N
5050 N

0·2% WO3 CUT-OFF

25m x 0·282% WO3

55m x 0·528 % WO3

0·2% WO3 CUT-OFF

30m x 0·288 % WO3

5 cm

72 415

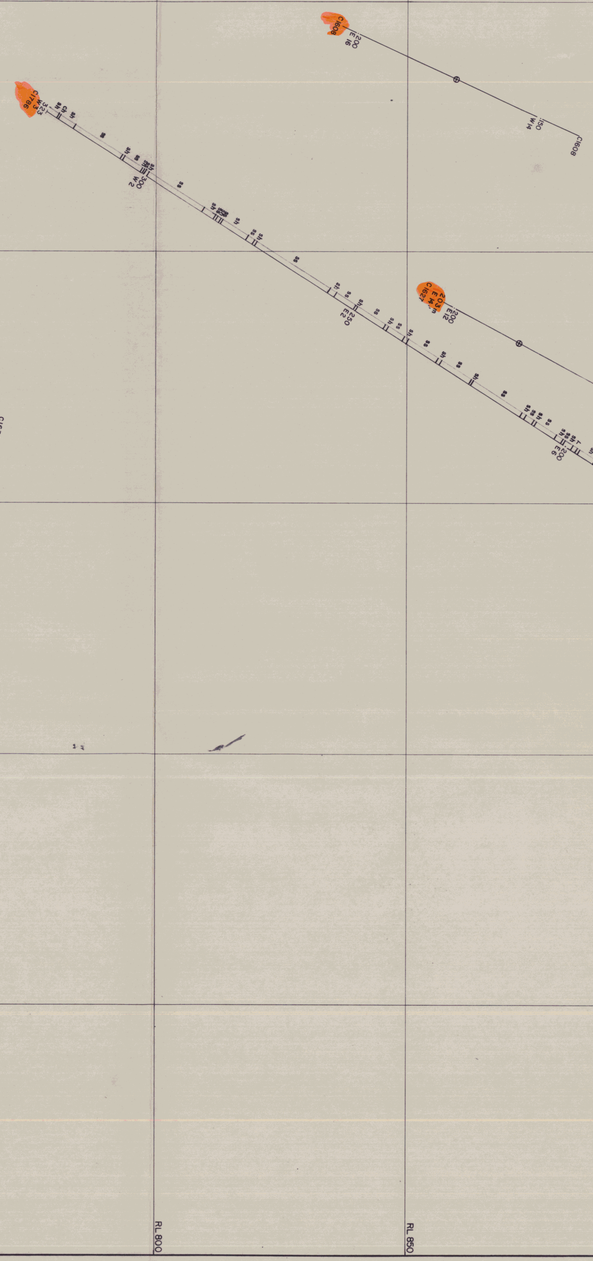
	CLEVELAND TIN LTD			DRAWING N°
	FOLEY ZONE 5040E SECTION 83-2028			MC - FOL - 005
DATE 10-5-83	DRAWN K.T.	TRACED K.T.	SCALE 1:500	SHEET

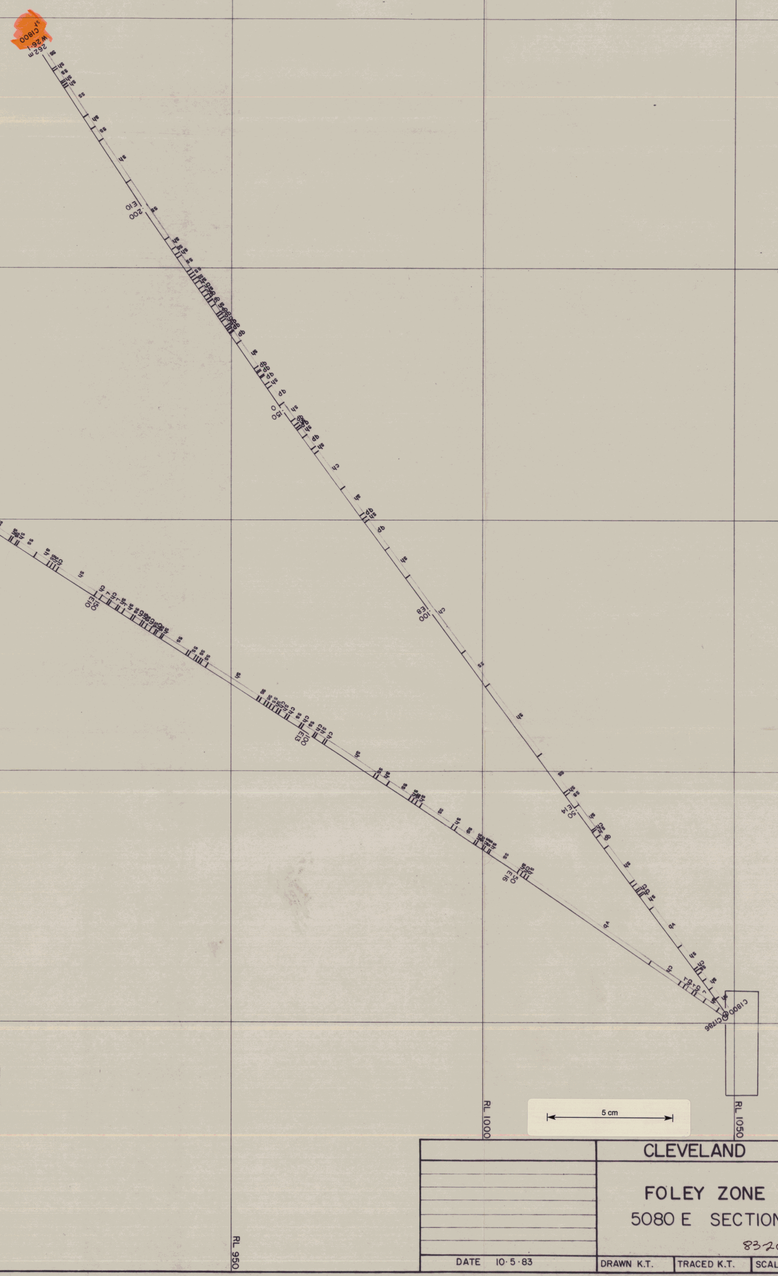
6404

RL 650 | RL 700 | RL 750 | RL 800 | RL 850 | RL 900 | RL 950 | RL 1000 | RL 1050

4800 N
4850 N
4900 N
4950 N
5000 N
5050 N







5 cm

72 416

	CLEVELAND TIN LTD	DRAWING N°
	FOLEY ZONE 5080 E SECTION 83-2028	MC-FOL-006
DATE 10·5·83	DRAWN K.T. / TRACED K.T. / SCALE 1:500	SHEET

6466

RL 650 RL 700 RL 750 RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

4800 N

4850 N

4900 N

4950 N

5000 N

5050 N

CLEVELAND TIN LTD

FOLEY ZONE

5120 E SECTION

83-2028

DRAWING N° MC - FOL - 007

5 cm

DATE 10-5-83 | DRAWN K.T. | TRACED K.T. | SCALE 1:500 | SHEET

72 417

6406

RL 550 RL 700 RL 750 RL RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

4800 N 4850 N 4900 N 4950 N 5000 N 5050 N

NOTE 10mm = 0·3 % WO3

5cm

72 418

	CLEVELAND TIN LTD		
	83-2028 FOLEY ZONE 4960 E SECTION ASSAY PROFILE WO3		DRAWING N° MC-FOL-003
DATE 11·5·83	DRAWN K.T.	TRACED K.T.	SCALE 1:500	SHEET

6407

RL 650 RL 700 RL 750 RL RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

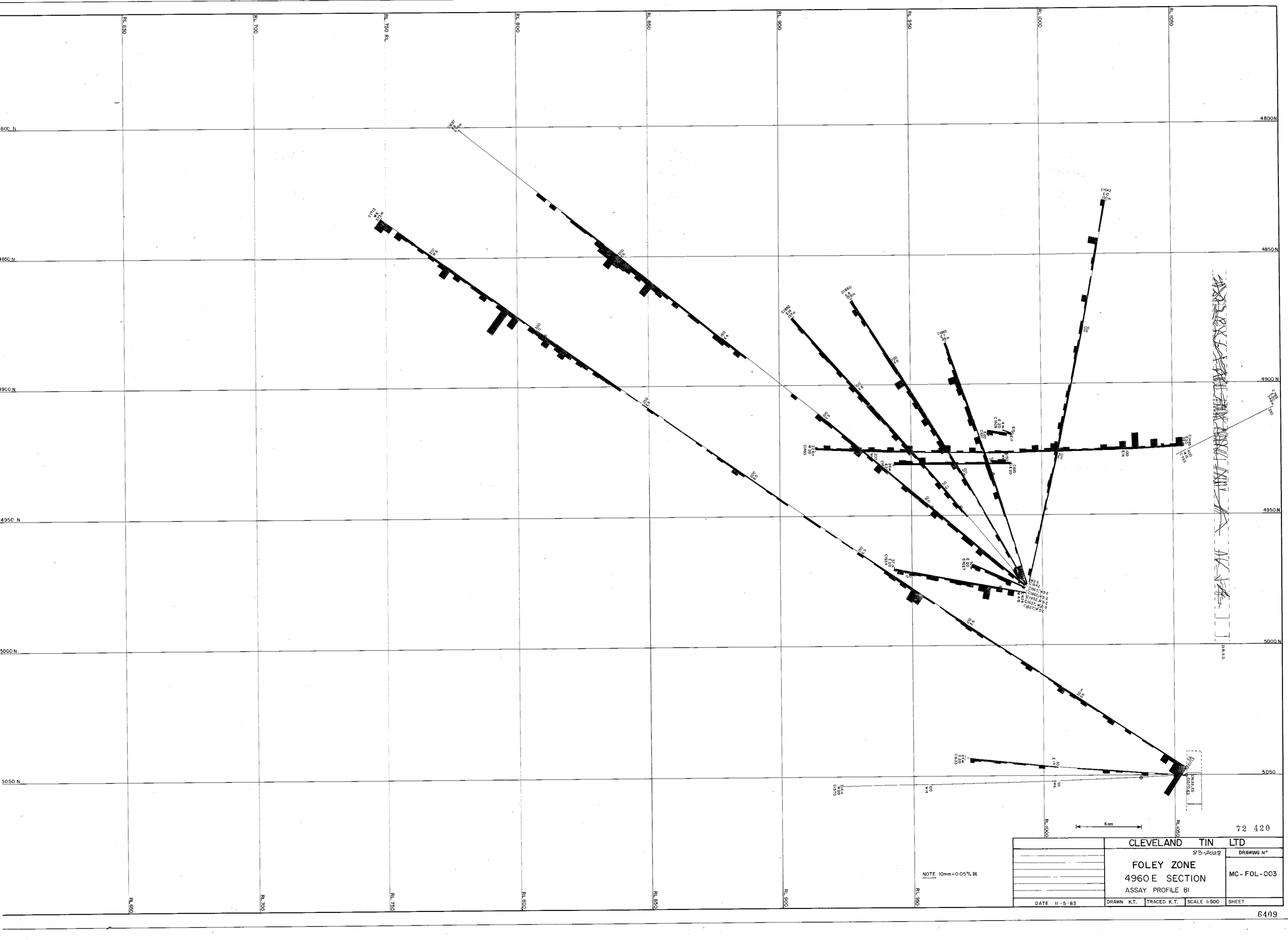
4800 N 4850 N 4900 N 4950 N 5000 N 5050 N

NOTE 10mm=0·05% MOS2

5 cm

72 419

CLEVELAND TIN LTD			
83-2028			DRAWING N°
FOLEY ZONE 4960 E SECTION ASSAY PROFILE MOS2			MC-FOL-003
DATE 11·5·83	DRAWN K.T.	TRACED K.T.	SCALE 1:500
			SHEET 6408


RL 650
RL 700
RL 750
RL 800
RL 850
RL 900
RL 950
RL 1000
RL 1050
4800 N
4850 N
4900 N
4950 N
5000 N
5050 N
C1642 E10 150m
C1713 W5 145m
C1860 E8 135m
C1858 E11 135m
C1980 E8 135m
C1635 E20 W20 C1635
C1637 W20 C1637
C1633 E20 C1633
C1633 E8 C1633
C1633 E8 C1633
C1633 E23 C1633
C1633 E14 C1633
C1633 E14 C1633
C1633 E14

RL 650 RL 700 RL 750 RL 800 RL 850 RL 900 RL 950 RL 1000 RL 1050

4800 N 4850 N 4900 N 4950 N 5000 N 5050 N

NOTE 10mm = 0·1% SnT

5cm

72 421

	CLEVELAND TIN LTD		
	83-2028		DRAWING N°
	FOLEY ZONE 4960 E SECTION ASSAY PROFILE 3nT		MC-FOL-003
DATE 11·5·83	DRAWN K.T.	TRACED K.T.	SCALE 1:500	SHEET

6410

RL 650 | RL 700 | RL 750 | RL 800 | RL 850 | RL 900 | RL 950 | RL 1000 | RL 1050

4800 N

4850 N

4900 N

4950 N

5000 N

5050 N

NOTE 10 mm = 0.05 % Cu

CLEVELAND TIN LTD

83-2028

FOLEY ZONE

4960 E SECTION

ASSAY PROFILE Cu

DRAWING N° MC-FOL-003

DATE 11-5-83 | DRAWN K.T. | TRACED K.T. | SCALE 1:500 | SHEET

72 422

6411

5cm

650RL 700RL 750RL 800RL 850RL 900RL 950RL 1000RL 1050RL

4840E 4880E 4920E 4960E 5000E 5040E 5080E 5120E

30/L 29/L 28/L 27/L 26/L

C1501 C1485 C969

C1570 C1713 C1637 C1615 C1633 C1611 C1634 C1786

C1869 C1826 C1837 C1840 C1883 C1852 C1860 C1665 C1652 C1611 C1608 C1615 C1741 C1730 C1754 C1803 C1824 C1809 C1822 C1800 C1842

0·2% WO3 CUT-OFF

ULTRABASIC CONTACT

0·4% WO3 CUT-OFF

HENRY'S LODE STRAT. POS.

HALLS B LODE STRAT. POS.

5 cm

72 423

	CLEVELAND TIN LTD			
	FOLEY ZONE LONGITUDINAL PROJECTION ASSAY INTERSECTIONS DRILLED · 0·2% WO3 CUT-OFF			DRAWING N° MC - FOL - 010
DATE 10/5/83	DRAWN T.C.M.	TRACED	SCALE 1:500	SHEET

G412

24-26 Decline Development, containing veins.

20-22 Decline Development, containing veins.

17 B/Sth, containg veins RL 1128

15-16 B/Sth Decline

25-26 Decline

Surveyed		FOLEY ZONE PLAN PROJECTION 83-2028	Drawing N° MC-FOL-020
Drawn			
Traced			
Checked			
Appd C/Survey			
Appd M/Supt			
7/1/82	K T	Scale 1:500	Date 9/5/83

72 424

6413

4840 E

4850 N

4900 N

4950 N

5000 N

4880 E

4920 E

4960 E

5000 E

5040 E

5080 E

C1869

C1833

C1826

C1485

C1860

C1852

C1637

C1865

C1634

C1713

C1615

C1611

C1627

C1608

C1811

C1730

C1741

C1809

C1824

C1803

C1754

C1800

C1786

72 425

LEGEND

0·2 % WO_3 CUT-OFF GRADE

0·4 % WO_3 CUT-OFF GRADE

QUARTZ PORPHYRY INTRUSIVE

HENRYS LODE

ULTRABASIC SEQUENCE CONTACT

DIAMOND DRILL HOLE INTERSECTION ON LEVEL

5 cm

CLEVELAND TIN LIMITED

FOLEY ZONE

83-2028

PLAN

26 LEVEL-RL 970

MC-FOL-021

DRAWN	K.T.
ORIGINATOR	E.V.D
DATE	12·5·83
SCALE	1:500
DRAWING No	

6414

4850 N | 4900 N | 4950 N | 5000 N

4880 E | 4920 E | 4960 E | 5000 E | 5040 E | 5080 E

C1869
C1826
C1833
C1485
C1637
C1860
C1852
C1713
C1634
C1615
C1611
C1627
C1730
C1608
C1741
C1809
C1824
C1803
C1754
C1800
C1786

LEGEND

- 0·2 % WO_3 CUT-OFF GRADE
- 0·4 % WO_3 CUT-OFF GRADE
- QUARTZ PORPHYRY INTRUSIVE
- HENRYS LODE
- ULTRABASIC SEQUENCE CONTACT
- DIAMOND DRILL HOLE INTERSECTION ON LEVEL

5 cm

CLEVELAND TIN LIMITED

FOLEY ZONE

PLAN 83-2028

27 LEVEL-RL 950

MC-FOL-022

DRAWN	P.V.
ORIGINATOR	E.V.D.
DATE	13·5·83
SCALE	1:500
DRAWING No	

72 426

6415

4840E 4850N 4900N 4950N 5000N 4840E

4880E 4880E

4920E 4920E

4960E 4960E

5000E 5000E

5040E 5040E

5080E 5080E

4850N 4900N 4950N 5000N

C1869 C1826 C1485 C1637 C1713 C1860 C1852 C1615 C1634 C1611 C1730 C1741 C1608 C1627 C1754 C1824 C1803 C1800 C1786

LEGEND

- 0·2 % WO_3 CUT-OFF GRADE
- 0·4 % WO_3 CUT-OFF GRADE
- QUARTZ PORPHYRY INTRUSIVE
- HENRYS LODE
- ULTRABASIC SEQUENCE CONTACT
- DIAMOND DRILL HOLE INTERSECTION ON LEVEL

5 cm

CLEVELAND TIN LIMITED

FOLEY ZONE

PLAN 83-2028

28 LEVEL-RL 930

MC-FOL-023

DRAWN	K.T.
ORIGINATOR	E.V.D.
DATE	12·5·83
SCALE	1:500
DRAWING No	

72 427

6416

4840E

4850 N

4900 N

4950 N

5000 N

4880E

C1869

4920E

C1826

C1485

4960E

C1837

C1713

C1852

C1615

C1634

5000E

C1611

C1741

5040E

C1754

C1608

C1803

C1627

C1800

5080E

C1786

4850 N

4900 N

4950 N

5000 N

LEGEND

- 0·2% WO_3 CUT-OFF GRADE
- 0·4% WO_3 CUT-OFF GRADE
- QUARTZ PORPHYRY INTRUSIVE
- HENRYS LODE
- ULTRABASIC SEQUENCE CONTACT
- DIAMOND DRILL HOLE INTERSECTION ON LEVEL

5 cm

CLEVELAND TIN LIMITED

FOLEY ZONE

83-2028

PLAN

29 LEVEL-RL910

MC-FOL-024

DRAWN	K.T.
ORIGINATOR	E.V.D.
DATE	12·5·83
SCALE	1:500
DRAWING No	

72 428

6417

4850 N
4900 N
4950 N
5000 N
4880 E
4920 E
4960 E
5000 E
5040 E
5080 E

C 1869
C1485
C1637
C1713
C1615
C1741
C1634
C1611
C1754
C1803
C1608
C1627
C1786

LEGEND

- 0·2 % WO_3 CUT-OFF GRADE
- 0·4 % WO_3 CUT-OFF GRADE
- QUARTZ PORPHYRY INTRUSIVE
- HENRYS LODE
- — ULTRABASIC SEQUENCE CONTACT
- DIAMOND DRILL HOLE INTERSECTION ON LEVEL

5 cm

CLEVELAND TIN LIMITED

FOLEY ZONE

83-2028

PLAN
30 LEVEL-RL 890

MC-FOL-025

DRAWN	K.T.
ORIGINATOR	E.V.D
DATE	13·5·83
SCALE	1:500
DRAWING No.	

72 429

6418