GEOLOGY OF THE MT. FARRELL OREBODIES

by

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Thesis - Geology of the Mt Farrell Orebodies

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ABSTRACT

The Mount Farrell ore deposits consist of a series of steeply-dipping lenticular fissure lodes of argentiferous galena, sphalerite with minor chalcopyrite, pyrite and siderite. The deposits occur in a half mile wide belt of unaltered steeply-dipping laminated mudstones, tuffs and greywackes which strikes NNE in Cambrian keratophyres, quartz keratophyres and pyroclastics of the Mount Read Volcanics. The lodes fill NNW to NNE trending fractures produced during Middle Devonian Tabberabberan tectonic activity.

Mineragraphically the ores consist of unsheared or sheared galena containing exsolutions of tetrahedrite with sphalerite, chalcopyrite, pyrite, arsenopyrite, jamesonite, marcasite, argentite and pyrargyrite in a gangue of quartz and carbonates. The lodes have a well defined, often sheared, footwall but are disseminated into the hanging wall. The ore shoots are controlled to some extent by structural and lithological factors.

Sulphur isotopic evidence sugtests a volcanic (Cambrian?) origin for the sulphur in these sulphides. Trace element studies of Co, Ni, Cd contents of Farrell sulphides suggest that the ores may have a Devonian granitic (magmatic-hydrothermal?) origin. Trace contents of Se are better interpreted as having followed sulphur in the volcanic cycle and thus being of similar origin to the sulphur.

The structural position and the unaltered nature of the walls are also consistent with the possibility of an origin related to Tabberabberan granitic intrusion.

INTRODUCTION

NATURE AND SCOPE OF INVESTIGATION

This thesis represents the results of a field and laboratory investigation undertaken to determine the genesis, structure, ore localisation controls and mineralogy of the Ag-Pb-Zn ore deposits of the Mt. Farrell district together with an examination of the suite of volcanic rocks and the sedimentary host rocks associated with these deposits.

Field mapping of an area of approximately 20 square miles, centred around Tullah was carried out during a twelve week period from December 1967 to February 1968. The area mapped lies between grid co-ordinates 852,000 N to 866,000 N and 363,000 E to 368,000 E. Mapping data was plotted on aerial photographs on a scale of 10 inches = mile.

Underground mapping of the New North Mount Farrell Mine was restricted to Nos. 1, 2, 3 levels in the abandoned workings and Nos. 7, 9 levels, both of which are being worked at the present.

Mineragraphic investigation was carried out on polished sections prepared by the writer as well as on specimens submitted by Brooks (1962). Petrological studies were made on approximately 100 thin sections including those submitted by Brooks (1962). Catalogue numbers for polished and thin sections refer to those in the Geology Department, University of Tasmania.

LOCATION AND ACCESS

Tullah is situated at the north-western end of the West Coast Range in Western Tasmania at latitude 41°44' N longitude 145°36' E.

The township of Tullah consists of about 25 houses, one hotel, post office, store and service station.

Tullah lies about 5 miles NE of Rosebery, to which it is connected by a sealed road, the Murchison Highway, about 9 miles in length. The Murchison Highway, opened in 1962, also provides access to Burnie, 69 miles to the north.

Prior to the opening of the Murchison Highway, access to Tullah was by way of the Emu Bay Railway to Farrell Siding, three miles west of Tullah. A five mile long, two foot gauge railway owned by the Farrell Mining Company connected Tullah to Farrell Siding. Since the removal of the rails in 1963, the railway bed has been accessible by car as far as Farrell Siding.

The areas north of Tullah along the Mackintosh River is accessible by two tracks which are usually open to four wheel drive vehicles. The track on the eastern bank follows Innes' Track as far as the HEC Mackintosh investigation damsite just south of Hanging Rock. The track on the western bank is a Bulldozed HEC track providing access to the Sophia Valley from the northern end.

The Murchison River is accessible upstream from the Murchison Gorge as far as the HEC Murchison investigation damsite by way of a narrow gravel track for four wheel drive vehicles. This track approximately follows the course of Kittson's Track. Branch roads provide access to the southern end of the Sophia Valley, at present however, these are blocked by numerous fallen trees.

The Stirling Valley is fairly accessible by four wheel drive vehicles during the dry season as far as the Stirling Valley Mine.

Access can be gained either along the bed of the old Stirling Valley tramway connecting the Sterling Valley Mine to Tullah or long tracks cross the buttongrass flood plain of the Stirling River.

PHYSIOGRAPHY

The topography of the area is one of high relief rising from an alluvial plain in the west (600 feet at Tullah) to a long narrow range up to 2,000 feet high (at the summit of Mt. Farrell). The high rugged topography owes its nature to the ridges of resistant siliceous Owen Conglomerate which comprise the range. The higher topography rises steeply at the southern end of the area to the summit of Mt. Murchison (4183 feet).

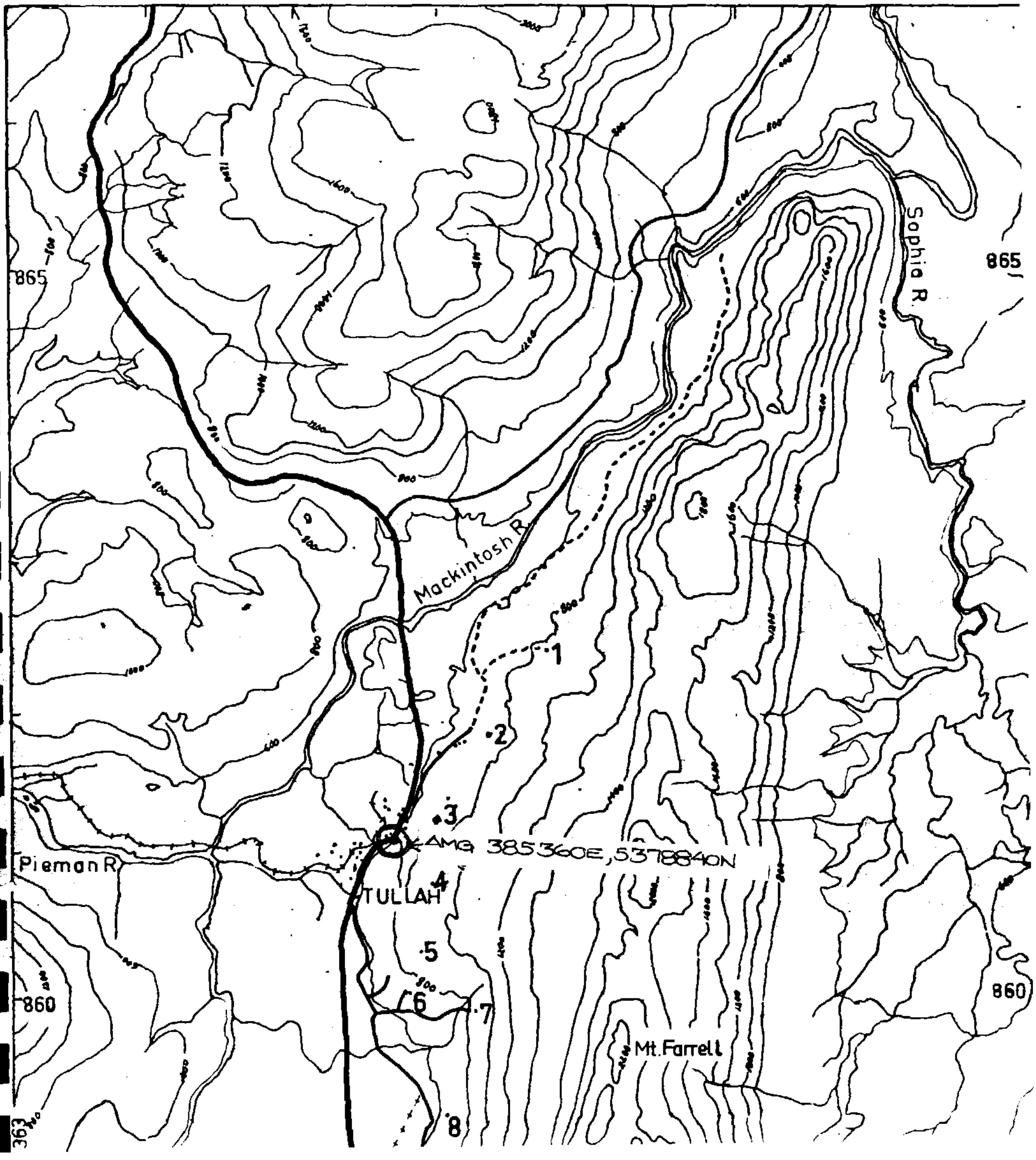
To the west of the Farrell Range lies a broad floodplain behind the confluence of the Murchison and Mackintosh Rivers which unite west of Tullah to form the Pieman River, flowing westwards to the sea. This plain extends southwards up the Stirling River Valley to the divide between Mts. Murchison and Black and extends northwards as a narrow valley around the end of the Farrell Range to the Mackintosh-Sophia River confluence.

Most of the mines are situated on the low rounded foothills on the western side of the range. These hills are drained by small westerly flowing streams.

The Murchison River cuts though the conglomerate range in a precipitous gorge south of Mt. Farrell and then flows northwesterly to the Mackintosh confluence. The river valleys contain extensive deposits of fluvioglacial materials up to 600 feet deep in places, suggesting valley glaciation during the Pleistocene.

The rivers are now actively downcutting through the floodplain. Traces of river terraces occur in the Mackintosh River Valley just north of Tullah indicating that the area has been elevated recently.

AMG REFERENCE POINTS ADDED



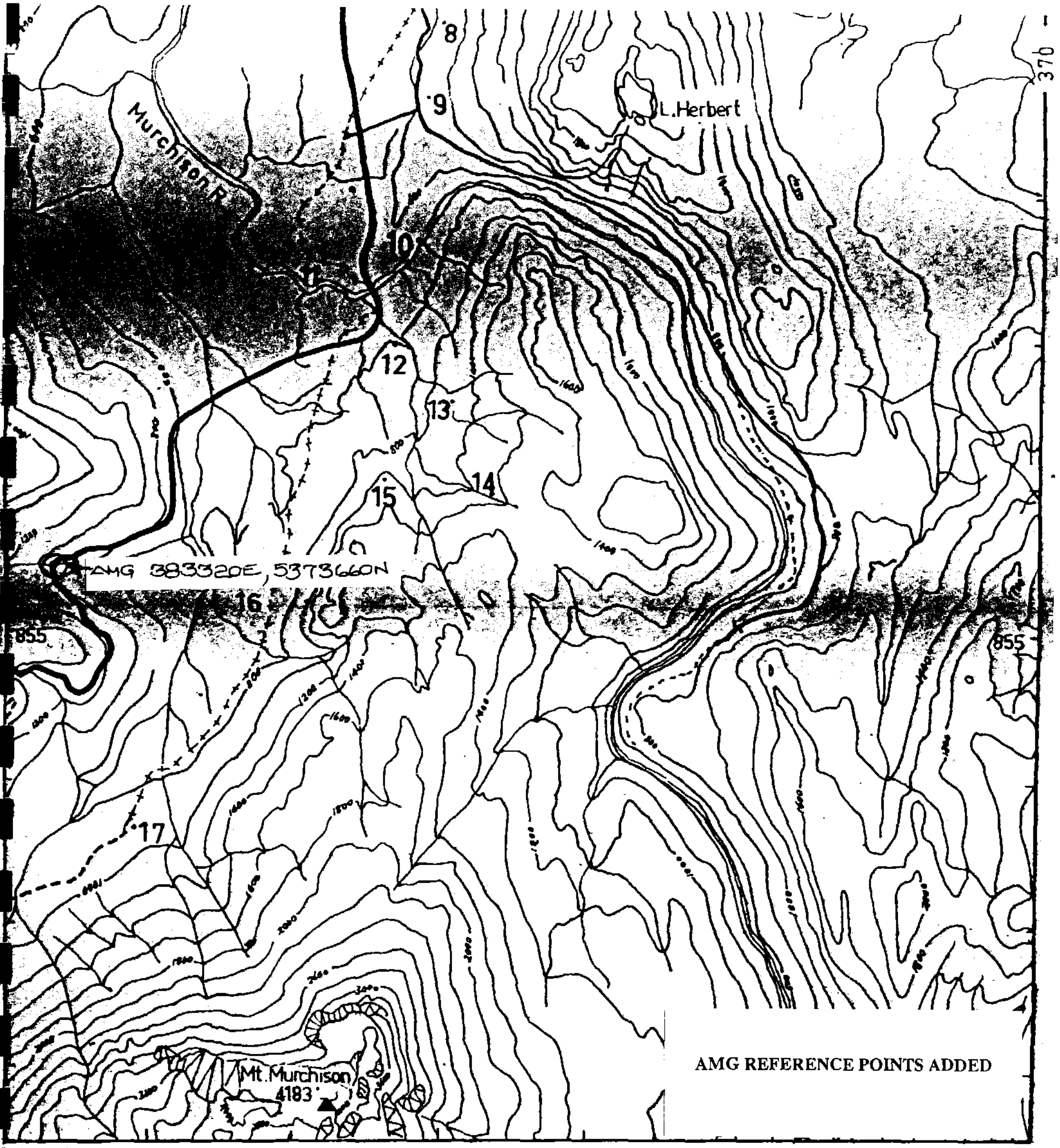


Fig.1 : Locality Map - Tullah-Stirling Valley Area

1 New North Mt. Farrell
2 South Mackintosh
3 North Mt. Farrell
4 Mt.Farrell N Workings
5 Mt Farrell S Workings
6 Dutton's Workings
7 Central Mine
8 Murchison Extended
9 Murchison Mine
10 South Murchison
11 Green&King's Wkgs.
12 Thomas' Blocks
13 Tullah Ag-Pb Mine
14 Mace's Prospect
15 Midson's Prospect
16 Finn's Prospect
17 Sterling Valley Mine

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Vegetation consists of a variety of types. The plain is covered by dense buttongrass and ti-tree scrub. The low rounded hills are covered either by low buttongrass or by fairly dense regrowth of bracken, *Eucalyptus ovata, E. simmondsii* and*Bavera.* The slopes of Mts. Murchison and Black and the Murchison River Gorge are vegetated with dense rain forest. The rain forest contains myrtle, sassafras and man-ferns.

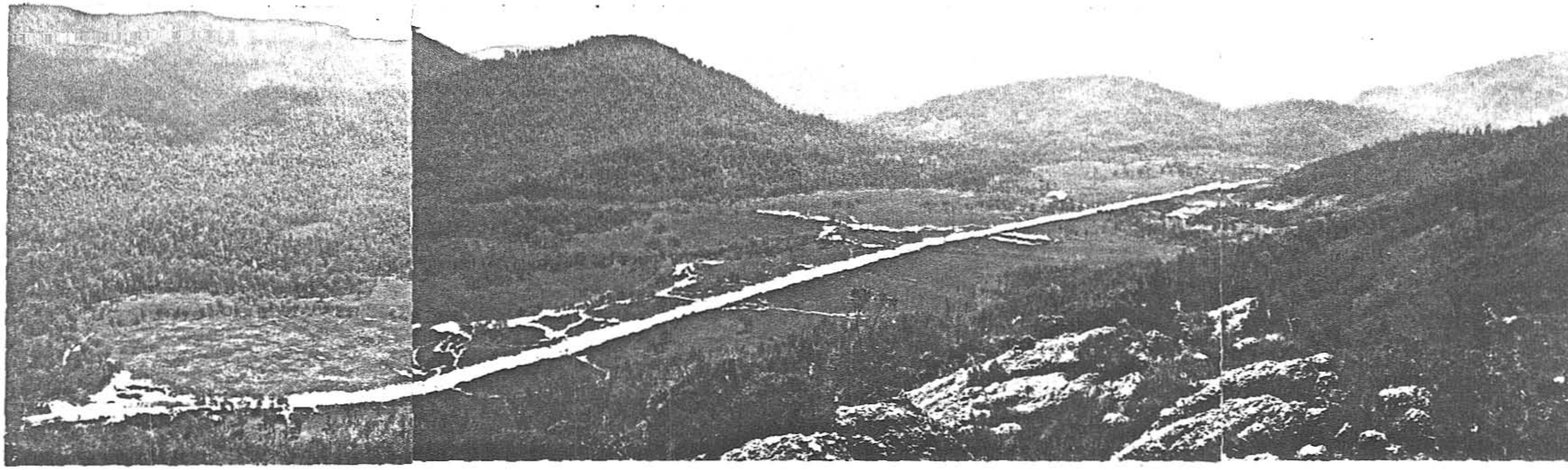

PLATE 2 : View from Little Farrell looking north, showing floodplain of Murchison and Mackintosh Rivers and the Pieman River confluence

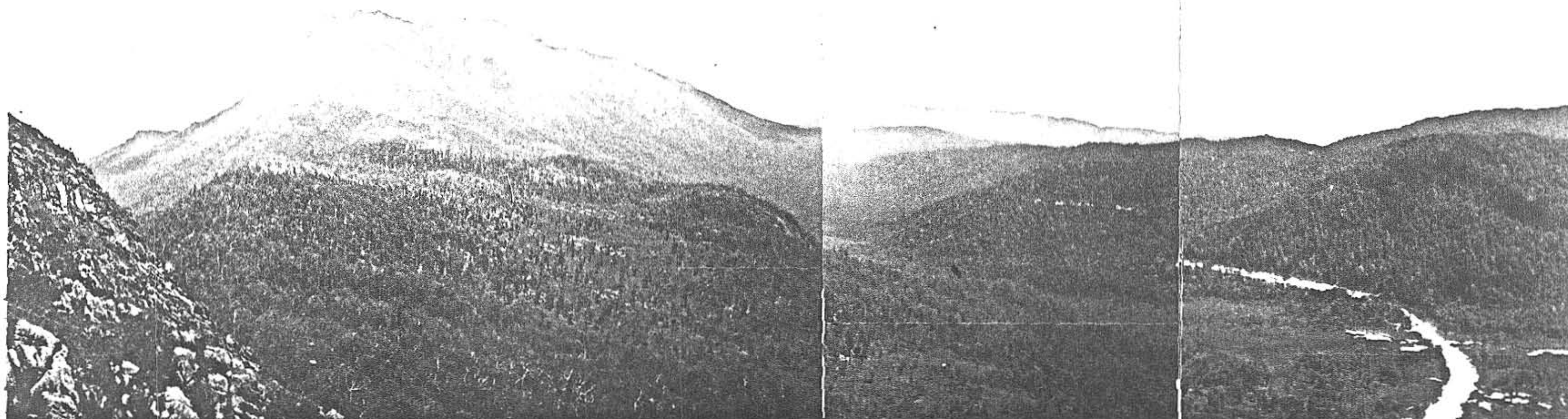

PLATE 3 : View from Little Farrell looking south, showing the Stirling River Valley, Mt. Murchison and Mt. Read (in background)

PREVIOUS LITERATURE

The literature on the geology and mineral deposits of the Tullah district is restricted. Twelvetrees (1901) examined all workings in active operation and described in detail the workings above No. 4 adit level, including the open cut, North Mt. Farrell Mine. Waller (1904) visited the area and investigated the North Mt. Farrell lodes and the prospect of the Mackintosh Copper and Gold Mining Company N.L. on the site of the present New North Mt. Farrell Mine.

Ward (1908) published a detailed and comprehensive account of the geology of the area, which remained the most complete description until Brooks (1962) investigated the area.

Reid (1927), Nye (1931) published brief typewritten reports on individual prospects in the area. Henderson (1945) investigated the mines of the Farrell Mining Co. Ltd. in some detail and gives a complete history of mining in the Mt. Farrell field.

Several large mining companies have carried out further studies concerning, in particular, the further development of the New North Mt. Farrell Mine (e.g. Drew, 1957).

Richardson (1951) carried out geophysical exploration of the area and defined several electromagnetic and self-potential anomalies. Further geophysical exploration was carried out by the Bureau of Mineral Resources in 1957.

The most recent summary of the mineral deposits of the Tullah area is that of Groves and Noldart (1964). It consists of a brief examination of the geology and economic potential of the Farrell mines.

BRIEF HISTORY

The mineral deposit first discovered in this area was that found by the pioneer prospector T. H. Farrell in 1895. He opened up a small chalcopyrite show in a creek running into the Mackintosh River, three miles above its confluence with the Sophia River. The Government Geologist, Montgomery inspected this property in 1895 and suggested that the rugged mountain range be named after Farrell.

Whitham (1923, p. 116) records that the existance of silver-lead mineralisation at Mt. Farrell was noticed by Joseph Innes during the surveying of Innes' Track from Mole Creek to Rosebery in 1896-7. At about this time, C. P. Smith was prospecting on the Mackintosh sections just south of the present New North Mount Farrell Mine.

(i) North Mount Farrell Mines

The first galena was discovered on the North Mount Farrell leases and in 1899 the North Mt. Farrell Company was formed. Mining was commenced by driving adits at successive levels eastwards to intersect the lode. The first ore was sold late in 1899.

The inaccessibility of the district, with consequent high transport charges, necessitated only the highest grade ore being sold. In 1902, the Company began the construction of a wooden horse tramway to Boco siding on the Emu Bay Railway, eight miles away. This was converted to a steam tramway in 1907.

The North Mount Farrell Mine earned the first profits in 1904 and sinking below the number No. 4 adit level was commenced. The first dividend was declared in 1905. In 1907 a water power scheme from Lake Herbert was completed but owing to the lack of catchment area it was a complete failure.

Henderson (1945) noted that in 1909 there was a serious tonnage reduction of ore mined at the North Mount Farrell Mine due to the rapid depletion of ore reserves above No. 4 adit level. As a consequence, an internal shaft was sunk from No. 4 level adit.

In 1926 a decision was made to sink a new shaft since the length of crosscuts necessary to reach the lode was becoming too great. Sinking of the main shaft was completed to the No. 10 level, 838 feet from surface, towards the end of 1930. Positioned as it was, the main shaft was only connected to the No. 8 and the No. 10 level.

The continuing low price of silver and lead, together with the complete lack of development and the shortage of power, forced a cessation of underground operations late in 1932.

After the closing down, the Government Unemployment Relief Fund provided employment for the men as prospectors north of the mine. In March, 1933 a six inch vein of galena was discovered on the surface on the old Mackintosh lease just north of the North Mount Farrell Mine.

The assets of the North Mount Farrell Mining Co., N.L. were purchased by the Farrell Mining Company Ltd. in June, 1933. The main shaft of the New North Mount Farrell Mine was commenced in 1934. The main shaft reached No. 7 level in a last sink in 1940. Since 1940 a two-compartment internal shaft has been sunk from No. 7 level a further two levels to No. 9 level.

At the beginning of December, 1964 the Electrolytic Zinc Company of Australasia, Ltd. purchased the assets of the Farrell Mining Company Ltd.. This Company is at present undertaking major development work in the New North Mount Farrell Mine and intends to dewater the flooded workings of the North Mount Farrell Mine.

(ii) The Sterling Valley Mine.

The Sterling Valley Mine is situated at the foot of the saddle connecting Mts. Murchison and Black. The lode was discovered by J. Lynch in 1911 (Reid, 1918, p. 111). The Sterling Valley Mining Company was formed in 1912 and crosscutting from surface adits and driving north and south began immediately. Active operations were continued until 1915, when temporary suspension of development occurred, as a result of labour shortage created by the World War I hostilities. During the period of active mining about 50 tons of galena were produced.

A well graded wooden tramway had been established on the bed of the Tullah-Rosebery Road from Tullah to the Sterling Valley Mine. Work was resumed on a limited basis until 1929 when the mine closed down.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation of the assistance provided by the Electrolytic Zinc Company of Australasia, Limited in giving permission to enter and work within Company mining leases and exploration areas. In addition, the Company provided accommodation at Rosebery during the field season and gave access to diamond drill core and relevant company information. The assistance of G. Griffith, J.G. Druett, D.J. Wilson and R.L. Brathwaite of the Electrolytic Zinc Company's Rosebery Office is gratefully acknowledged.

Mr. J. Smythe, Tullah assisted the writer by providing information regarding many of the old mines and gave valuable time in directing the writer through a number of these workings.

The help and advice of the staff of the Geology Department, University of Tasmania is gratefully acknowledged. Dr. M. Solomon acted as supervisor throughout the year. Discussions with postgraduate students, in particular G. Loftus-Hills, in the Geology Department were particularly fruitful and to them I express my thanks. To Miss N. Gee, who typed the thesis and assisted with drafting, I extend my grateful thanks.

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STRATIGRAPHY

CAMBRIAN

A thick belt of Cambrian rocks, dipping westward occurs on the western flank of the Farrell Range. The orientation of this succession is controversial although the majority of recent authors have considered it overturned. On the basis of overturned sedimentary structures (current bedding and ripple marks) in the Farrell Slates at the Murchison River Bridge, Brooks (1962) considered the succession overturned. Groves and Noldart (1964) questioned the validity of Brooks' structures suggesting that they may have been produced by modification of bedding by cleavage at an acute angle of bedding. The writer observed one occurrence (SP 36101) of recognisable graded bedding in fine grained mudstones at the Murchison Bridge. This structure gave an east facing for the sediments indicating that the succession is overturned at that locality.

South-east of Tullah in the Murchison Gorge, the Cambrian sequence appears to be intruded by an elongate body of adamellite, the Murchison Granite. The Cambrian rocks are unconformably overlain by Jukes Breccia and Owen Conglomerate of Ordovician age.

Mount Read Volcanics

The belt of rocks to the west of Tullah consists mainly of soda-rich volcanic rocks of basic and intermediate composition. Rock types include lavas, tuff, breccia and Volcanic sandstone. These rocks form a portion of an arcuate belt of volcanic rocks, the Mount Read Volcanics, about five miles wide which flank the Precambrian Tyennan Block from Macquarie Harbour to Moina.

The Mount Read Volcanics, defined by Campana and King (1963, p. 15) include the porphyroids of early workers (Twelvetrees and Petterd, 1899; Ward, 1908; Hills, 1915), the Mt. Read Felsite (Twelvetrees and Petterd, 1899), the Massive Pyroclastics (Hall *et al.*, 1953), the Read-Rosebery Volcanics (Hills and Carey 1949) and the Volcanic Assemblage (Campana *et al.*, 1958).

The origin of this suite of rocks has been a controversial topic. Twelvetrees and Petterd (1899), Ward (1908) and Hills (1915) regarded the suite as volcanic in origin. However Scott (1954) regarded them as albitized and silicified basaltic bodies and Bradley (1954) considered they had been derived by a complex process of metasomatism, involving silicification and feldsphatisation, of sediments. More recently the extrusive and pyroclastics origin of most of these rocks has been generally accepted. (Hall and Cattle, 1959; Carey, 1947; Banks, 1957; Campana *et al.*, 1958; Hall *et al.*, 1953; Campana and King, 1963).

The age of the Mount Read Volcanics and their relationship to the associated Cambrian sediments has been a major controversy among students of West Coast stratigraphy (Campana *et al.*, 1958; Campana *et al.*, 1960; Banks and Solomon, 1961; Campana and King, 1963; Loftus-Hills *et al.*, 1967). Loftus-Hills *et al.*, (1967) have summerised the evidence and conclude that the Mount Read Volcanics are in part equivalent to the Dundas Group (lower Middle - middle Upper Cambrian) and may extend down as far as the Oonah Quartzite and Slate.

The predominant rock types are sodic lavas characterised (Spry, 1962 p. 257) by high soda content and mineralogically by strong alteration resulting in the presence of albite, actinolite, chlorite, epidote, calcite etc. The lavas include keratophyres, quartz keratophyres, rhyolite, quartz porphyries and feldspar porphyries. The rocks are frequently sheared strongly and usually show considerable alteration.

The keratophyres (SP 36117) contain phenocrysts of feldspar, pyroxene, quartz and leucoxene in a groundmass which is usually fine grained alteration products (chlorite, sericite). The feldspara are usually albite with some oligoclase. Phenocrysts of augite are sometimes altered to actinolite-tremolite, chlorite or epidote. Clots of calcite, albite or quartz have been suggested (Groves and Noldart, 1964, p. 47) as possible amygdules.

MURCHISON GRANITE

An elongate body of granite, the Murchison Granite, occurs in the Murchison Gorge, south east of Tullah. It occurs in the core of a secondary monocline (Brooks, 1962). The contacts of the granite with the surrounding Mount Read Volcanics are very irregular and appears to be transitional and there is evidence of shearing and alteration (Ward, 1908, p. 10; Bradley 1954, p. 227). Ward (1908, p.33) and Campana and King (1963, p. 48) considered that the Murchison Granite was essentially coeval and comagmatic with the adjacent volcanics.

The granite is believed to represent a high-level, late-volcanic intrusion (Solomon, 1962; McDougall and Leggo, 1965, p. 307) having the same composition as the lavas and possibly the same parentage

(Loftus-Hills and Solomon, 1967, p.235).

A specimen of fresh hornblende from an adamellite which was strongly altered gave a K-Ar age of 515 $\pm$ 15 m.y. confirming the pre-Devonian age for the Muchison granite (McDougall and Leggo, 1965 p.235). This is a Late Cambrian date but would be a minimum estimate owing to the likelihood of Ar loss during the subsequent Jukesian Movement (Tyennan Orogeny) and the Tabberabberan Orogeny due to deformation and possible temperature elevation.

The granite body is composed largely of adamellite and syenite. The adamellite is generally medium grained and consists of p lagioclase, perthitic K - feldspar, quartz, biotite, hornblende, minor pyroxene and opaque iron ore. Shearing has produced marked undulose extinction in the quartz and fragmentation of some crystals into mosaics of smaller grains is quite common. Strong alteration of biotite to chlorite is common and hornblende may be less altered. Plagioclase is usually slightly sericitized and K - feldspar is sometimes kaolinized. Sulphides are present in the granite; usually pyrite and chalcopyrite is minor disseminations.

FARRELL SLATE

Interbedded with the volcanic rocks, and structurally underlying the western volcanics, is a sequence of slates, tuffs and tuffaceous sandstone (or volcanic sandstone. Groves and Noldart, 1964, p. 47), approximately 2000 feet thick. These sediments crop out from the Sterling Valley Mine to north of the Farrell Range and are the host rocks for the important ore deposits in the area.

These sediments are known in the literature as the Farrell Slates (Mills, 1915), Farrell Slate series (Henderson, 1945), "bedded series"

(Hall, *et al.*, 1953), Slates and Breccias (Carey, 1953) and Tullah Slates (Solomon, 1958). They are in places highly sheared with cleavage acute to the bedding.

The slates are blue or black to grey mudstones which are in places finely laminated (See Plate 4). Finely disseminated pyrite is present in the bedding planes; particularly in the black slates. The thickness of the slate varies from a few feet to hundreds of feet. It is composed of elongate sheared quartz gains showing undulose extinction (SP 30010) in a matrix of sericite, chlorite and calcite. Veinlets of calcite and rock fragments are present. Groves and Noldart (1964, p. 48) note that 'adjacent to the lode channels the slate is talcose due to alteration during mineralisation'. This alteration is extremely local and specimens taken 2 feet from the lode channel show no recognisable alteration.

Campana and King (1963, p. 16) consider the slates to represent terrigenous deposits laid down under subaqueous conditions.

Pyroclastic members of the Farrell Slate include tuffs and tuffaceous sandstones which Groves and Noldart (1964, p. 48) name volcanic sandstone. These units are often discontinuous and probably represent lenticular bodies about 150 feet wide. The tuff is green grey (SP 36102) and contains quartz, albite, volcanic rock fragments, slate fragments and fine grained muscovite matrix.

Minor lenses of greywacke occur in the Slate near the Murchison Bridge. They are composed mainly of rock fragments including chert.

The structural position of the Farrell Slate is problematical. Sedimentary structures suggest overturning with an east facing. Regional mapping by Campana and King (1963, p. 17) suggests that the

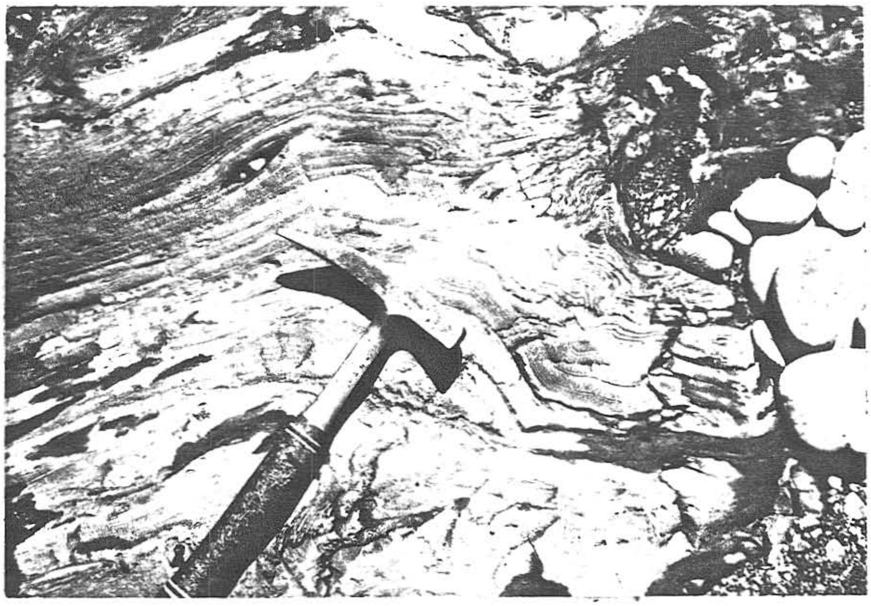

PLATE 4 : Slump folding in Farrell Slates , Murchison River Bridge .

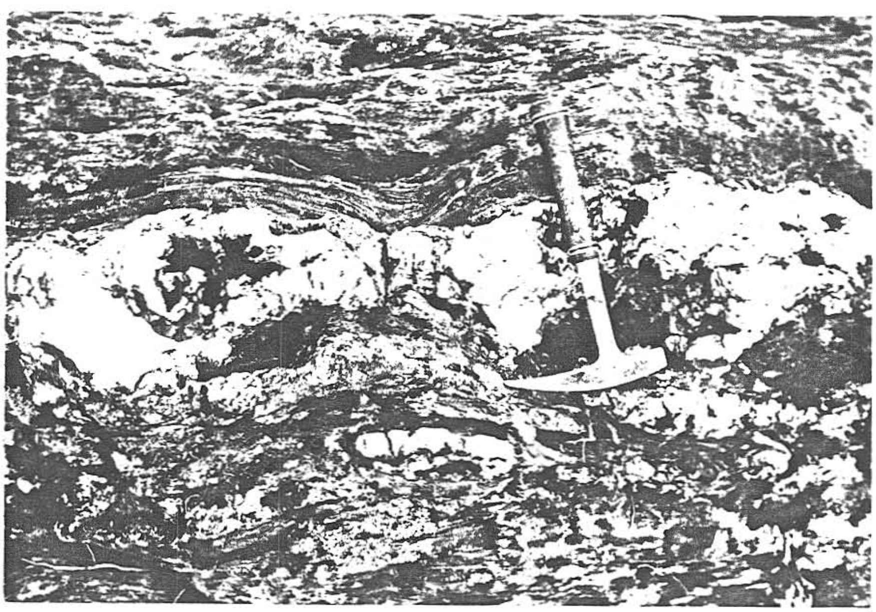

PLATE 5 : Boudinaged quartz vein in Farrell Slate Murchison River Bridge .

Farrell Slate would join, West of Mt. Cripps, the Gold Hill - Bulgobac slaty band in anticlinal disposition, with the Farrell Slate representing the overturned eastern limb of the anticline.

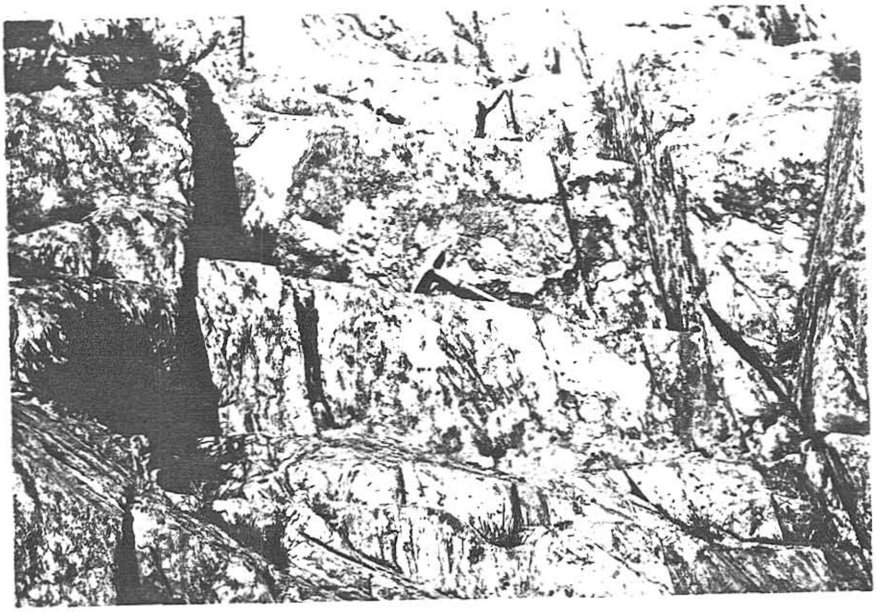

PLATE 6 : Joint blocks in laminated mudstones of Farrell Slate , Murchison River Bridge .

PLATE 7 : Cleaved keratophyre of Mt. Read Volcanics , ½ mile east of Murchison Mine. Murchison Gorge .

QUATERNARY

To the east of the confluence of the Murchison and Mackintosh Rivers lies an extensive flood plain cut in thick deposits of gravel, sand and clay. The deposits consist of unstratified cobble and gravel material (See Plate) but in places there are minor lenses of well sorted coarse grained sand, fine silt and rarely beds of clay up to 1 foot thick. Brooks (1962), Groves and Noldart (1964), and the writer regard these as glacial deposits which have been reworked by rivers.

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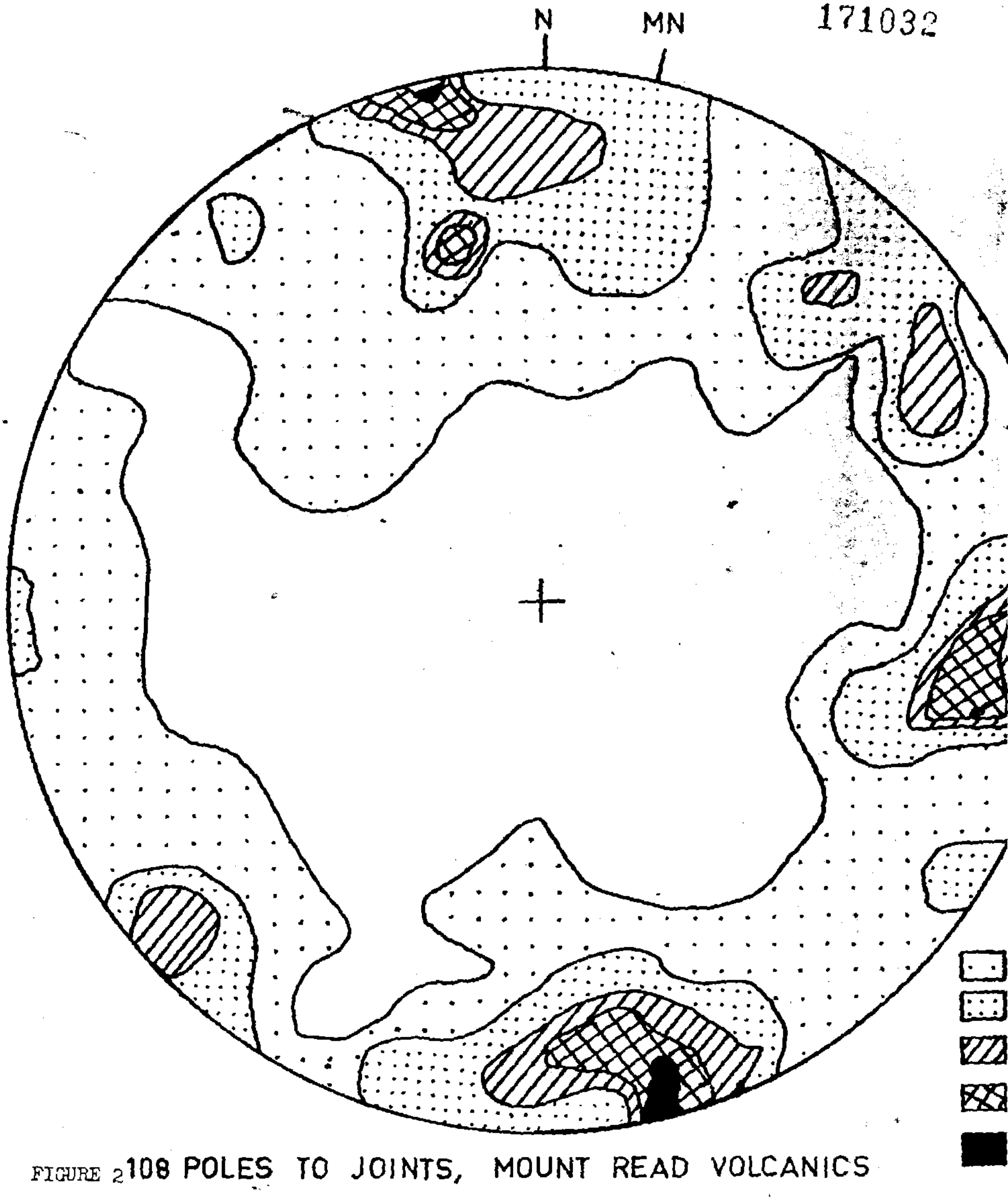

FIGURE 2108 POLES TO JOINTS, MOUNT READ VOLCANICS
TULLAH - FARRELL JUNCTION

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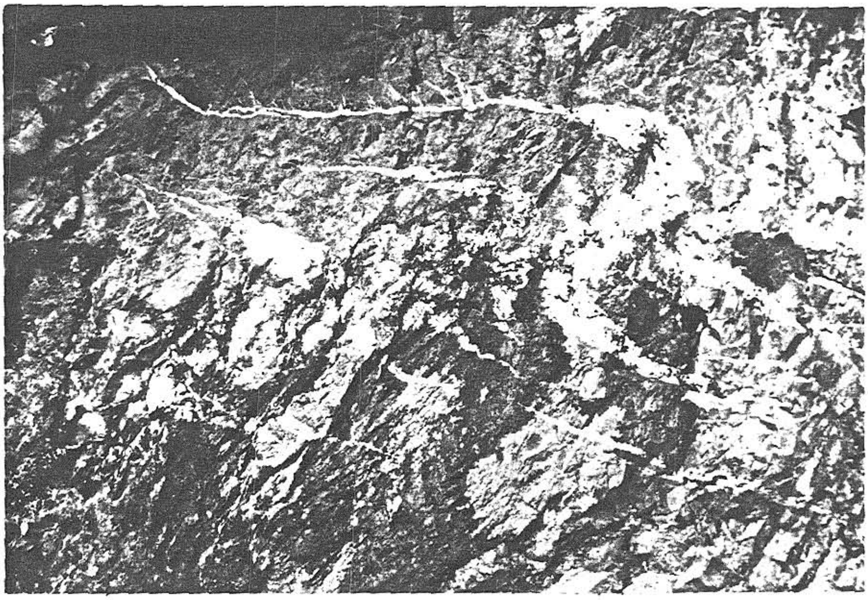


PLATE 8 : Sigmoidal tension gashes , filled with quartz and albite, in keratophyre of Mt. Read Volcanics .

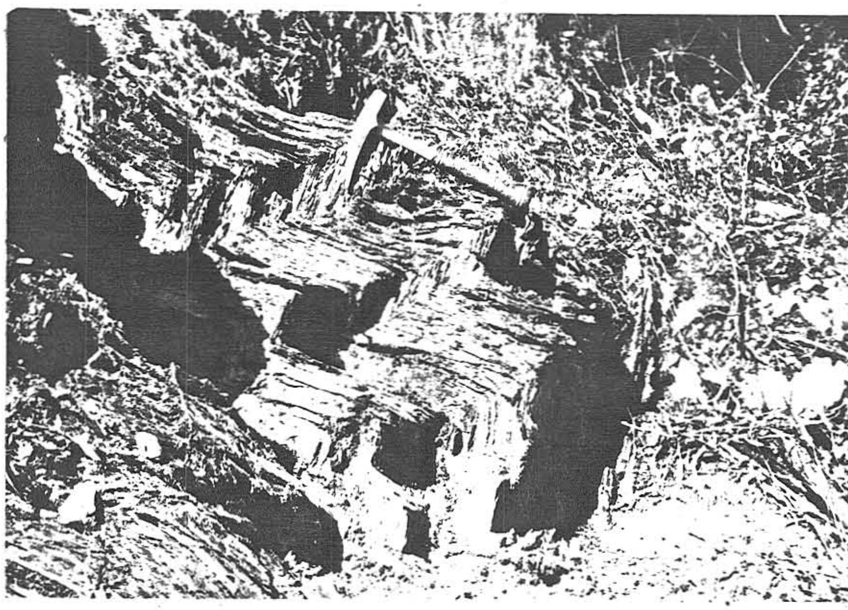


PLATE 9 : Kink bands in mudstones , Farrell Slate. ½ mile north of New North Mt. Farrell Mine.

PLATE 10 : Enlargement of part of Plate 9 .

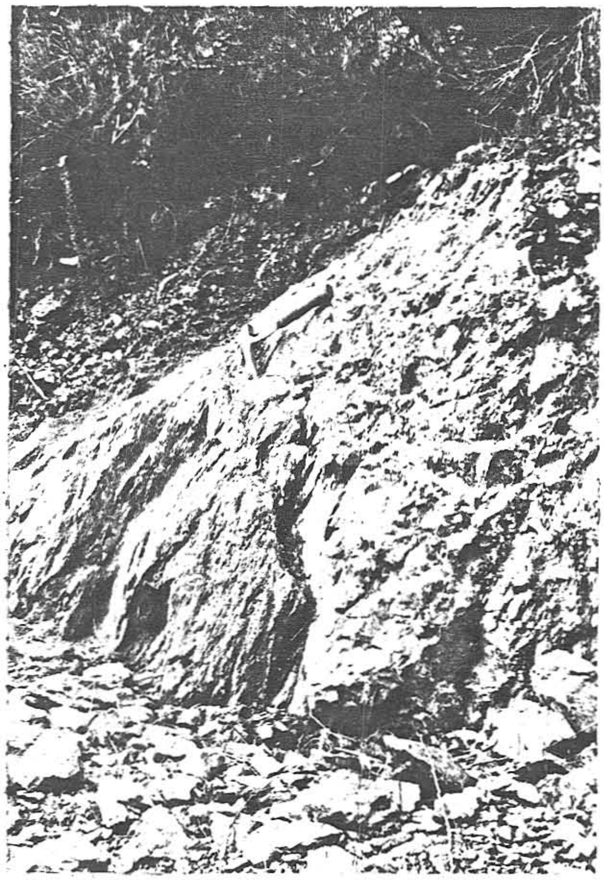


PLATE 11 : Base of Ordovician Owen Conglomerate, overlying sheared Jukes Conglomerate. Murchison River Gorge .

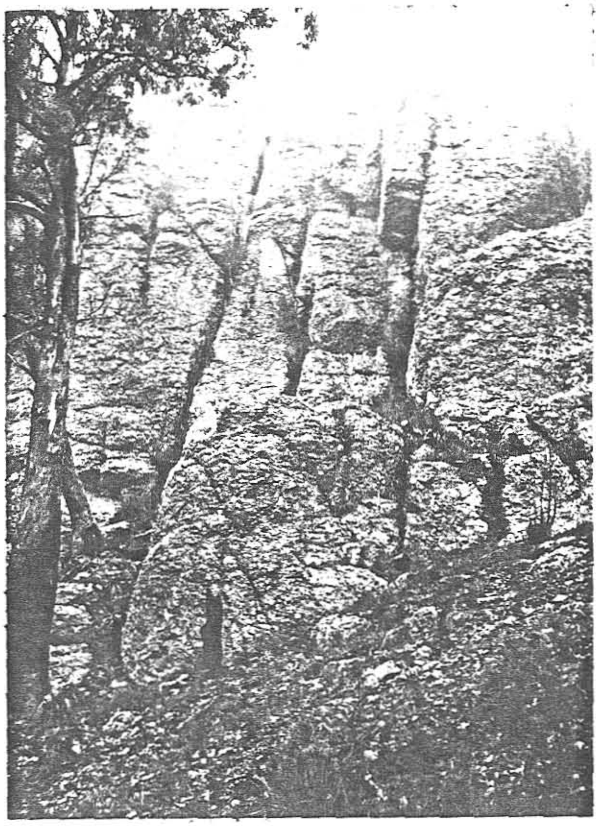


PLATE 12 : E-W cross faults Owen Conglomerate. EAST of New North Mt. Farrell Mine

MINERAGRAPHY

The lodes at Mount Farrell comprise generally coarse-grained sheared or unsheared aggregates of argentiferous galena, sphalerite, pyrite marcasite and chalcopyrite with minor tetrahedrite, jamesonite, pyrargyrite and argentite in a gangue consisting of quartz and carbonates (mainly siderite). Two lines of lode have been recognised by Brooks (1962) and Solomon (1965); viz: the Farrell lode and the Murchsion lode. These two lode zones have fairly similar mineralogy but differ in proportion and appearance. The mineralogy of these lodes is:

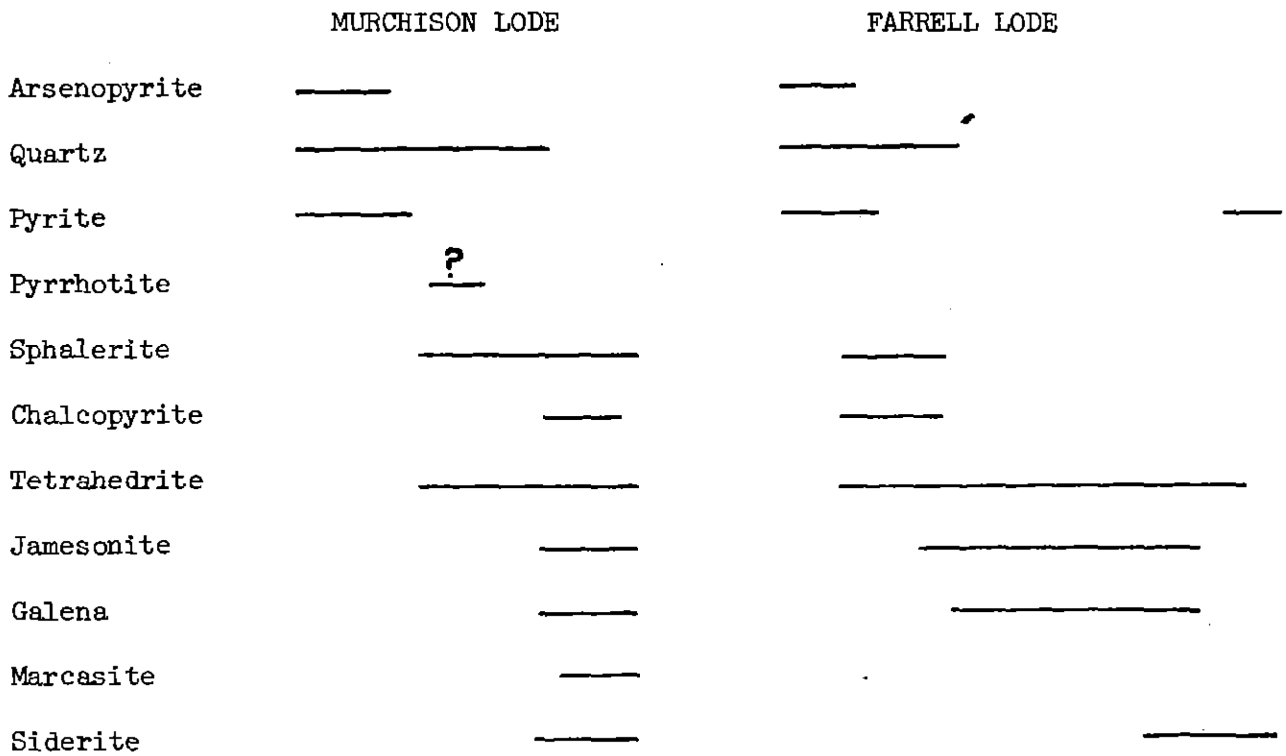
	FARRELL	MURCHISON
	Galena	Galena
	Sphalerite	Sphalerite
	Chalcopyrite	Chalcopyrite
	Pyrite	Pyrite
	Arsenopyrite	Arsenopyrite
*	——	Pyrrhotite
*	——	Marcasite
	Tetrahedrite	Tetrahedrite
	Jamesonite	Jamesonite
*	Argentite	——
*	Pyrargyrite	——

Gangue minerals include quartz and siderite with minor barite, fluorite (Ward, 1908 at Thomas' Blocks) ankerite, chlorite.

The mineralogy of the Farrell orebodies is much simpler and poorer in sulphosalts then the adjacent Rosebery-Hercules ore deposits (Williams, 1960).

The paragenesis of the ore minerals has been worked out by Brooks (1962) using some criteria which have been disputed in the literature. The writer has attempted to describe a paragenesis using, as a relative age criterion, the veining of one mineral by another to determine order of deposition. The effect of subsequent shearing is unknown as, for instance, galena is seen to invade fractures in brecciated sphalerite on shearing.

The paragenesis determined is essentially similar to that of Brooks (1962) viz.



EXSOLUTION TEXTURES

Five exsolution textures have been recognised in sulphides in the ores; namely chalcopyrite,-sphalerite, sphalerite - chalcopyrite, chalcopyrite - tetrahedrite, galena - tetrahedrite, galena - jamesonite.

Edwards (1946, p. 141) notes that solid solution intergrowths of chalcopyrite and tetrahedrite are rare despite their frequent association in ores, and their related atomic structures. In SP 10438, from the New North Mount Farrell Mine, an intimate intergrowth of tetrahedrite and chalcopyrite, apparently a product of unmixing of a solid solution of tetrahedrite in chalcopyrite occurs in an area of about 1 mm X ½ mm. The tetrahedrite appears as minute curved lamellae with slightly bulbous terminations. No tetrahedrite is observed at grain boundaries.

Exsolution of chalcopyrite in sphalerite was observed in many polished sections with sub-ovate blebs of chalcopyrite up to ½ mm in diameter. Some bodies of chalcopyrite at grain boundaries of the sphalerite may have migrated from the sphalerite.

Solid solutions of galena with a variety of silver minerals at high temperature have been observed but at normal temperatures galena can accommodate not more than 0.1% silver in its structure (Edwards, 1947, p. 110). Edwards (1947) notes that argentiferous galena containing less than 0.1% silver tends to be homogeneous.

Included in galena from Mount Farrell are numerous belbs of tetrahedrite up to 2 microns in diameter and rod like crystals up to 40 microns long and 2 microns thick oriented in (001) and (111) planes. These appear to have been precipitated from solid solution.

As these inclusions of tetrahedrite are present in the highest magnifications, it was not possible to determine the silver content of the galena alone. A plot of Ag versus Pb in galena from the New North Mount Farrell Mine is shown in Fig. 3

The application of experimental temperatures of homogenization of sulphide exsolution intergrowths to the problems of determining temperatures of deposition of ores is well known. Chalcopyrite

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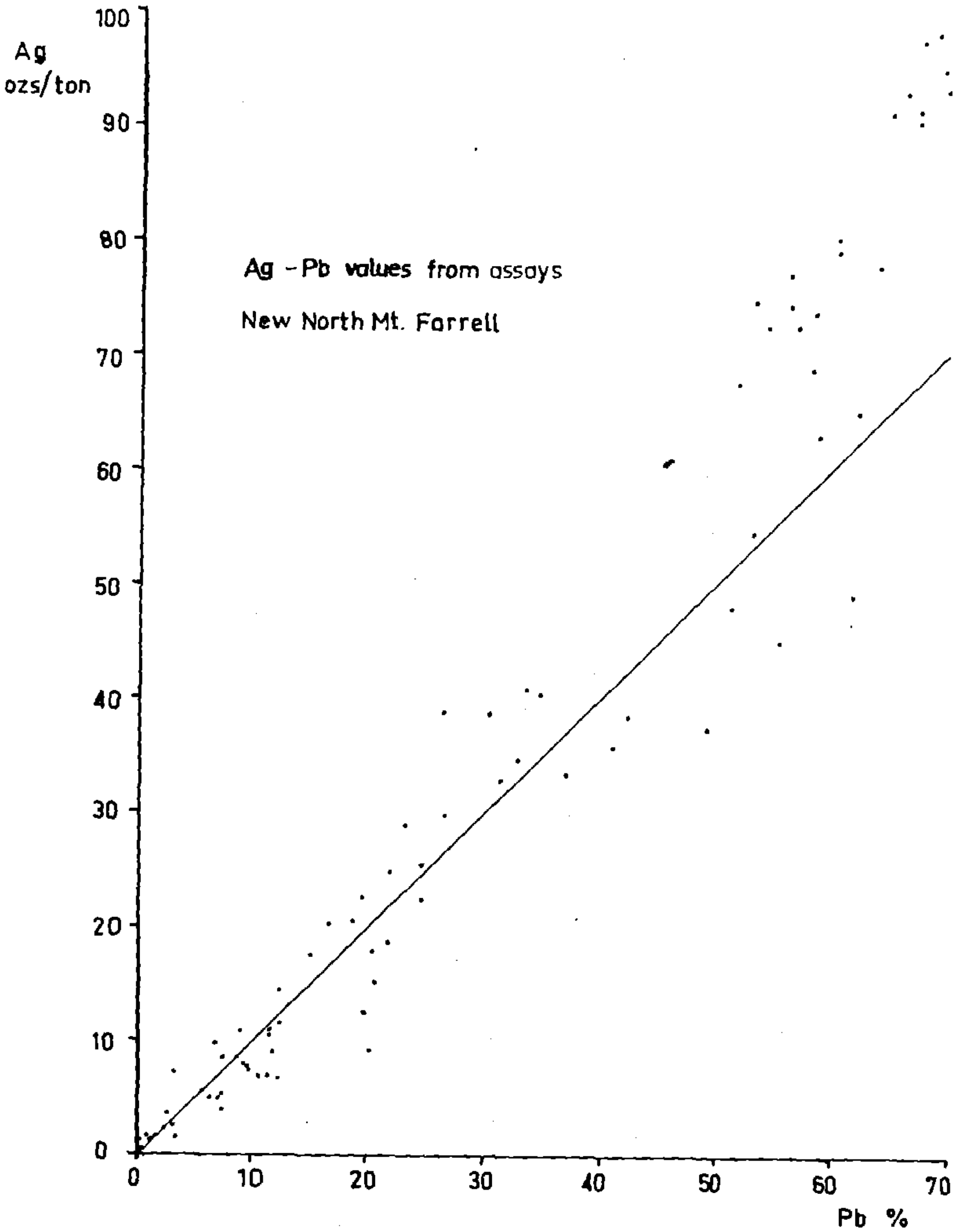


FIGURE : 3

precipitates sphalerite at 550°C, Sphalerite precipitates chalcopyrite at 350 - 450°C and chalcopyrite precipitates tetrahedrite at 550°C (Edwards, 1947). The problems, however, in applying these experimental results to the determination of depositional temperatures severely restrict their usage in ore deposit geothermometry.

IRON CONTENT OF SPHALERITE

Brooks (1962) has determined the iron contents of sphalerites from Mount Farrell and showed that Murchison sphalerite averages 12% Fe and Sterling Valley sphalerite averages 10.6% Fe. The sphalerite is practically black (marmatite) with a resinous lustre. In polished sections it shows deep red to orange internal reflections. The use of the Fe content of sphalerite as a geological thermometer has been invalidated as a result of work by Barton and Toulmin (1966).

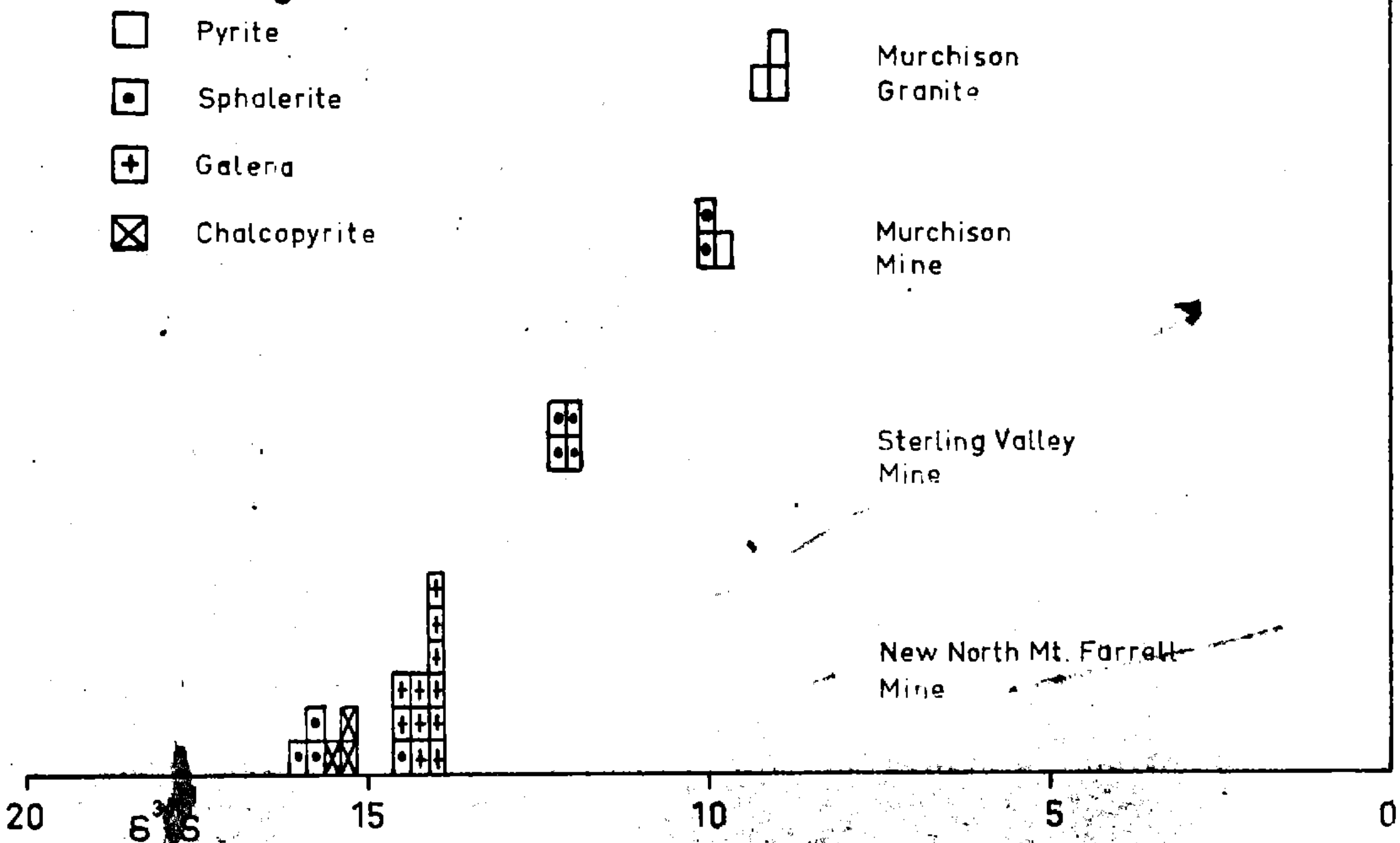
EXPERIMENTAL INVESTIGATIONS

A Number of investigators have recently applied sulphur and lead isotope and trace element geochemical techniques to the problem of genesis of the ore deposits of the Mt. Farrell area as part of a larger investigation of Tasmanian sulphide ore bodies (Solomon *et al.* 1968; Rafter and Solomon, 1967; Loftus-Hills 1967; Loftus-Hills and Solomon, 1967; Richards, 1967; Ostic *et al.*, 1966).

SULPHUR ISOTOPE STUDIES

Rafter and Solomon (1967) and Solomon *et al.* (1968) have determined a number of $\delta^{34}S$ values of sulphides (pyrite, sphalerite, chalcopyrite and galena) from the New North Mount Farrell, Sterling Valley and Murchison Mines and the Murchison Granite (see Tables 2, 3). The $\delta^{34}S$ values of New North Mount Farrell sulphides range from +17.0 $^{o}/oo$ to +13.0 $^{o}/oo$ and average 14.4 $^{o}/oo$. The four values of the Sterling Valley Mine are similar (see Fig. 4) but those from the Murchison Mine are lower and are similar to those of the Rosebery lode. The narrow range of $\delta^{34}S$ values and the pronounced enrichment of ^{34}S have been noted by Solomon and Rafter, (1967, p. 13). The similarity of the distribution of the sulphur isotope values in the Farrell ores to that in the Rosebery lead-zinc deposit has led (Solomon *et al.*, 1968; Rafter and Solomon, 1967) to suggest the possibility of a similar origin for the sulphur. i.e. an exhalative volcanic origin related to Cambrian activity. The sulphur is certainly unlike that in ores related to Devonian granites and in the Ag-Pb (galena) deposits at Zeehan which are also probably of granitic origin. In addition the $\delta^{34}S$ values seem unlike those recorded for magmatic-hydrothermal deposits (Solomon *pers. comm.*).

FIGURE: 4 $\delta^{34}S$ VALUES TULLAH AREA



As a result of this analysis Solomon *et al.* (1968) and Rafter and Solomon (1967) suggest that the association of the Farrell lodes with volcanic rocks, the absence of obvious wall rock alteration and the lack of an obvious igneous source raises the possibility that the Farrell deposits represent remobilised ores of volcanic origin.

Studies of sulphur isotope fractionation between co-existing sulphide pairs of minerals in apparent equilibrium (separated by less than 1 cm.) have been undertaken by Solomon *et al.* (1968) and Rafter and Solomon (1967). The following pattern of ^{34}S enrichment is observed.

pyrite $>$ sphalerite $\lessgtr$ chalcopyrite $>$ galena

and is apparently consistent with results obtained by other workers for volcanic ores.

The fractionation of ^{34}S between galena and sphalerite in equilibrium has been calculated by Hulston (DSIR, New Zeland) and shows an inverse relationship to temperature (*pers. comm.* to M. Solomon). As a result, it is theoretically possible to use the $\delta^{34}S$ values of co-existing galena and sphalerite as a geological thermometer. Dr. Rafter (DSIR, New Zeland) has determined sulphur isotopic fractionation between galena and sphalerite in two specimens of New North Mount Farrell ore (Table 3). If the fractionation at Mt. Farrell is at equilibrium then the temperature of deposition or metamorphism is approximately 340°C (Specimen 101067; $\delta^{34}S$ values for SP 101066 are currently being checked owing to a mistake in results forwarded in correspondence).

LEAD ISOTOPE STUDIES

Studies of the lead isotopic composition of galena from the Mt. Farrell area have been undertaken by Ostic *et al.*, (1967) and Richards, (1967). Six galena specimens were analysed by Ostic to determine the isotopic composition of the galenas and since then one further determination has been carried out by Richards. These results are given in Table 4 below and illustrated in Fig. 5 which is modified from Richards' paper.

TABLE 4: ISOTOPIC COMPOSITION OF MOUNT FARRELL GALENAS +

$^{206}Pb/^{204}Pb$	$^{207}Pb/^{204}Pb$	$^{208}Pb/^{204}Pb$
18.701 (0.004)	15.791 (0.006)	38.938 (0.009)
18. 698 (0.004)	15.791 (0.006)	38.938 (0.009)
18.736 (0.003)	15.790 (0.007)	38.980 (0.007)
18.743 (0.003)	15.797 (0.007)	38.984 (0.007)
18.687 (0.001)	15.780 (0.000)	38.916 (0.007)
18.699 (DS)	15.782 (DS)	38.930 (DS)

+ Analysed by R. G. Ostic; from Ostic, Russel and Stanton (1967) Table V, p. 254. The figures in parentheses following the isotope ratios are the loop misclosures. District standards are indicated by (DS).

Ostic *et. al.* (1967) studied the apparent correlation between lead isotope abundance characteristics and features of the deposits in which the lead is discovered. They suggested that leads from stratiform deposits should have an isotopic composition closer to primary systems lead than do vein leads, many of which involve transport for extensive distances and complex modes of emplacement. On this basis vein leads are more likely to be anomalous (multistage) than leads from stratiform deposits.

It was observed that lead isotope ratios for Read-Rosebery ores give an age discrepancy of about 390 million years for the deposit. As a result, six vein leads from Mt. Farrell were analysed and the ratios $^{207}Pb/^{204}Pb$ and $^{206}Pb/^{204}Pb$ for the Read-Rosebery and Mount Farrell samples were shown to be linearly (see Fig. 5). This is characteristic of all anomalous leads and Ostic *et al.* interpret it to be the result of admixture of lead produced by radioactive decay in local crustal rocks i.e. the local rock supply radiogenic lead to lead derived from a primary system in sufficient amount to explain the apparent age anomaly.

Quantitative agreement was obtained by Ostic *et al.*(1967, p. 267) by assuming that the lead in the Read-Rosebery and Mount Farrell deposits was derived from the primary system nearly 2,000 million years ago and was deposited in its present sites very much later. They concluded, however, that it was unlikely to be possible to establish the difference between stratiform and vein leads on lead isotope evidence alone due to the gradational contamination between them. Richards (1967, p. 8), following on from the above work, pointed out the linearity of the relationships between isotope ratios from Rosebery and Mt. Farrell. He noted the isotopic similarity of leads from Mt. Lyell and Rosebery and considered that the Mount Farrell, and possibly Magnet, samples represent leads with a greater radiogenic contamination. After consideration of the geological setting and tectonic history of the deposits Richards suggests that original lead mineralisation (Rosebery and Mt. Lyell?) could have occurred at the same time as deposition of the Mount Read

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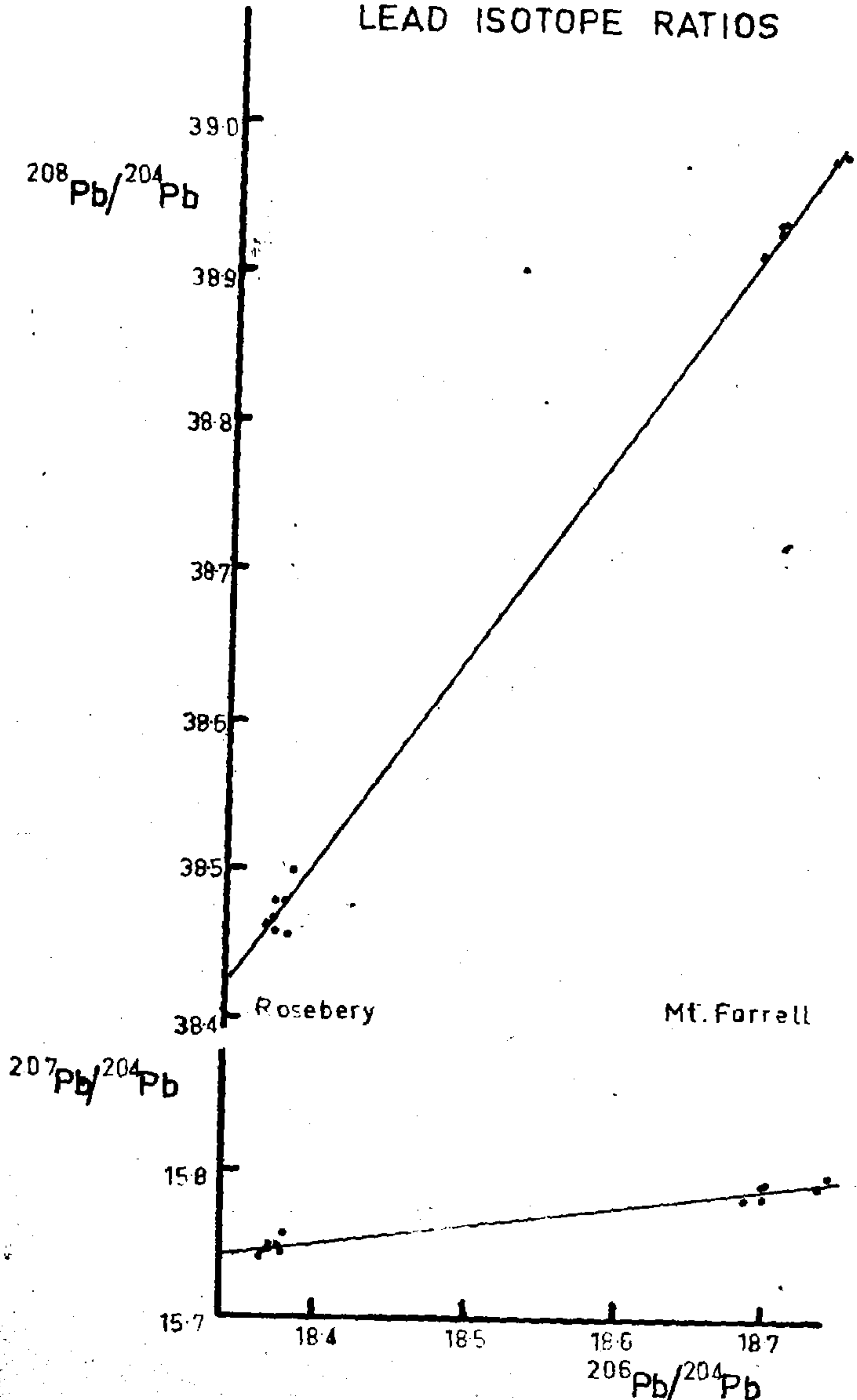

FIGURE 5

Volcanics. The anomalous leads may be a result of local remobilisation and mixing of original lead during subsequent tectonic events: isotopic evidence supporting a Jukesian ? (515-520 m.y.) period and a 340 to 350 m.y. period (Tabberabberan?).

In conclusion, the Mt. Farrell lead ores show an isotopic composition distinctly different from the Rosebery lead ores, although both deposits occurr in similar geological environments and in close proximity. It is unfortunately not possible to conclusively attribute this difference to either of the possible causes:

(i) That these ore deposits have different geneses: namely the Rosebery ore body is a stratiform volcanic exhalative deposit whereas Mt. Farrell is a vein (magmatic-hydrothermal?) deposit.

or (ii) That Farrell lead is the result of remobilisation and mixing of lead derived from original lead mineralisation associated with Cambrian vulcanism with products of radiogenic decay within the host rocks.

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TRACE ELEMENT STUDIES

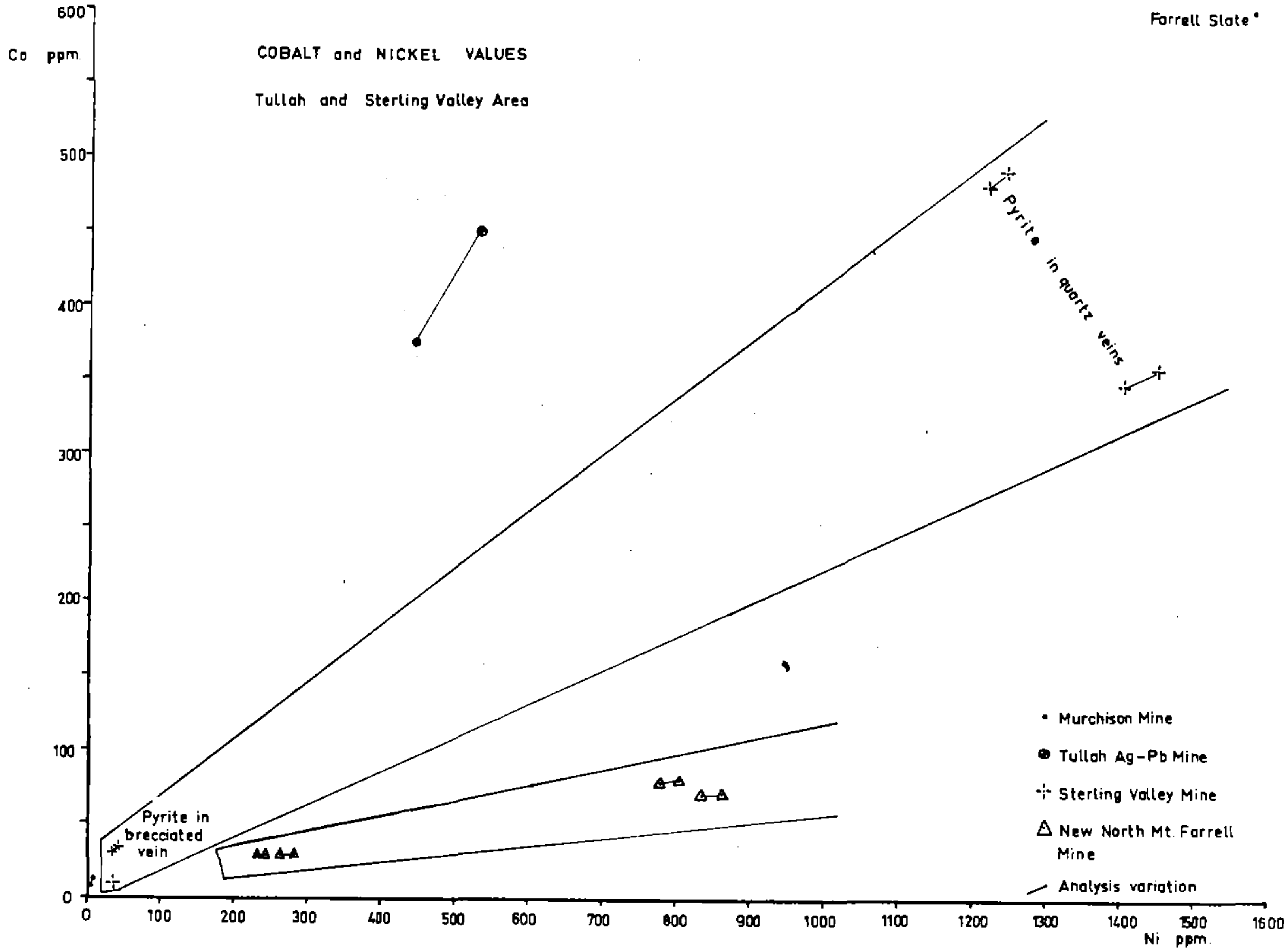
Analyses of trace element contents of sulphide minerals (pyrite, chalcopyrite, sphalerite) from Tasmanian ore deposits have been made by G. D. Loftus-Hills and D. I. Groves (University of Tasmania). These studies have been directed mainly towards the analysis of Co and Ni in pyrite, Se in chalcopyrite, pyrite and Cd in sphalerite in order to evaluate the potential usefulness of these trace elements as discriminators between environments of ore deposition (magmatic-hydrothermal and sedimentary) and as a means of identifying metallogenic provinces.

Cobalt and Nickel

Loftus-Hills (1967), Loftus-Hills and Solomon (1967) have presented analyses and interpretations of trace element distributions in pyrite and associated minerals from a wide variety of depositional environments throughout Western Tasmania. The basic aim of this work was to test the usefulness of Co and Ni trace contents as a means of indicating differences in ore genesis between different classes of ore deposits. Empirical studies have shown that, for example Co, Ni, Se, As may show significant differences in their patterns of concentration in different types of sulphide deposits. The assumptions and theory of the interpretation of Co and Ni trace element values have been adequately treated in the above papers.

Co and Ni determinations on pyrites from Mt. Farrell ore deposits have been summarised in Table 1. A plot of these results (Fig. 6) shows that the Farrell pyrites show high Ni, low Co contents with low Co:Ni ratios (<1). The Co:Ni ratios in Farrell pyrites are

FIG 5



COBALT and NICKEL VALUES
Tullah and Sterling Valley Area
Co ppm
Ni ppm
600
500
400
300
200
100
0
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
Farrell Slate*
Pyrite in quartz veins
Pyrite in brecciated vein
Murchison Mine
Tullah Ag-Pb Mine
Sterling Valley Mine
New North Mt. Farrell Mine
Analysis variation

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distinctly lower than those determined from samples of pyrite in the Mount Read Volcanics and the related Murchison Granite and are distinguished from pyrites from Mt. Lyell by much lower Co contents. The trend towards high Ni observed in the Mt. Farrell values is considered by Loftus-Hills (1968) to be distinct from the trends shown by ore deposits related to Cambrian vulcanism (Rosebery and Mt. Lyell?) and he correlates it with Co-Ni trends in ores related to Devonian granitic rocks.

Selenium

Selenium is common in a number of sulphide minerals including chalcopyrite, galena, sphalerite and pyrite (Fleischer, 1955). In a study of Australian ores, Edwards and Carlos (1954) suggested that the S:Se ratio in pyrites may be useful as a discriminator between pyrites of magmatic-hydrothermal and pyrites of sedimentary roigin. They showed that the stratiform ores of the Lower Palaeozoic in Eastern Australia associated with volcanic rocks tend to be relatively enriched in selenium compared to adjacent ores.

Se values (Table 1) in chalcopyrite, pyrite and sphalerite from the New North Mount Farrell Mine show a large range (Loftus-Hills, 1968) with distinct selenium enrichment in chalcopyrite (SP 10523A). The large spread of Se values is similar to the range at Mt. Lyell but is unlike the range shown by Devonian Sn and Pb-Zn-Ag deposits. Selenium follows sulphur in the magmatic cycle and it is possible that the Se may have a volcanic (Cambrian) origin as has been suggested for the sulphur in the Farrell ores by Solomon *et al.* (1968). However there still exists an anomalous enrichment in Se which remains essentially unexplained as the Mt. Farrell ores are far less cupriferous that the Mt Lyell ores. In addition the Rosebery ores which are more similar mineralogically and closer geographically than the Mt. Lyell ores are relatively impoverished in Se.

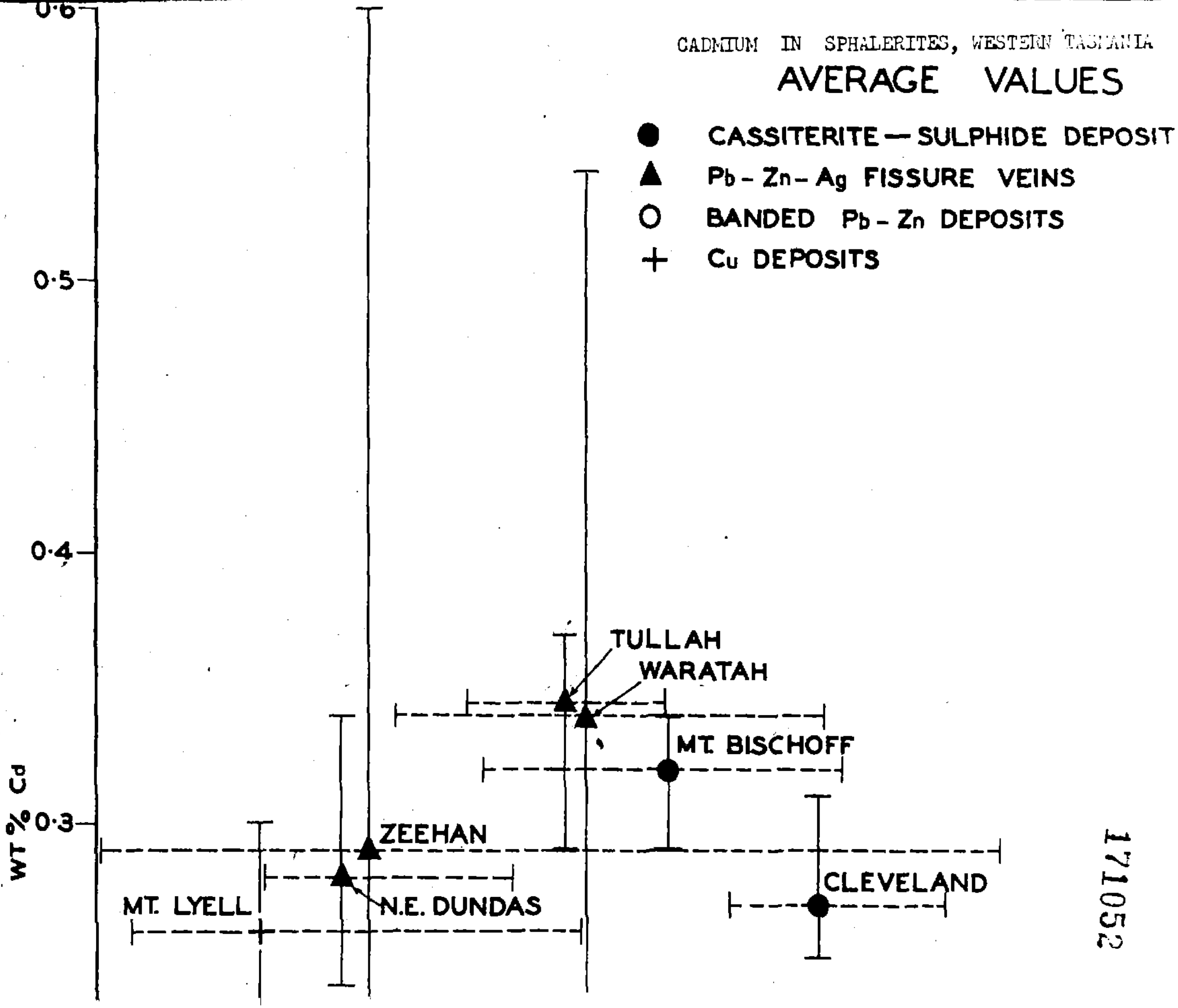
It is felt that the S:Se ratio of the Mt. Farrell ores is as yet not sufficiently diagnostic to be a useful indicator of ore genesis. It is not inconsistent with a volcanic origin for the ores.

Cadmium

The distribution of cadmium in sphalerites from ore deposits in Western Tasmania has been discussed by Groves and Loftus-Hills (1968). The distribution of Cd relative to Fe in these sphalerites is shown in Fig. 7 . Seven samples from the Mt. Farrell area have been analysed by Groves using X-ray fluorescence spectrography and the results are tabulated in Table 5.

TABLE 5: CADMIUM CONTENTS OF MT. FARRELL SPHALERITES

SPECIMEN NO.	Wt % Cd	Wt % Fe
New North Mount Farrell		
100035	0.29	5.5
100036	0.30	6.0
10523A	0.33	8.0
10523B	0.36	8.3
10528	0.36	
Murchison Mine		
11199	0.37	


CADMIUM IN SPHALERITES, WESTERN TASMANIA
AVERAGE VALUES
CASSITERITE — SULPHIDE DEPOSIT
Pb - Zn - Ag FISSURE VEINS
BANDED Pb - Zn DEPOSITS
Cu DEPOSITS
WT % Cd
0·6
0·5
0·4
0·3
TULLAH
WARATAH
MT. BISCHOFF
ZEEHAN
CLEVELAND
MT. LYELL
N.E. DUNDAS

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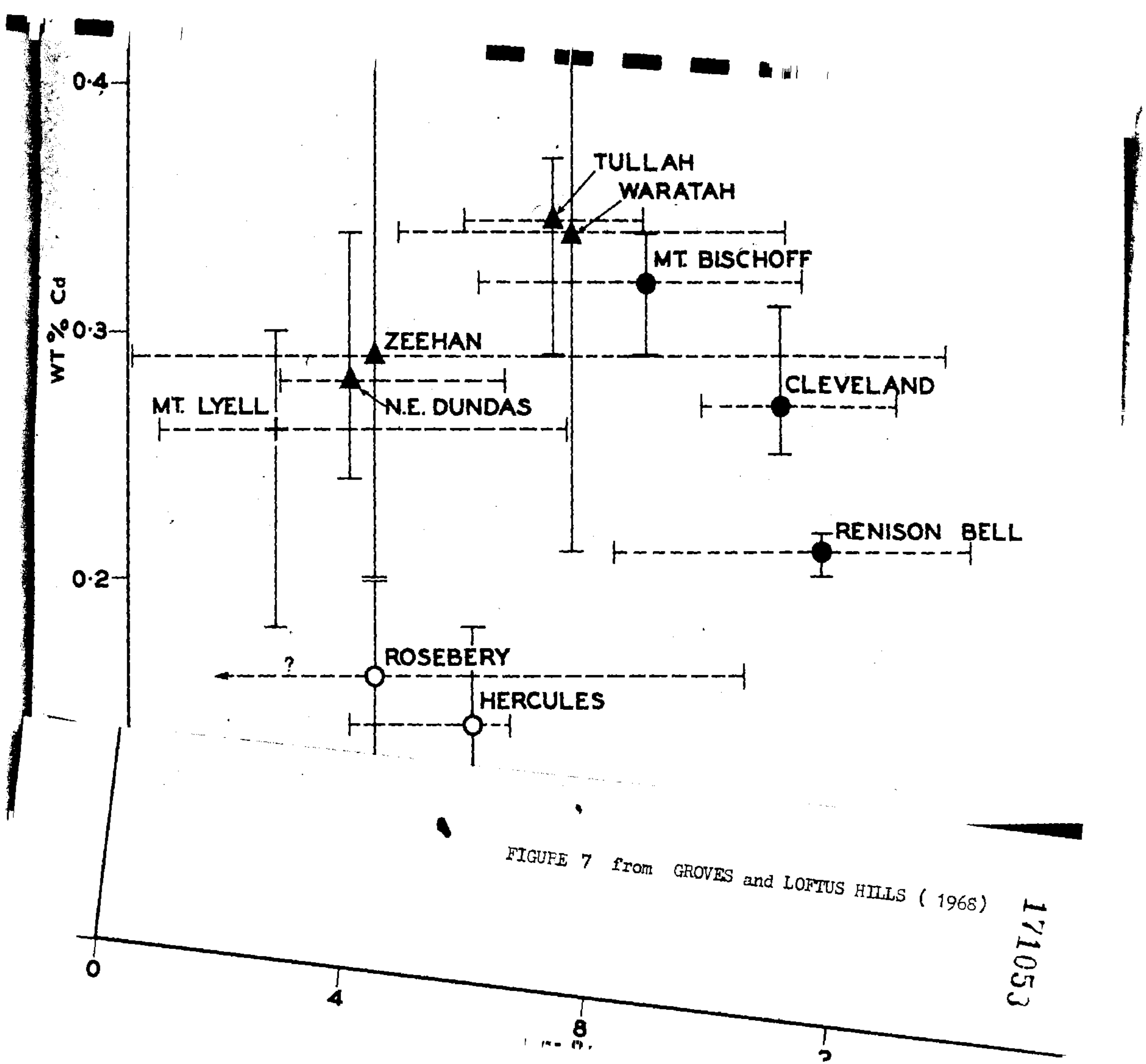

FIGURE 7 from GROVES and LOFTUS HILLS (1968)

Loftus-Hills (1968) has shown, using an F-test, that the Cd contents of sphalerite from Tullah and Magnet are similar, at the 95% level of confidence, to those for the Devonian Pb-Zn-Ag (around Mt. Bischoff) and cassiterite-sulphide deposits. There is a marked difference between the Cd content of sphalerites from ore deposits related to Devonian igneous activity and that from Rosebery-Hercules ore.

These preliminary results indicate that the Cd concentrations of Mt. Farrell sphalerites are more consistent with a Devonian granitic origin that with a volcanic (Cambrian) origin.

Conclusion

Sulphur and lead isotope and Co, Ni, Se and Cd trace element studies of Mt. Farrell sulphides present conflicting evidence for the genesis of these orebodies.

Solomon *et al.* (1968) have pointed out the possibility of a volcanic (Cambrian) origin for the sulphur and it appears that the Se may also have a similar history. The lead isotopes are anomalous; Richards (1967) has interpreted this as a result of local remobilization and mixing of the lead in at least two periods of tectonism. Trace element data for Co, Ni and Cd are more consistent with those trace element values obtained from deposits related to Devonian granitic activity.

In the present state of conflict between the different approaches to the problem of genesis, the writer hesitates to place emphasis on either possibility (volcanic or magmatic-hydrothermal) until more experimental data is available. There is a need for a criterion for assessing the relative validity and reliability of deductions from sulphur isotopic and from trace element methods.

ECONOMIC GEOLOGY.

MINERALISATION

The mineralisation in the Mt. Farrell district occurs in a five-mile belt from the Sterling Valley Mine to the New North Mount Farrell Mine. The ore deposits are largely confined to a narrow belt of cleaved and folded laminated mudstones, shales, tuffs and greywackes (the Farrell Slates of Hills, 1915B, part II) which strike NNW to NNE and dip steeply west at about 70°. The host rocks lie within keratophyres, quartz keratophyres, and pyroclastics (ignimbrites?) of the Cambrian Mount Read Volcaniccs.

The Farrell Slates from a narrow belt of highly cleaved and tightly folded rocks representing one limb of a pre-Ordovician fold (Solomon 1965, p. 490).

The ore deposits consist of steeply dipping lenticular fissure fillings of argentiferous galena, sphalerite, pyrite, chalcopyrite, marcasite, jamesonite, tetrahedrite and arsenopyrite with minor argentite and pyrargyrite in a gangue of carbonates (mainly siderite but restricted occurrences of ankerite e.g. Thomas' Blocks) and quartz. The orebodies are localised in NNW and NNE shears which follow Middle Devonian Tabberabberan trends and the lodes mainly appear to fill fractures. Solomon *et al.* (1968) consider that "some replacement of the wall rocks is apparent". The writer questions the validity of this statement. The lodes have a sharply defined (often slickensided) footwall with disseminated mineralisation passing into the hanging wall. The hanging wall mineralisation appears to work out into minor tensional cracks and joints roughly perpendicular to the main shears. Wall rock alteration is slight: examination of thin sections of slates and tuffs adjacent to the lodes did not reveal any significant changes in wall rock mineralogy towards the lode. Disseminated pyrite occurs close to the lodes distributed along cleavages and joints. It is texturally distinct from sedimentary pyrite (syngenetic, Hall *et al.*, 1953) but may represent recrystallised syngenetic pyrite produced by segregation.

The lodes are up to 300 feet wide, 250 feet long and average three to five feet in width. The oreshoots comprising the lodes have a general southerly pitch. The richest ore shoots occur (Hall *et al.*, 1953; Solomon, 1965b) at the intersections of the shears with tuff beds (e.g. Murchison Mine) and at intersections between shears. Hall *et al.* (1953) note that in the New North Mount Farrell Mine the best mineralisation occurs where minor branch fractures intersect the main fractures.

Brooks (1962) and Solomon (1965b) have differentiated two lode zones: the Murchison and Farrell. The Farrell lodes consist of early quartz and late siderite with the main ore minerals being pyrite, galena, sphalerite, chalcopyrite, jamesonite and tetrahedrite. The Murchison lodes contain more pyrite and arsenopyrite and less galena and siderite that the Farrell lodes as well as marcasite and pyrrhotite in small quantity.

The ore is generally unsheared but in places (New North Mount Farrell, Dutton's Workings, Murchison Extended) slickensided galena on the footwall and the presence of schistose galena and highly brecciated veins indicates that local post-ore movement has occurred on the shears.

MINE WORKINGS

NEW NORTH MOUNT FARRELL MINE

In the New North Mount Farrell Mine, two sub-parallel lenticular fissure lodes about 100 ft. apart are localised in Tabberabberan shears. Ore occurs over a strike length of 1,200 ft. (Hall, *et al.*, 1953). The orebody has been worked from nine underground levels to a depth of 900 feet. The main three compartment shaft extends from the surface to No. 7 level and a two compartment shaft, operated internally, connects Nos. 7, 8 and 9 levels.

Since 1934, the New North Mount Farrell Mine has produced 39,500 tons of lead, 4,287,600 ounces of silver, and 2,400 tons of zinc. The ore has averaged 15.5 per cent Pb, 16.8 oz/ton Ag, 2.5 per cent Zn and 0.5 per cent Cu, with the Ag:Pb ratio approximately 1:1 (Wilson, 1967).

The fissures, in which the lodes are developed, swing in strike from NNE to NNW and take a sinuous course. The lodes bifurcate frequently rejoin or some branches make out into the wall rocks and dip steeply to the west. The general strike of the lodes is about 10°, with a dip of 60-80°W.

The main or hangingwall lode strikes from 0° to 10° and dips at 65° to 80°W. Groves and Noldart (1964, p. 51) note that it comprises three main ore shoots which contain abundant argentiferous galena in places. Most of the production has been obtained from this lode. The most extensive of these ore shoots has a maximum level length of 400 feet, a plunge length of 700 feet, an average width of four to five feet and an overall plunge of 75°S (conforming to the genral southerly pitch

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Plate 13 : Quaternary fluvioglacial deposits Murchison River Bridge

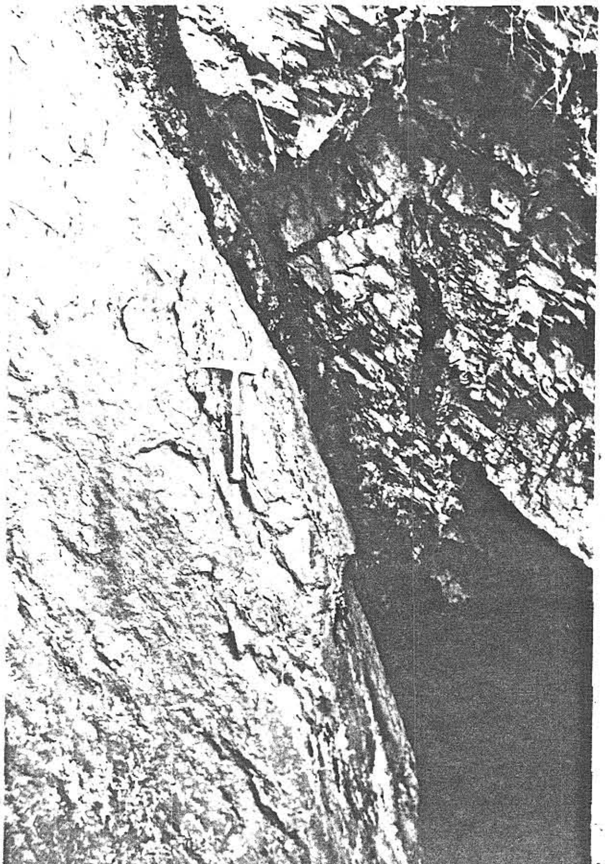

Plate 14 : Mineralised shear New North Mt . Farrell Mine .

of the Farrell lodes). The lode width is quite variable being up to 45 feet wide for a short distance at the intersection of the main and a branch lode.

The two smaller ore shoots of the main lode occurred south of the main shaft. The upper most shoot, stoped between the surface and No. 7 level had an average width of two feet and a plunge of 30°S. It had a maximum level length of 340 feet and was stoped over a plunge length of some 1100 feet. (Groves and Noldart, 1964, p. 51.) The third shoot was stoped from No. 5 to No. 8 level over a plunge length of 450 feet and plunges steeply south.

The footwall fissure subparallel to the main lode is predominantly mineralized by barren quartz. It dips at about 45°W above No. 4 level. Four small ore shoots in this quartz - footwall lode have been stoped to a maximum height of about 30 feet over a stope length of 150 feet on various levels.

NORTH MT. FARRELL MINE.

The lodes at the North Mt. Farrell Mine were worked from 1904 to 1933 from an open cut, four adit levels and ten underground levels. The underground levels to No. 9 level were connected by an internal three compartment shaft to No. 4 adit level. A three compartment shaft connecting Nos. 8 and 10 levels to the surface was sunk just prior to the closure of the mine. At present the workings are filled with water to the shaft collar and hence all the following details have been extracted from the literature.

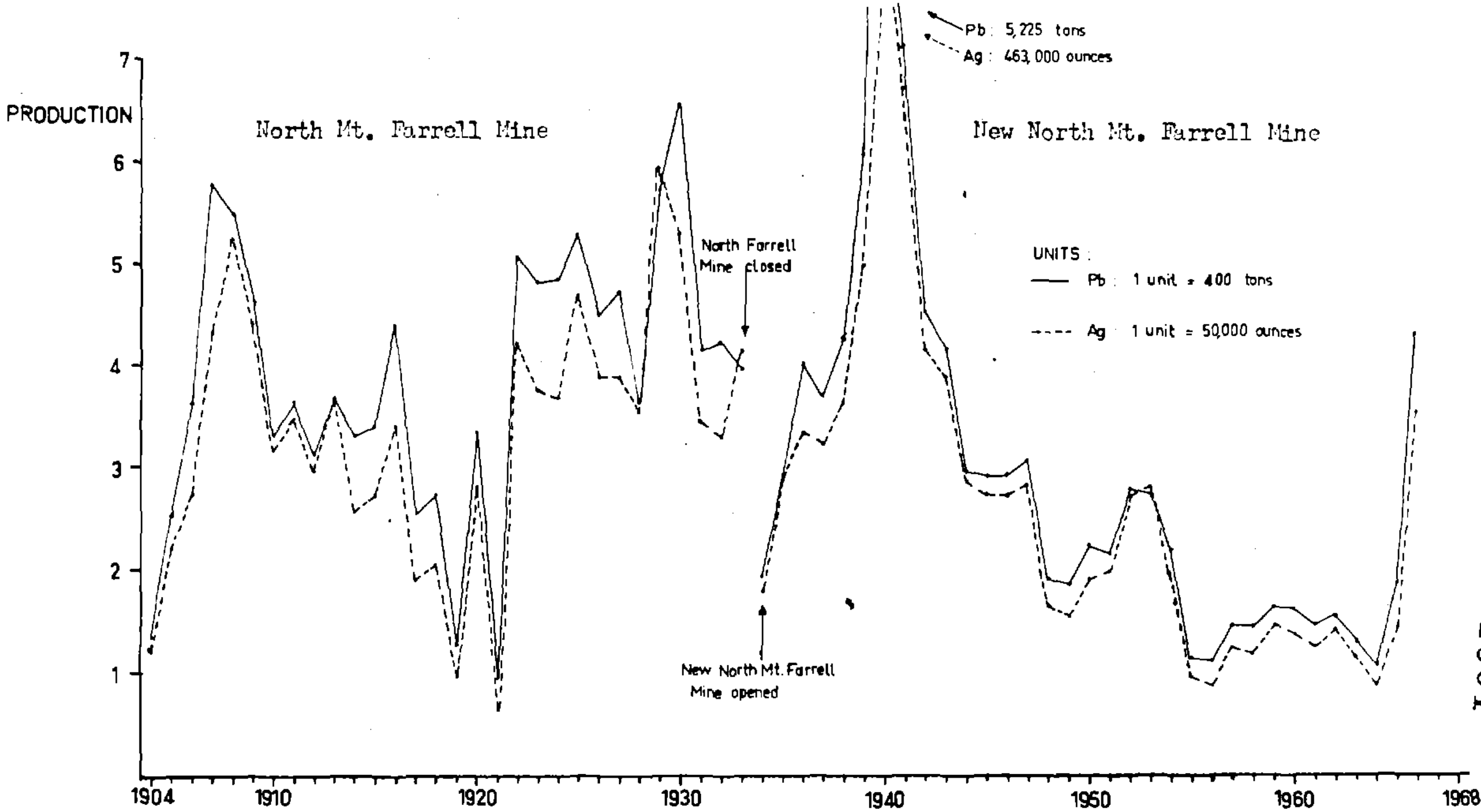

FIGURE 8 Ag and Pb production

A total of 46,600 tons of lead and 4,962,000 ounces of silver were recovered from crude ore mined and from retreated tailings. The ore grade determined from statistics compiled by Wilson (1967) averaged 9.13 per cent Pb and 9.47 ozs./ton Ag. The ore grade determined from tonnages given by Drew (1957) averaged 11.5 per cent Pb and 11.5 oz./ton Ag. Production figures are shown in Fig. 8

The main lode in the North Mt. Farrell Mine strikes approximately magnetic north and dips 60°W, the ore shoot pitching at 70°S (Jensen, 1959). It averaged about 4 feet in width. Three branch lodes were also worked above No. 6 level.

MURCHISON MINE

The Murchison Mine is situated 1.5 miles south of Tullah. The workings consist of an open cut, three adits and some trenches. The Murchison orebody is a lenticular fissure filling, consisting mainly of pyrite, arsenopyrite, galena, sphalerite, pyrrhotite and siderite, which strikes at 30° and dips almost vertically. Arsenopyrite and pyrite are abundant with galena and siderite less abundant in the Murchison lodes than in the Farrell lodes.

The sulphide mineralisation is confined to a shatter zone in a 50 ft. wide tuff bed enclosed within the Farrell Slates. The shatter zone is portion of a NNE tensional fault striking at about 15° and dipping vertically. The intersection of the steeply dipping fault and the tuff bed, which strikes north and dips 70°W, has produced a structural control resulting in an orebody with a dominant south pitch of 55°. The more favourable nature of the tuff as a host for sulphide mineralisation is observed elsewhere in the area (e.g. New North Mount Farrell).

STERLING VALLEY MINE

The Sterling Valley Mine is situated at the foot of the ridge between Mts. Murchison and Black at the head of the Stirling River. The workings consist of two adits close to the surface.

The mineralisation occurs (Whitten, 1950) in a zone striking 27° and dipping 70°E. The orebody is a fissure filling in sheared and contorted black graphitic slates with interbedded tuffs. Mineralisation is reported (Gregory, 1963) to occur over a width of up to 20 ft. The ore consists dominantly of galena and sphalerite with abundant pyrite and arsenopyrite, chalcopyrite and siderite in a quartz gangue. Quartz veins fill a fault zone and these veins contain segregations of sulphides, mainly pyrite, in shoots 20 to 50 feet in length (Reid, 1918).

The high grade mineralisation lies close to the footwall with sphalerite veins up to six inches wide in intimate association with galena. Galena occurs irregularly in the hanging wall rocks as much as ten feet from the lode proper (Reid, 1918, p. 112). The lode averages four ft. wide but varies greatly.

Diamond drill core intersections of the lode at depth were examined. There is no evidence of significant replacement of the wall rocks - the mineralisation being entirely confined to the fissure zone with little tendency to invade the wall rocks.

REFERENCES

BANKS, M.R., 1956: The Middle and Upper Cambrian Series (Dundas Group and its Correlates) in Tasmania. *in* El Sistema Cambrico 2, *20th Int. geol. Congr.*, 165-242.

BANKS, M.R., and SOLOMON, M., 1961: Cambrian Succession in West Tasmania. *Aust. J. Sci.*, 23, 337.

BARTON, P.B., and TOULMIN, P., 1966: Phase Relations involving sphalerite in the Fe-Zn-S system. *Econ. Geol.*, 61, 815-849.

BASTIN, E.S., 1950: Interpretation of Ore Textures. *Memoir Geol. Soc. Amer.*, 45,

BOUNSALL, E.J., 1961: The content of trace amounts of Ag in galena ores from Broken Hill. *Econ. Geol.*, 56, 608-611.

BRADLEY, J., 1954: The Geology of the West Coast Range of Tasmania.

1954 Part I: Stratigraphy and Metasomatism. *Pap. roy. Soc. Tasm.*, 88, 193-241.

1956 Part II: Structure and Ore Deposits. *Pap. roy. Soc. Tasm.*, 90, 65-129.

1957 Part III: Porphyroid Metasomatism. *Pap. roy. Soc. Tasm.*, 91, 163-190.

BROOKS, C., 1962: Geology of the Tullah Area. *Thesis, Univ. of Tas. (unpublished).*

CAMERON, E.N., 1961: Ore Microscopy. John Wiley and Sons, Inc., New York.

CAMPANA, B., 1961: Comment on the Note of Banks and Solomon. *Aust. J. Sci.*, 23, 339-340.

CAMPANA, B., DICKINSON, S.B., KING, D. and MATHESON, R.S., 1958:

171065

The mineralised rift valleys of Tasmania; *in* Stilwell Anniversary Volume, *Aust. Inst. Min. Metall.*, 41-60. (Discussion: *Proc. A.I.M.M.* 190, 125-137; 191, 191-202; 192, 33-39.)

CAMPANA, B. and KING, D., 1963: Palaeozoic tectonism, sedimentation and mineralization in West Tasmania. *J. Geol. Soc. Aust.*, 10 (1), 1-53.

CAMPANA, B., KING, D. and McKENNA, D., 1960: Unconformable Units of the Cambrian Succession of West Tasmania. *Aust. J. Sci.*, 22, 352-353.

CAREY, S.W., 1947: Report of the Government Geologist. *Rep. Dir. Min. Tasm.*, 1945, 22-27.

CAREY, S.W., 1953: The geological structure of Tasmania in relation to mineralization ; *in* Geology of Australian Ore Deposits. *5th Emp. Min. Metall. Congr.*, 1, 1108-1128.

DREW, B.J., 1957: Appraisal of the Farrell Mining Field, Tullah, Tasmania. *Rio Tinto Aust. Expl. Pty. Ltd. Rep.*, No. 2, 1957 *(Unpublished)*.

EDWARDS, A.B., 1943: The Composition of Lead-Zinc Ores at Captain's Flat, N.S.W.. *Proc. Aust. Inst. Min. Met.*, 129, 23-40.

EDWARDS, A.B., 1946: Solid Solution of Tetrahedrite in Chalcopyrite and Bornite. *Proc. Aust. Inst. Min. Met.*, 143-144, 141-155.

EDWARDS, A.B., 1947: Textures of the Ore Minerals.

EDWARDS, A.B., 1960: Contrasting Textures in the Ag-Pb-Zn ores of the Magnet Mine, Tasmania. *Neves Jb. Miner.* Abh. Bd. 94 H. 1, 298-318.

EDWARDS, A.B. and CARLOS, G.C., 1954: The Se content of some Australian sulphide deposits. *Proc. Aust. Inst. Min. Met.*, 172, 31-63.

FLEISCHER, Michael, 1955: Minor elements in some sulphide minerals. *Econ. Geol.*, 50th Anniversary Volume, 970-1024.

GREGORY, I.S., 1963: Final Report on the Testing of the Sterling Valley Mine, West Coast, Tasmania. *Rept. E.Z. Co. Aust. Ltd. (Unpublished).*

GROVES, D.I. and NOLDART, A.J., 1964: Geology of the Tullah Mining Field. *Tech. Rept. Dept. Mines Tasm.*, 9, 43-54.

HALL, G. and COTTLE, V.M., 1959: The Mineralized Rift Valleys of Tasmania. Discussion and Contributions. *Proc. Aust. Inst. Min. Met.*, 190, 125-131.

HALL, G., COTTLE, V.M., ROSENHAIN, P.B. and McGHIE, R.R., 1953: Lead-zinc deposits of Read-Rosebery and Mount Farrell Mines; *in* Geology of Australian Ore Deposits. *5th Emp. Min. Metall. Cong.* 1, 1145-1159.

HALL, G. and SOLOMON, M., 1962: Metallic mineral deposits. *in* Geology of Tasmania. *J. Geol. Soc. Aust.*, 9 (2), 285-309.

HENDERSON, Q.J. 1945: The Farrell Mining Co. Ltd. Mines. Tullah. *Rep. Dep. Min. Tas. (Unpublished).*

HILLS, C.L., 1915a: Preliminary Report on the Zinc-Lead Sulphide Deposits of the Rosebery District. *Tas. Geol. Surv. Rept.* 7.

____, 1915b: The zinclead sulphide deposits of the Read-Rosebery District.

Part I. Mount Read Group. *Bull. Geol. Surv. Tas.* 19.

Part II. Rosebery Group. *Bull. Geol. Surv. Tas.* 23.

HILLS, C.L., and CAREY, S.W., 1949: Geology and the Mineral Industry. *in* Handbook for Tasmania. *Aust. Ass. Adv. Sci.*, 21-44.

JENSEN, H.E., 1959: Examination of the Farrell Mining Company's properties at Tullah, Tasmania. *Rept. Rio Tinto Aust. Expl. Pty. Ltd.* No. 20/1959. *(unpublished)*

LOFTUS-HILLS, G.D., 1967: Cobalt and Nickel in Tasmanian Pyrites. *in* Geology of Western Tasmania, *Symposium, Univ. of Tas., Hobart.*

LOFTUS-HILLS, G. and SOLOMON, M., 1967: Cobalt, Nickel and Selenium in Sulphides as Indicators of Ore Genesis. *Mineralium Deposita* 2, 228-242.

McDOUGALL, I. and LEGGO, P.J., 1965: Isotopic age determinations on granitic rocks from Tasmania. *J. Geol. Soc. Aust.*, 12, 295-332.

NOLDART, A.J., 1963: Notes on future exploration, Mt. Farrell Lodes, Tasmania. *Rep. Dep. Min. Tas. (unpublished).*

NYE, P.B., 1931: The Tribute at North Mount Farrell, Tullah. *Rep. Dep. Min. Tas. (unpublished).*

OELSNER, O., 1961: Atlas of the most important ore mineral parageneses under the microscope. Pergamon Press, Leipzig.

OSTIC, R.G., RUSSELL, R.D. and STANTON, R.L., 1967: Additional Measurements of the Isotopic Composition of Lead from Stratiform Deposits. *Can. J. Earth Sci.*, 4, 245-269.

RAMDOHR, P., 1960: Die Erzmineralien und Ihre Verwachsungen. Akademie Verlag, Berlin.

RAFTER, T.A. and SOLOMON, M., 1967: Sulphur Isotope and Oxygen Isotope Studies of Tasmanian Ore Deposits. *in* Geology of Western Tasmania, *Symposium, Univ. of Tas., Hobart.*

REID, A.M., 1918: The North Pieman, Huskisson and Sterling Valley Mining Fields. *Bull. Geol. Surv. Tas.* 28.

REID, A.M., 1927: Supplementary report on some mines in Mt. Farrell District. *Rep. Dep. Min. Tas. (unpublished).*

RICHARDS, J.R., 1967: Lead Isotopes and Geochronology. *in* Geology of Western Tasmania, *Symposium, Univ. of Tas., Hobart.*

RICHARDSON, L.A., 1951: Geophysical Survey of Mackintosh Area, Tullah. *E.Z. Co. Rept. (unpublished).*

SCHOUTEN, C., 1962: Determination Tables for Ore Microscopy. Elsevier Publishing Co., Amsterdam.

SCOTT, Beryl, 1954: The metamorphism of the Cambrian Basic volcanic Rocks of Tasmania and its relationship to the Geosynclinal environment. *Pap. roy. Soc. Tasm.,* 88, 129-149.

SCOTT, J.B., 1929: The New Stirling Valley Mine, Murchison District. *Rept. Sec. Mines. Tasm. (unpublished).*

SCOTT, J. B., 1929: Notes on Tin Bearing Quartz Lodes, Mt. Murchison District. *Rept. Dep. Mines Tasm. (unpublished).*

SMITH, A.W., 1964: Remobilization of Sulphide Orebodies. *Econ. Geol.*, 59 (5), 930-935.

SOLOMON, M., 1958: Report on Regional Mapping, Western Tasmania. *Rept. Rio Tinto Aust. Exp. Pty. Ltd.* 80/20 *(unpublished).*

SOLOMON, M., 1962: Tectonic History of Tasmania. *in* Geology of Tasmania, *J. Geol. Soc. Aust.,* 9 (2), 311-339.

SOLOMON, M., 1964: The spilite - keratophyre association of West Tasmania and the ore deposits at Mt. Lyell, Rosebery and

and Hercules. *Ph. D. Thesis, Univ. of Tas. (unpublished).*

SOLOMON, M., 1965: Geology and mineralization of Tasmania. *Proc. 8th Comm. Min. Metall. Congr.*, 1, 464-477.

SOLOMON, M., 1965: Lead-Silver-Zinc Ore Deposits at Mt. Farrell. *Proc. 8th Comm. Min. Metall. Congr.*, 1, 490.

SORENSON, A.H., 1963: A re-examination of some suggested mechanisms for remobilization of sulphide orebodies. *Econ. Geol.*, 58 (7), 1071-1088.

SPRY, A. and BANKS, M.R., 1962: The Geology of Tasmania. *J. Geol. Soc. Aust.*, 9 (2).

STANTON, R.L., 1955: The composition of some Pb-Zn ores from Wiseman's Creek, N.S.W.. *Proc. Aust. Inst. Min. Met.*, 176, 37-46.

STANTON R.L., 1957: Studies of Polished Surfaces of Pyrite and some implications. *Can. Min.*, 6, 87-118.

STANTON, R.L., : Mineral interfaces in stratiform ores. *Bull. Inst. Min. Metall.*, 74 (11), 807-811.

STANTON, R.L. and RUSSELL, R.P., 1959: Anomalous leads and the emplacement of lead sulphide ores. *Econ. Geol.* 54 (4), 588-607.

TATE, K.H., 1958: Geophysical Survey at the Mt. Farrell Mine, Tullah, Tasmania. *Rec. Bur. Miner. Resour. Aust.*, 35/1958. *(unpublished).*

TWELVETREES, W.H., 1901: Report on the Mount Farrell District. *Rept. Sec. Mines. Tas. for* 1900-01.

TWELVETREES, W.H. and PETTERD, W.F., 1899: On the Felsites and associated rocks of Mt. Read and vicinity. *Rept. Sec. Min. Tas. for* 1898-1899, XXIX-XXXII.

UYTENBOGAARDT, W., 1951: Tables for Microscopic Identification of Ore Minerals Princeton University Press, Princeton, New Jersey.

WALLER, G.A., 1904: Report on the Mt. Farrell Mining Field. *Rept. Dep. Min. Tas.*.

WARD, L.K., 1908: The Mount Farrell Mining Field. *Bull. Geol. Surv. Tas.* 3.

WHITHAM, C., 1949: Western Tasmania.Sticht Memorial Library, Queenstown.

WHITTEN, G.F., 1947a: First Report on the Murchison Mine, Silver-Lead-Zinc, Mount Farrell. *Rept. E.Z. Co. Aust. Ltd. (unpublished)*.

WHITTEN, G.F., 1947b: Second Report on the Murchison Mine, Silver-Lead-Zinc, Mount Farrell. *Rept. E.Z. Co. Aust. Ltd. (unpublished)*.

WHITTEN, G.F., 1948: First Report on Dutton's Workings, Silver-Lead, Mount Farrell. *Rept. E.Z. Co. Aust. Ltd. (unpublished)*.

WHITTEN, G.F., 1950: First Report on Thomas' Blocks and Pennefathers' Prospect, Lead-Zinc and Silver, Sterling Mine Area. *Rept. E.Z. Co. Aust. Ltd. (unpublished)*.

WILLIAMS, K.L., 1960: Some less common minerals in the Rosebery and Hercules Zn-Pb ores. *Proc. Aust. Inst. Min. Met.*, 196, 51-59.

WILSON, D.J., 1967: Preliminary Investigations into Future Exploitation of the Mount Farrell Mine. *Rept. E.Z. Co. Aust. Ltd. (unpublished)*.

PAPERS IN PRESS

GROVES, D.I. and LOFTUS-HILLS, G.D., 1968: Cadmium in Tasmanian Sphalerites. *Proc. Aust. Inst. Min. Met.*

LOFTUS-HILLS, G.D., 1968: Cobalt, Nickel and Selenium in Tasmanian Ore Minerals. *Ph.D. Thesis, Univ. of Tasmania.*

SOLOMON, M.; RAFTER, T.A. and JENSEN, M.L., 1968: Isotope Studies on the Rosebery, Mount Farrell and Mount Lyell Ores, Tasmania. *Econ. Geol.*

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APPENDIX

Trace Element and Isotopic Data

TABLE 1: Summary of Trace Element Data

Mount Farrell Area+

UNIV. TAS. SAMPLE NO.	Mineral	Co1	Ni1	Co2	Ni2	Co/Ni	Se	Se/S*	REMARKS
A. Veins in Cambrian mudstones, Sterling Valley Mine, No. 1 Level Adit Dump.									
100649A	Pyrite	9	37	9	36	0.25			Brecciated veins in slate
100649B	Arsenopyrite	33	41	30	38	0.81			
100650A	Pyrite	488	1247	478	1221	0.39			
100560B	Pyrite	356	1453	345	1408	0.24	81	15.17	
B. Vein in Mount Read Volcanics, Tullah Silver-Lead, Upper No. 1 Adit Dump.									
100651	Pyrite	449	530	375	443	0.85			
C. Veins in Cambrian mudstones and tuffs, Murchison Mine, No. 2 Level.									
100528	Pyrite	11	7	8	5	1.69			
D. Veins in Cambrian mudstones and slates, New North Mount Farrell Mine.									
10438C	Chalcopyrite						17	4.86	
10523A	Chalcopyrite						321	91.71	9 Level
10523B	Sphalerite						10	3.03	
10730	Chalcopyrite						6	1.71	8 Level
100035	Sphalerite						15	4.55	
100036	Sphalerite						0	0.00	
100645	Pyrite	29	283	28	267	0.10			7-9 Levels from Dump
100646	Pyrite	80	804	78	779	0.10	23	4.31	
100647	Pyrite	29	243	28	236	0.12	32	5.99	
100648	Pyrite	72	861	70	835	0.08			

\+ Analysed by G. Loftus-Hills be Techtron AA3 atomic absorption spectrophotometer (see Loftus-Hills and Solomon, 1967, p. 234).

* Se/S = (Se ppm x 10^5) % S.

TABLE 2: Sulphur Isotopic Composition of Sulphides from Mount Farrell+

LOCALITY, UNIV. TAS. SAMPLE NO.	DETAILS	$\delta^{34}S$ values w.r.t. meteoritic sulphur*			
		Pyrite	Sphalerite	Chalcopyrite	Galena
New North Mt. Farrell Mine					
10429	Coexisting sphalerite and chalcopyrite. 9 level.		16.5	16.2	
10430	Coarse crystals of galena. 9 level				13.2
10434	" " "				13.2
10431	" 8 level				13.5 13.3
10436	" 7 level				13.8
10438	Coexisting chalcopyrite and galena pairs			15.3 15.6	13.7 13.0
10522	Sphalerite 4 level		14.0		
101066	Galena with 0.25% ZnS. Sphalerite with 0.5% PbS. 8 level		17.0		13.7
101067	Galena with 1.3%ZnS Sphalerite with negligible PbS, 9 level		16.6		14.2
Sterling Valley Mine					
10526	Sphalerite. Surface dump		13.9 13.7 14.4		
10527	" "		14.2±0.2		
Murchison Mine					
10528	Sphalerite, 2 level		10.0±0.2		
11198	Pyrite in open cut	9.6			
11199	Sphalerite in open cut		10.2		

TABLE 2: Sulphur Isotopic Composition of Sulphides from Mount Farrell+
(cont'd.)

LOCALITY, UNIV. TAS. SAMPLE NO.	DETAILS	$\delta^{34}S$ values w.r.t. meteoritic sulphur*			
		Pyrite	Sphalerite	Chalco-pyrite	Galena
Murchison Granite					
11211	Pyrite disseminated in granite. HEC, DH 6630 at 235 feet	8.1 7.9			
11212	" HEC, DH 6639 at 204 feet	8.6			

\+ Analyses made by Jensen in 1965 and Rafter in 1966-68. Table compiled from Rafter and Solomon (1967) and Solomon, Rafter and Jensen (in preparation).

* Accuracy ±0.1, unless otherwise stated; referred to Canon Diablo meteorite standard.

TABLE 3: Sulphur Isotopic Composition in Co-existing Sulphides from the New North Mount Farrell Mine.+

UNIV. TAS. SAMPLE NO.	DETAILS	$\delta^{34}S$ values w.r.t. meteoritic sulphur*			$\delta^{34}S_{ZnS} - \delta^{34}S_{PbS}$	ISOTOPIC EQ. TEMP. °C.
		Sphalerite	Galena	Chalco-pyrite		
10429A	Level 9, sphalerite chalcopyrite and galena adjacent	16.5		16.2		
10438	Co-existing chal-copyrite and galena		13.7 13.0	15.3 15.6		
101066	Level 9, galena with about 0.25% ZnS		13.7 (?)			
					2.3(??)	332 (?)
101066	Level 9, sphalerite with 0.5% PbS	17.0 (?)				
101067	Level 9, galena with about 1.3% ZnS		14.2			
					2.4	343
101067	Level 9, sphalerite with negligible PbS	16.6				

\+ Analysis carried out by T.A. Rafter, Institute of Nuclear Sciences, DSIR, New Zealand.
* Accuracy ± 0.1; referred to Cañon Diablo meteorite atandard.