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TASMANIA
DEPARTMENT OF MINES

GEOLOGICAL SURVEY
EXPLANATORY REPORT

ONE MILE GEOLOGICAL MAP SERIES

K'55-5-50

ZEEHAN

by

A. H. BLISSETT

Issued under the authority of
The Honourable ERIC ELLIOTT REECE, M.H.A.,
Minister for Mines for Tasmania



1962

L. G. SHEA, Government Printer, Tasmania.

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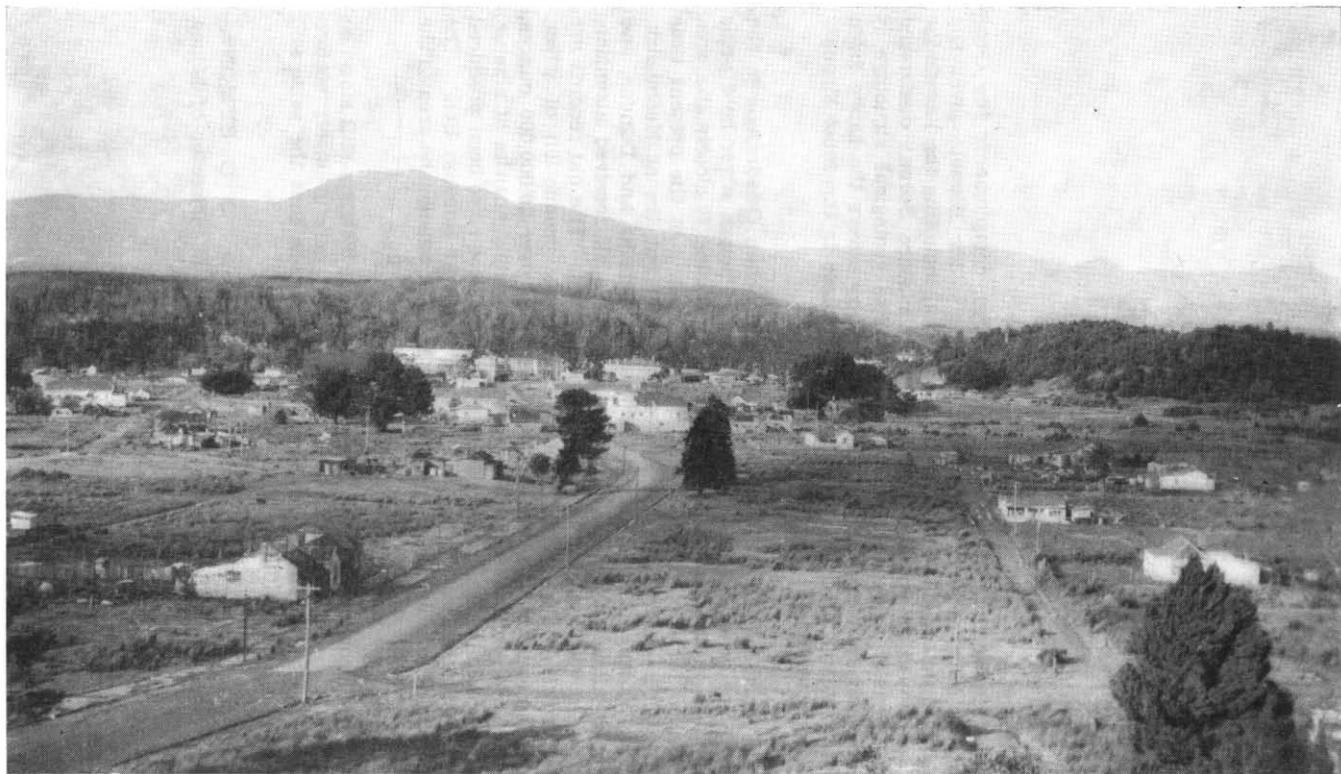
PREFACE

This Report, the second of the series, complements the Geological Map of the Zeehan Quadrangle. Mr Blissett gives the present picture of geological interpretation, including the knowledge acquired painstakingly by many workers since Sprent discovered tin in 1876 in the Heemskirk area. The geological structure is extremely complicated and the stratigraphy covers the range from Proterozoic to Recent, though the Palaeozoic is the most strongly represented period.

The most important feature of the Zeehan Quadrangle is the emphasis on mining and mineralization. Though silver held pride of place in the past with tin and lead pressing it closely the area is noted for the variety of minerals present. At the present time interest is centred on tin at Renison Bell but tin at Heemskirk, silver-lead at Zeehan, Comstock (South Zeehan) and Dundas, and copper-nickel at the Five Mile (Cuni) have all received attention, together with many minerals in other places. The old records are incomplete, but reliable estimates place the production of silver, lead and tin for the whole Quadrangle at over 29,000,000 ounces, 220,000 tons and 4300 tons respectively. Small quantities of arsenic, asbestos, cadmium, copper, gold, nickel and zinc have been produced also. The major product at present is tin at Renison Bell. The important mining district of Rosebery lies just outside the area to the NE.

The problems of Zeehan and surrounding districts still stand as a challenge to the mining industry—much careful interpretation and search remains to be done but it is certain that the prize still remains to be claimed.

J. G. SYMONS,
Director of Mines.



Zeehan in 1962. (Mt Dundas in the distance).

CONTENTS

	Page
INTRODUCTION and ACKNOWLEDGMENTS	7
LOCATION and COMMUNICATIONS	8
PHYSIOGRAPHY and GEOGRAPHY	9
HISTORY OF EXPLORATION and DEVELOPMENT	14
GEOLOGY	17
Proterozoic System	20
Cambrian System	25
1. Crimson Creek Formation	26
2. Dundas Group	31
3. Mt Read Volcanics	41
4. Probable Cambrian Rocks	42
Cambrian Sedimentation	42
Cambrian Ultrabasic and Basic Intrusions	44
Ordovician System (June Group)	48
Silurian and Devonian Systems (Eldon Group)	62
Tabberabberan Orogeny	66
Devonian Granitic Intrusions	67
Pre-Permian Erosion Surface	70
Permian System	72
Jurassic Dolerite	74
Cainozoic Rocks	75
STRUCTURAL GEOLOGY	77
ECONOMIC GEOLOGY	86
SUMMARY OF MINERALS IN THE ZEEHAN QUAD- RANGLE	88
MINES AND PROSPECTS	93
1. Tin	93
The Heemskirk Tinfield	93
The Renison Bell Tinfield	114
Exe River District	123
Dundas	127
Zeehan	128
Miscellaneous Tin Prospects	129
2. Silver-Lead	130
Zeehan Area	130
South Zeehan	193
North Zeehan	212
Dundas District	216
Crimson Creek District	227

	Page
3. Copper-Lead-Silver	232
4. Axinite-Sulphides	243
5. Copper-Nickel	246
The Five Mile (or Cuni) District	246
Trial Harbour District	251
6. Asbestos	251
7. Iron	253
8. Miscellaneous Ores	255
TOTAL PRODUCTION OF THE ZEEHAN QUAD- RANGLE	257
BIBLIOGRAPHY	258

FIGURES

	Page
1. Locality Map	6
2. Solid Geology—Zeehan Quadrangle	18
3. Generalized Stratigraphical Column—Zeehan Quadrangle	19
4. Dundas Group—Huskisson River	37
5. Geological Map—Misery Hill Area	54-55
6. Facies in Ordovician Deposition	61
7. Structural Geology—Zeehan Quadrangle	79
8. Federation Mine—South Heemskirk	99
9. Maynes and Kelvin Mines	105
10. Geology—Renison Bell Area	115
11. Section through Battery Mine	117
12. Montana Silver-Lead Mine	133
13. Sketch Plan—Comstock and South Comstock Mines	196
14. Proterozoic to Upper Cambrian—Zeehan Quadrangle	} in folder at back
15. Detailed Geology—Zeehan Area	
16. Geological Sections—Zeehan Quadrangle	}
17. The Five-Mile Copper-Nickel Deposits—Detailed Geological Plan	

PLATES

Zeehan in 1962	Frontis- piece
1. View looking towards Dundas from N of Zeehan	} Back of Book
2. Hills of Proterozoic quartzite	
3. Metamorphosed Silurian Amber Slate	
4. Cleaved Devonian Florence Quartzite	
5. Mt Dundas from Misery Hill	
6. E side of Mt Dundas	
7. Mt Zeehan Conglomerate	
8. Moina Sandstone	
9. The Henty Surface	
10. Glacial Till near Henty Bridge	
11. Site of the old town of Ringville	

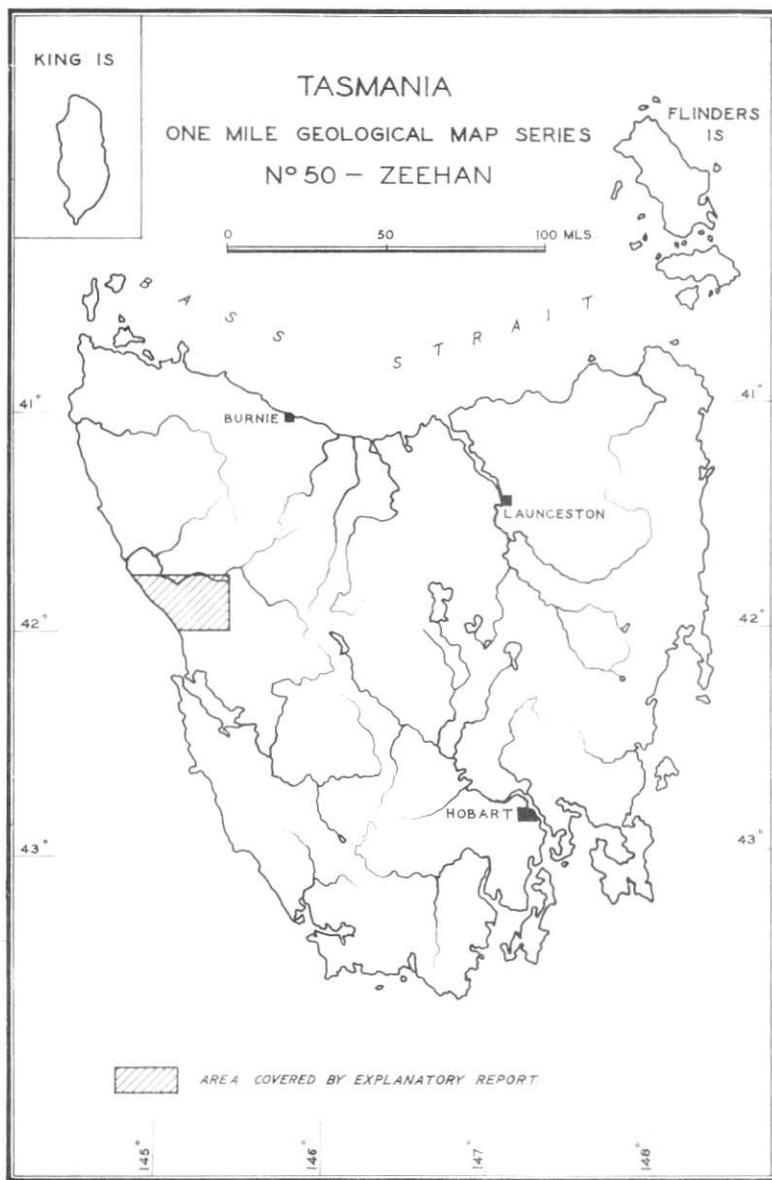


FIGURE 1.—Locality Map.

INTRODUCTION & ACKNOWLEDGMENTS

This Report describes the physiography, geology and mineralization of the Zeehan Quadrangle (1" : 1 mile Geological Sheet No. 50), which covers about 350 sq miles of the West Coast round Zeehan. Since tin was discovered in 1876 and silver-lead in 1882, many geologists have reported on mines and prospects within the area. In particular, during the past 15 years, a considerable amount of mapping has been carried out on different problems, so that there is a vast amount of literature (listed in the Bibliography) to which reference is made in the relevant chapters. This information forms a firm basis for the present regional survey and has simplified the task of attempting to work out the complicated stratigraphy and structure in an area notorious for its heavy rainfall, dense bush and limited exposures. As most of the abandoned mines are now inaccessible, old records which give details of underground workings have been of great assistance.

Field work was carried out between September 15th, 1958 and April 10th, 1961. Mapping was done on aerial photographs on a scale of 1" : 20 chains (4" : 1 mile) and boundaries were transferred to 1" : 20 chain dyelines produced by the Department of Lands and Surveys. During the survey, 20 camps were installed, including 13 by helicopter in the more inaccessible parts of the Quadrangle. By this means, it was possible to map previously unknown ground, in addition to making a systematic re-examination of areas previously mapped in varying degrees of detail and accuracy.

A number of new fossiliferous Cambrian localities were found near Dundas, Henty River, and Trial Harbour. On the Huskisson River a dendroid was discovered in proved Upper Cambrian shale. A modified Proterozoic-Cambrian succession is suggested, and new exposures of Ordovician and Silurian rocks near Duck Creek and SE of Trial Harbour described. A study has been made of the complex structural pattern, particularly that controlling mineralization, and recommendations made as guides to future exploration. Thanks are due to my colleague, Mr A. B. Gulline, for valuable assistance throughout the course of the survey, and to Mr R. P. B. Pitt, honours student of geology in the University of Tasmania, who acted as a field assistant from December 2nd, 1958 to March 6th, 1959, and who assisted on the mapping during vacations in 1960. Student field assistants who also helped during the long vacations were T. Doe, D. Groves, B. Mack and J. Tate. Other field assistants at various periods included K. Billett, J. Dillon, D. Fisher, T. W. Johnstone, D. Swan and W. Whellum.

The friendly co-operation of the management and staff of the various mines was appreciated and I am grateful for permission to publish information concerning their workings. In particular I am indebted to Messrs R. R. McGhie, J. Gilfillan and A. Mackenzie of Renison Associated Tin Mines, N.L., and Mr W. J. Hodge of the Razorback mine.

Mr K. Kendall, Senior Draughtsman in the Department of Mines, Hobart, supervised preparation of the final drafts of maps, plans and sections produced by the Drawing Office Staff.

LOCATION & COMMUNICATIONS

Map Sheet No. 50, centred on the township of Zeehan, covers the part of the West Coast of Tasmania lying between the sea and the Dundas Range. The coast line extends from Hoyle Creek in the north, about 5 miles north of Granville Harbour, to a point near the mouth of Badger River in the south. One of the major West Coast rivers, the Pieman, winds across the northern part of the quadrangle. Rosebery lies 2 miles east of the NE corner, and Queenstown is about 9 miles SE of the southern margin.

The only permanent settlements are Zeehan, with a population of 808*, and Renison Bell with 106*. In the former town of Dundas, which once had 2000 inhabitants, there is now only one house. There are a number of week-end shacks at Trial Harbour (the site of the old settlement of Reminé) and at Granville Harbour.

Zeehan is about 4 miles west of the main graded road from Queenstown to Renison Bell and Rosebery, and is connected to it by a branch road which turns off 20 miles north of Queenstown. From Zeehan, gravel roads lead south to the Oceana mine, west to Trial Harbour and NW towards Granville. The last named can be used for all vehicles for about 8 miles, after which the track follows the line of the old Granville tram and is suitable only for those with 4-wheel drive. It is used as a stock route to the Granville Estate, about 1 mile east of Granville Harbour, and by prospectors working on the North Heemskirk alluvial tin field. A foot-track leads north from North Heemskirk towards Corinna. In recent years the Zeehan Progress Association has constructed a gravel road along the coast from the Trial Harbour road to Granville Harbour. A track, negotiable by jeep or landrover, was bulldozed by the Department of Mines a few years ago from the North Heemskirk road north to a cage-crossing over the Pieman River, near the mouth of the Stanley River. A similar track cut by the Hydro-Electric Commission runs north from the North Heemskirk road on Eureka Plains to their camp and cage-crossing over the Pieman River.

Other minor roads or tracks shown on the map provide access to mines or prospects, for example the road to Dundas, and thence to the Razorback mine and the old Comet mine, which turns east off the Queenstown-Rosebery road 1 mile north of the Zeehan road junction. Forestry tracks cut through thick bush, particularly on the rugged flanks of Mt Dundas, are a great help to the geologist.

Former mineral tramways which served scattered mines are sometimes accessible by jeep. The most important are the North-East Dundas Tram between Zeehan and Williamsford, which crosses Confidence Saddle north of Carbine Hill, and part of Dunkley's tram north of Zeehan.

The Emu Bay Railway connects Zeehan with Burnie on the North-West Coast 88 miles to the north. The railway service from Zeehan to Strahan was discontinued in 1960 and the line is at present only used for the haulage of timber from Firewood Siding. A timber tram operated by R. J. Howard Pty. Ltd. runs from the Queenstown road near Farrell Rivulet eastwards over a long forested southern spur of Mt. Dundas.

* 1954 Census.

PHYSIOGRAPHY AND GEOGRAPHY

GENERAL

The Zeehan region is mountainous and reflects the influence of recent vigorous stream erosion on a complex terrain of variable folded sedimentary and igneous rocks ranging in age from Proterozoic to Tertiary. There is evidence of a pre-Permian erosional surface and at least one in Tertiary times, later subjected to faulting and subsequent dissection, which have played an important role in the shaping of the topography.

The highest point is Mt Dundas which rises to 3750 feet on the western edge of the Read-Dundas Plateau about 6 miles east of Zeehan. West of Zeehan, the Heemskirk Range covers a roughly circular area of about 35 square miles, with a number of peaks over 2500 feet, including Mt Agnew (2769 ft) and Mt Heemskirk (2450 ft). Mt Zeehan is a monadnock, 2300 feet high, about 3 miles south of Zeehan. A range of hills extends NW from the Plateau north of Mt Dundas between Dundas and Renison Bell and includes Carbine Hill (2350 ft) and Commonwealth Hill (2200 ft). Other hills are Mt Razorback (1900 ft), the Professor Range (1350 ft) and Misery Hill (1200 ft).

Relief is most marked on the western and NW edges of the Read-Dundas Plateau, where streams may fall 1000 feet in less than $\frac{1}{2}$ mile, with many waterfalls and rapids, and characteristic steep wooded ridges between the creeks. North and NW of Zeehan, the Tertiary surface is being dissected deeply by tributaries of the Pieman River which have formed rolling hills rising up to about 1600 feet, sometimes capped by patches of Tertiary gravel. In the south and west, relief is largely controlled by major folds in Ordovician, Silurian and Lower Devonian rocks truncated by a Tertiary erosional surface. Differential weathering led to the development of typical hogback ridges and cuestas, particularly in the Keel Quartzite. The swampy buttongrass flat at about 600 feet above sea level east of Zeehan is a local base-level for the upper reaches of the Little Henty River and its tributaries, and may represent part of a Tertiary surface blanketed by older alluvium. Recent uplift is indicated by the present down-cutting by the Little Henty here and the formation of recent alluvium.

Since Pleistocene times, the Pieman River has cut down 300 feet below glacial deposits north of Renison Bell, while on the coast north of Granville Harbour there are raised beaches up to about 60 feet above present sea level, typical of an emerged shoreline.

STRUCTURAL CONTROLS OF RELIEF

During the Tabberabberan Orogeny the Proterozoic to Lower Devonian formations were intensely folded along north-westerly axes, with warping to a nearly westerly trend west of Mt Zeehan and at Duck Creek, and in a roughly N-S direction in the east. Cross-folding separated the Zeehan and Huskisson Synclines and produced a complex pattern of plunging minor folds, sometimes with reversal of pitch. The effects on relief are therefore variable and complicated by intense faulting, of both Devonian and post Jurassic age.

The Proterozoic rocks which consist largely of rapid alterations of quartzite and slate or shale usually behave in a homogenous manner, except where thicker hard quartzite forms

resistant strike ridges, or depressions are eroded in the finer sediments and along shear zones. The Cambrian rocks have a similar effect, with a more pronounced control in the Middle to Upper Cambrian where a number of massive breccia-conglomerates are separated by greywacke, siltstone and shale. The Razorback Conglomerate is a hard chert conglomerate capping Mt Razorback, a prominent strike ridge, and similar ridges may be seen along the North-East Dundas Tram. However, some greywacke-conglomerates are susceptible to weathering, so that indurated siltstone and argillite occasionally form well-marked ridges rising above the eroded conglomerate.

Mt Zeehan displays the prominent relief produced by a thick development of Ordovician Owen Conglomerate. The conglomerate is coarse and siliceous and, with the overlying Moina Sandstone, has been folded into a NW trending anticline with E-W warping in the NW and SE. On Mt Professor, the conglomerate is finer and forms a NW trending angular ridge, while Misery Hill is a similar ridge of steeply dipping coarse but thin conglomerate overlain by Moina Sandstone. In contrast, the Owen Conglomerate south of the Little Henty River about 3 miles SW of Mt Zeehan has been peneplaned into a gently undulating plateau.

Strong control of topography by folds is shown by the Gordon Limestone and the thick alternation of quartzite and shale in the Silurian-Lower Devonian sequence at Zeehan, and to the south and SW. The limestone invariably weathers into low swampy flats near the watertable and is rarely exposed. The succeeding Crotty Sandstone can be recognized by broad sinuous ridges separated from the characteristic steep and narrow hog-back ridges of Keel Quartzite by a depression eroded in the Amber Slate. The Florence Sandstone forms another broad rounded ridge, while the Bell Shale occupies lower ground in the cores of the synclines. More resistant bands of quartzite or siltstone are marked by low ridges.

After Carboniferous peneplanation, Permian tillite, mudstone, arkose and pebbly grit were laid down. In the SW of the Quadrangle, they are overlain by the remains of a Jurassic dolerite sill, and have been tilted to the SW. Cuestas of pebbly grit and quartzose conglomerate trending NW have been partly modified by a late Tertiary surface.

Effect of igneous rocks

Ultrabasic Rocks.—There are a number of intrusive sills or large dykes of gabbro and pyroxenite which weather into craggy hills or ridges, for example on Serpentine Hill which reaches a height of a little over 1300 feet near the Argent Tunnel, south of Renison Bell. The pyroxenite is often serpentinized, and where alteration is almost complete, it is marked by undulating swampy flats such as in the Melba valley and the valley east of the Razorback mine.

Granite.—The rugged Heemskirk Range is composed of a core of granite intruded into Proterozoic or Lower Cambrian quartzite and slate and topography is influenced by prominent joint or fault planes which have also modified the drainage pattern. A quartz-porphry sill or dyke caps Pine Hill (1950 ft) south of Renison Bell.

Dolerite.—About 700 feet of dolerite rests on the pre-Permian surface at Mt Dundas. Strong columnar jointing has led to the development of steep angular crags rising out of a talus slope of dolerite blocks. The Eureka Cone Sheet has formed a broken ring of forested hills with rounded crags of dolerite, while in the SW

(north of Firewood Siding), the thin remnants of a dolerite sill are tilted to the SW in company with the underlying Permian sediments, showing some of the features of gentle dip slopes partly truncated by the Henty Surface.

Basalt.—The basalt overlying Tertiary sediments north and NW of the Heemskirk Range is rarely more than about 30 feet thick and has been separated by erosion into a number of outliers. The largest outcrop is on a low undulating plateau, tilted gently to the SW, covering about 3 square miles east of Granville Harbour. The smaller patches occur as low hills and ridges further east.

Effect of lithology and minor structures

On the Proterozoic or Lower Cambrian quartzite and slate the mantle is usually thin and consists of angular fragments of quartzite and milky quartz derived from veins, with occasional fragments of slate or schist. The effect of weathering is frequently hastened by zones of shearing or cleavage. The quartzite is sometimes shaly, with abundant flakes of muscovite on bedding planes, so aiding disintegration.

The Cambrian rocks are rich in iron and in the mild and wet environment, deep soils are formed, particularly on the greywacke and mudstone. Soil and down wash accumulate on steep slopes, as in the Dundas district, and masses may slip into the creeks under the lubricating influence of water. On lower ground, the mantle is thick, often supporting dense scrub, and outcrops are rare.

Soils are usually deep and swampy on the Gordon Limestone and the less resistant Silurian formations. Rapid alternation of quartzite or siltstone and shale in the Bell Shale give rise to hummocky topography often covered by thick bush.

The Heemskirk Range shows erosional features typical of granite. The higher slopes have weathered into rounded tors and crags, strongly influenced by prominent joint and shear planes. There is a thin mantle of fine quartz and tourmaline gravel, which is deeper and more widespread on the peneplaned western and NW margins of the granite. Streams flow through smooth gorges and over rounded falls and rapids with many potholes.

North of Zeehan, the Permian tillite is relatively unconsolidated and occupies an uneven depression below the level of the Proterozoic quartzite which has been overthrust from the east. In the SW, the ridges of Permian arkosic sandstone and pebbly grit are strewn with fine quartz gravel and sand.

The Tertiary sediments are a valuable succession of loose gravel, sand and soft clay which usually weather into deep sandy yellowish-brown soil. Iron pans occur in the sand, especially where there has been a cover of basalt clay. Although the basalt is thin, it is deeply weathered into a typical reddish-brown soil which is of agricultural importance on the Granville Estate. Outcrops of basalt are not common although scattered blocks and fragments may be found.

DRAINAGE PATTERN

Within the Zeehan Quadrangle, streams belong to four main systems. In addition, minor creeks flow off the Heemskirk Range directly to the Southern Ocean.

(a) *Pieman Catchment Area.*—The Pieman River is one of the most important in the West Coast of Tasmania. It cuts across the major structures in the Zeehan Quadrangle, with many angular bends produced by fault or fracture zones and prominent strike

ridges, and was probably initiated on the Henty Surface in late Tertiary times. Uplift resulted in the rejuvenation of its tributaries and the Pieman has become deeply entrenched below the erosional surface. Tributaries enter the Pieman over falls and rapids and the drainage pattern is a youthful one, with vigorous erosion by the headwaters, especially the Ring River and the Argent River which rise in the rugged ranges in the north west slopes of the Read-Dundas Plateau. From west to east, the chief tributaries flowing from the north are the Stanley, Wilson and Huskisson Rivers. The most important southern tributaries are the Heemskirk River which enters the Pieman over waterfalls; Pine Creek, Crimson Creek, the Argent River and the Ring River.

(b) *Little Henty Catchment Area.*—Lies entirely within the Zeehan Quadrangle. Downstream from the railway bridge (four miles SE of Zeehan), the river is incised below the Henty Surface and follows a sinuous course, partly controlled by structures in Ordovician to Devonian rocks. Tributaries are chiefly subsequent streams strongly influenced by folds in less resistant formations such as the Gordon Limestone and the Amber Slate. SE and east of Zeehan the Little Henty winds across a swampy button-grass plain and its headwaters are relatively mature. In contrast, the creeks flowing into its main tributaries, the Dundas Rivulet and Farrell Rivulet, rise on the steep western slopes of the Read-Dundas Plateau. Degradation is active, with many waterfalls and rapids, and stream beds are littered with piles of large boulders.

(c) Although most of the *Henty Catchment Area* lies outside the Quadrangle, its easterly flowing headwaters are briskly attacking the Plateau SE and NE of Mt Dundas. Grades are less steep and erosion is less intense than that due to streams flowing west into the Little Henty catchment, so that the edge of the Plateau will tend to shift eastwards.

(d) In the south and SW, the upper reaches of the *Badger River* wind across a swampy flat along the strike of weathered Gordon Limestone. A few minor streams flow into the Badger River from the escarpment to the north, while to the south and east, larger tributaries are cutting deeply into the Henty Surface worn across Moina Sandstone and Owen Conglomerate.

Westwards the Badger River is cutting down through north westerly trending Permian sediments.

(e) *Coastal Drainage.*—In the Heemskirk Range, drainage is dendritic, in a roughly radial pattern, but faulting and well-marked joint planes sometimes impose a local lineation. The north, east and south slopes are part of the Pieman River or Little Henty River catchments. To the west, small but youthful creeks flow directly to the sea and are actively dissecting the Henty Surface.

CLIMATE AND RAINFALL

The region has a wet and mild temperate climate. Table 1 shows the average monthly and annual rainfall figure (by courtesy of the Commonwealth Bureau of Meteorology, Hobart). Rosebery is about 12 miles NE of Zeehan and Lake Margaret lies 15 miles to the SE. Rain falls throughout the year, chiefly from April to November. During the summer months, the weather is often hot and dry, interspersed with periods of heavy rain, and the smaller creeks may dry up. Snow sometimes falls on the higher ground in winter but rarely remains in the lowlands. Weathering under such conditions is deep and rock exposures are often poor, except in the beds of the larger rivers, or creeks with an appreciable gradient.

TABLE 1 — AVERAGE RAINFALL (Inches)

Period Averaged	Station	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Average
1891-1959	Zeehan ..	5.62	4.47	6.01	8.58	9.38	9.66	10.56	10.48	9.10	9.08	7.50	6.62	97.06
1913-1959	Rosebery ..	4.82	4.03	4.94	6.76	7.76	8.07	9.00	9.25	8.11	7.54	6.80	5.43	82.51
1913-1959	Lake Margaret ..	9.51	7.90	9.87	12.58	13.52	12.90	14.18	14.77	13.63	13.18	12.47	10.06	144.57

(Figures supplied by the Commonwealth Bureau of Meteorology, Hobart)

Vegetation

The growth of vegetation is vigorous in a wet, mild climate. Button-grass is typical of swampy flats with acid, peaty soils, for example those overlying decomposed Gordon Limestone. It is widespread on the undulating erosional surfaces which have a thin cover of detrital quartz and quartzite gravel, particularly on the Precambrian sediments and the peneplaned granite NW and SW of Zeehan. In creek valleys and gullies there may be dense stands of ti-tree and young eucalypts with *Bauera* bordering the button-grass.

Mature myrtle rain-forest, usually with an understorey of tree-ferns, covers much of the rest of the district, especially in the deeply dissected highlands and is edged with tangled *Bauera*, young ti-tree and cutting-grass. "Horizontal" scrub is common on flatter ground or on gentle slopes where drainage is poor. Here specimens of Huon pine may be found in the Pieman valley, while King William pine is present on the flanks of Mt Dundas and the north slopes of Carbine Hill. Stunted King William pine and varieties of *Richea* are plentiful above about 2000 feet on the Read-Dundas Plateau.

Eucalypts are characteristic on outcrops of basic or ultrabasic rocks as in the Melba Valley and the dolerite hills round Eureka Plains. After forest fires or timber cutting, the quicker growing eucalypts tend to become established at the expense of the myrtle rain forest.

HISTORY OF EXPLORATION AND DEVELOPMENT

In 1876, a party led by C. P. Sprent, the Government Surveyor, pushed southwards from Waratah through rugged country covered in dense rain forest. Crossing the Pieman River 30 miles SW of Waratah, they found traces of tin and gold near Mt Heemskirk, so paving the way for the exploration of the West Coast mineral fields. The following year, Owen and George Meredith pegged four 80 acre leases at North Heemskirk on behalf of the Emu Bay and Pieman River Prospecting Co. and they were closely followed by parties under C. Donnelly and T. B. Moore. The first vein tin was discovered in 1879 at South Heemskirk. A wave of speculation followed and many companies were floated in spite of the difficult conditions and poor communications. All supplies and equipment had to be brought in by pack-horse, either from the poor anchorage at Pieman Heads, 20 miles to the north, or along the coast from Macquarie Harbour, 20 miles south. In 1881 the supply position was eased by the use of Trial Harbour near the South Heemskirk mines. Although the harbour is little more than a gap in a reef, with a granite headland to the north, small ships could anchor with some risk and the settlement of Reminé grew up to serve the mineral field. However, the field was badly managed and several mines installed expensive equipment before development, so exhausting scarce capital. The ore-bodies were found to be small and widely scattered and little exploration was done to find new deposits. The cost of treatment was high and many miners were unable to recognize cassiterite. These and other factors led to the temporary collapse of the field in 1884, at which time nearly 200 men were at work.

In 1882, Frank Long, who had been a member of Sprent's 1876 expedition, discovered traces of gold and argentiferous galena in a small creek near the present site of Zeehan Post Office. A short distance away, he found a silver-lead orebody. Long pegged 80 acres for the Arthur and Long Plains Prospecting Association which was later to become the Mt Zeehan mine. His companion, J. Healy, pegged the adjoining 80 acres for the Despatch Company. Development of the new field was slow until 1887 when public interest was stimulated by the discovery of galena by G. Bell near what was later to become the Silver Queen mine. All ore had to be taken out along the Zeehan-Trial Harbour road completed in 1889, but by 1891 there were 159 companies and syndicates at work. Tin was found in 1890 in the Ring River near the present township of Renison Bell, and also alluvial gold in 1891.

On August 3rd, 1891, the Bank of Van Diemens Land crashed and the next day 27 mines closed. A few mines carried on, but development was hampered by lack of capital. In 1892, production was encouraged by the opening of the Zeehan-Strahan railway, and copper-nickel ore was discovered in the Cuni area in 1893.

Montgomery (1893) pointed out that in Zeehan and Dundas over 80,000 acres had been pegged, so that money for exploration was thinly spread. He estimated that about 14,000 tons of silver-lead ore had been raised up to March, 1893, and, despite the depression, the rate of production in that year (about 13,400 tons) was nearly double that of 1892. The chief mines were the Silver Queen, Western and Oceana at Zeehan, and Maestrie's Broken Hill at Dundas.

An important advance was the construction of the smelters at Zeehan in 1898 by the Tasmanian Smelting Company. Although a great boon to the Zeehan and Dundas mines, there was insufficient local ore to keep the plant fully occupied. At this time, the Hercules mine at Mt Read was in difficulties with its ore, which incurred a penalty for the removal of the zinc content. Heberlein, the general manager of the Tasmanian Smelting Company, helped to develop the Huntington-Heberlein process and after 1901, Hercules ore was railed to the Zeehan Smelters where the lead, silver and gold were recovered, but the zinc lost. Communications had been improved by the construction of the North East Dundas Tramway from Zeehan to Williamsford (near Mt Read) in 1898, and in 1900 by the completion of the Emu Bay Railway which linked Zeehan to the North West Coast. Tin-bearing sulphide ore was discovered in a cutting near Renison Bell during the construction of the railway.

At the census of 1901, the population of Zeehan had grown to 5014 from about 130 in 1889. The future of the town was to be vitally affected by the fortunes of the smelters. A strike at the Hercules mine from 1905 to 1907 cut off much of its ore and local ore was insufficient. The plant closed down in August 1909 and re-opened in 1911 to continue treating Hercules ore. The Zeehan mines were beginning to run out of shallow ore and most of them lacked resources for further exploration. In 1913 a merger was planned between the Tasmanian Smelting Co., the Hercules mines at Mt Read and the Primrose mine at Rosebery. There

appeared every possibility that new methods of removing zinc from lead ore would prevent the loss of the zinc and that Zeehan would flourish round the smelters. The outbreak of war in 1914 cut off the West Coast mines from their European markets and closed the smelters.

In 1916, the Hercules and Primrose mines joined the Mt Lyell Co. (Queenstown) and the Tasmanian Copper Company to form Mt Read and Rosebery mines. New flotation processes allowed the recovery of Rosebery's zinc sulphide and it was planned to treat the ore at Zeehan. The electrolytic process had recently been developed in the U.S.A. and in 1917 the Tasmanian Government agreed to supply power. A dam to produce hydro-electric power was planned at Lake Rolleston in 1919 and it was anticipated that by 1924 the Zeehan plant would be producing 50 tons of electrolytic zinc per day. However, in 1920, the plans were changed and the Mt Read and Rosebery mines merged with the Electrolytic Zinc Company of Australasia whose zinc works at Risdon near Hobart had treated concentrates from Broken Hill, N.S.W., since 1918. Ore from the Rosebery mines was to be processed at Risdon and the Zeehan smelters was doomed. The plant carried on intermittently treating small quantities of local ore, as well as concentrates from Rosebery ore, but finally closed in 1948.

Although some silver-lead ore was produced from Zeehan and Dundas mines after World War I, the most important development was on the complex tin-sulphide orebodies near Risdon Bell. The cassiterite is very fine, posing problems of treatment, and was exploited by a number of small companies. In 1936, Renison Associated Tin Mines, N.L. took over most of the leases and instigated a comprehensive programme of development and experimental treatment. Since 1940, over 237,000 tons of ore have been treated, yielding 2130 tons of concentrates containing over 1400 tons of metallic tin. In recent years, geophysical surveys supported by a vigorous drilling programme have provided the company with much valuable information.

Asbestos was discovered near Argent Tunnel during the construction of the Zeehan to Renison Bell road in 1940, and was worked in 1945-1946. After World War II, exhaustive surveys were carried out by Zeehan Explorations (North Broken Hill and Broken Hill South) on the Zeehan and Dundas fields. The old Oceana mine was re-opened in 1947, and from 1954 to 1960 about 590,000 oz of silver as well as 14,000 tons of lead were produced before operations ceased. Geophysical surveys were made by the Bureau of Mineral Resources over the copper-nickel field at Cuni, north of Zeehan, Renison Bell, and in 1960, between the tin-sulphide orebodies at Mt Razorback and the Grand Prize. From 1951 to 1954, detailed geological surveys were made near Zeehan, Renison Bell, and north beyond the Pieman River by the Department of Mines, while since 1956 the old Zeehan and Dundas fields have been re-examined by geologists and geophysicists of Rio Tinto Australian Exploration Pty. Ltd.

GEOLOGY

STRATIGRAPHY

(See Figure 2)

Fossiliferous Silurian rocks were first recognized on the West Coast by Gould (1862) and near Zeehan by Thureau (1888a). For many years, the age of older formations was unknown and was further complicated by the reporting of *Diplograptus* by Hall (1902) in rocks now known to be Cambrian. Since 1945, a number of important contributions have helped to clarify the stratigraphy of Proterozoic and Palaeozoic rocks. They are described in detail in subsequent chapters and are summarized below:—

Thomas (1945) rejected Hall's identification of *Diplograptus* and therefore the supposed Ordovician age of the rocks.

Dendroids were described by Thomas and Henderson (1945) in black slate at the Razorback Mine, Dundas, so establishing a Middle Cambrian age for this horizon in the Dundas Group.

Lewis (1940) and Kobayashi (1940) proved the Ordovician age of the Junee Group which overlies the Dundas Group, and which is overlain in turn by the Eldon Group (Silurian to Lower Devonian).

All formations in Tasmania lying above the older Precambrian and below the Junee Group were placed by Hills and Carey (1949) in the "Pieman Group", a provisional term to include rocks considered to range from Upper Proterozoic to Cambrian.

Opik (1951a, b, c), showed that the Dundas Group includes Middle to Upper Cambrian rocks, basing his argument on (a) trilobites, including agnostids, collected by Elliston, May and others at Dundas in 1950; (b) fossils including dendroids found by Elliston and Taylor on the Huskisson River in 1951; (c) trilobites discovered in the Leven Gorge in northern Tasmania by Cooper and Banks.

Elliston (1954) defined the Dundas Group, based on Opik's interpretation, and also the underlying Carbine Group which he believed to be probably Upper Proterozoic to Lower Cambrian. The two sequences thus replaced the Pieman Group of Hills and Carey (1949).

Consequently, there has been established a fossiliferous sequence ranging from Middle Cambrian to Lower Devonian. But there has been a tendency for authors to place in the Middle to Upper Cambrian, rocks correlated on lithological grounds with the Dundas Group defined by Elliston (1954). On the other hand, the underlying quartzite and slate have been generally accepted as Proterozoic or Lower Cambrian and so an angular unconformity has been inferred below the Dundas Group.

It will be demonstrated that in the Zeehan region:—

1. The fossiliferous Middle to Upper Cambrian Dundas Group is conformable upon a sequence with similar lithology (the Crimson Creek Formation).

2. The Upper Proterozoic or Lower Cambrian Onah Quartzite and Slate passes up without a major hiatus into the Crimson Creek Formation, which may therefore extend from Lower to Middle Cambrian.

GENERALIZED STRATIGRAPHICAL COLUMN ZEEHAN QUADRANGLE

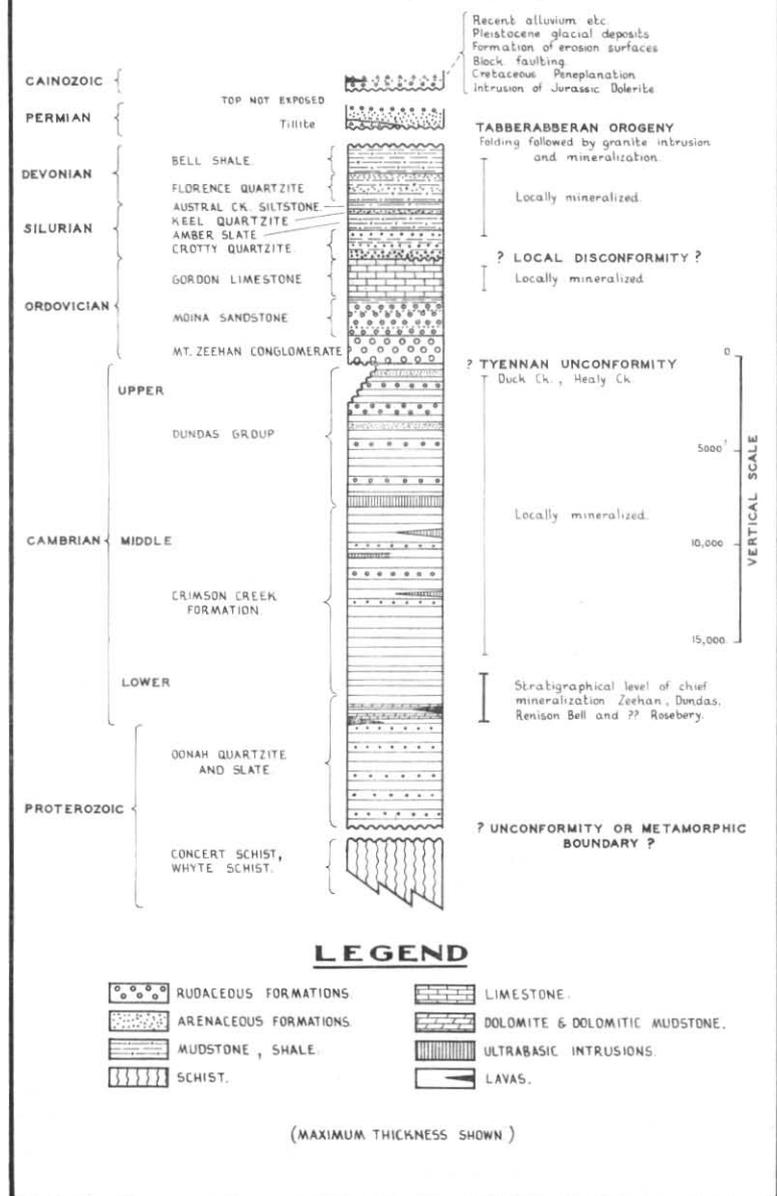


FIGURE 3.

5 cm

3. Rocks whose stratigraphical position was doubtful can now be placed within the Proterozoic-Cambrian succession. They include the highly disturbed sequence near Zeehan, between Trial Harbour and Zeehan, at Dundas, Renison Bell, and west of Rosebery.

4. There may be a passage from the Dundas Group up into the Ordovician Junee Group on Misery Hill, McLean Creek and on the Huskisson River.

The stratigraphical succession is illustrated in Figure 3. Except for Triassic rocks, the Zeehan region includes all the major formations in Tasmania, both sedimentary and igneous, and in particular the succession from the Proterozoic to Lower Devonian is well-developed. In Tasmania, some formations are diachronous, for example the Ordovician Moina Sandstone and Gordon Limestone, and the relationships of their correlates in the Zeehan region are discussed in the relevant sections. It is possible that the Oonah Quartzite and Slate is also diachronous though there is at present insufficient evidence to decide the question. It may be a rock unit whose exact time relationship is not yet known and therefore correlation should be made with caution, as pointed out by Spry and Banks (1955) in their general discussion of correlation problems in the Precambrian of Australia.

PROTEROZOIC SYSTEM

Introduction

Schist and quartzite exposed in an inlier east of Dundas were assigned to the Proterozoic by Reid (1925a) and were correlated with the Davey Group by Elliston (1954). However, as mentioned by Carey (1953) the term "Davey Group" has never been defined, and the basement rocks at Dundas are therefore defined in the present works as the Concert Schist. Similar rocks mapped on the lower reaches of the Pieman River are an extension of the Whyte Schist named by Spry (1962a).

The Concert Schist and Whyte Schist appear to underlie a thick series of pale quartzite, grey micaceous siltstone and dark shale or slate correlated throughout the Zeehan Quadrangle in this report with the Oonah Quartzite and Slate of Spry (1958). Spry (1962a) pointed out that in Tasmania generally it is a major problem to decide whether the Proterozoic rocks belong to an older, regionally metamorphosed series overlain unconformably by a less altered and younger series, or whether they are part of one sequence metamorphosed to different degrees. Both series include miogeosynclinal arenaceous and pelitic rocks with basic intrusions, and Spry suggested the provisional name "Frenchman Metamorphic Period" for the boundary between them. From evidence in the Devonport district, Burns (in Spry, 1962b) believed that there the difference is due to variations in the intensity of metamorphism and tectonic style, and he demonstrated that sheared bands of quartzite appear to break up and disappear as augen in quartz-mica-schist. No conclusive evidence was found in the Zeehan Quadrangle. Outcrops of the Concert Schist and the Whyte Schist are usually poor and discontinuous and no unconformable contact with the Oonah Quartzite and Slate was seen, though the Concert Schist at Dundas is exposed within a structural high, suggesting that it is older than the overlying Oonah Quartzite and Slate. On the other hand, broad bands of quartzite containing conglomerate

occur within schist north of the Lower Palaeozoic syncline at Duck Creek, while to the south, there appears to be a passage southwards from schist into less altered quartzite and siltstone. A detailed study here would provide valuable data.

The following description is based on the assumption that the Concert Schist and Whyte Schist are Older Proterozoic while the Oonah Quartzite and Slate probably ranges from Upper Proterozoic to Lower Cambrian.

Older Proterozoic

CONCERT SCHIST

The Concert Schist is defined as that group of metasediments which appear to form the basement to the sedimentary succession in the Dundas district. The type section is on Concert Creek between co-ordinates 350500E 844900N and 351700E 845150N. The series, which was formerly known as the Davey Group (Elliston, 1954), outcrops over about 1 square mile and is apparently overlain unconformably by the Oonah Quartzite and Slate (Carbine Group of Elliston, 1954), thought to range from Upper Proterozoic to Lower Cambrian.

The formation consists of an unknown thickness of greenish-grey and grey sandstone, siltstone and shale which have been converted by low-grade regional metamorphism into a variable suite of quartz schist, quartz-mica schist, sericite and graphite schists. Schistosity strikes generally NW and the finer schists are often intensely crumpled and crenulated while bedding has been largely obliterated. Veins of quartz with pyrite cut the beds in a similar direction to schistosity but no mineralization of economic value has been found in the Concert Schist.

WHYTE SCHIST

Scattered outcrops of the Whyte Schist were mapped along the Pieman River near the northern boundary of the Zeehan Quadrangle. Rock types include sericite schist, quartz-mica schist and pale greenish-grey schistose quartzite, which are often riddled with veins and knots of barren milky quartz.

Similar rocks on the coast north of Duck Creek are provisionally assigned to the Whyte Schist. About $\frac{1}{4}$ mile north of the mouth of Duck Creek, intensely folded Ordovician Gordon Limestone is faulted against crumpled green schist displaying chevron folding. The sequence includes sericite schist, quartz-mica schist and schistose quartzite riddled with milky quartz veins and stringers. About $\frac{1}{4}$ mile north of the fault, green schist is in contact with laminated pale green pink and purplish-red silty shale and fine cherty quartzite with a band at least 10 feet thick of shattered conglomerate containing many rounded or sub-rounded pebbles of pink quartzite up to 4 inches in diameter. Northwards, green and pink laminated quartzite becomes increasingly more schistose, passing once more into crenulated schist and deformed quartzite. Schistosity and bedding strike consistently NE or NNE. The less deformed rocks, particularly the conglomerate, bear a superficial resemblance to the top of the Oonah Quartzite and Slate, or the lower part of the Cambrian Crimson Creek Formation and the possibility that they are metamorphosed members of these beds cannot at present be entirely ruled out. On the southern limb of the Duck Creek Syncline, Ordo-

vician Moina Sandstone is in contact with similar green schist and quartzite, though deformation is less complete and southwards there is a gradual passage into quartzite and siltstone indurated by contact metamorphism associated with Heemskirk Granite. These rocks are tentatively grouped with the Oonah Quartzite and Slate.

Upper Proterozoic to Lower Cambrian

OONAH QUARTZITE AND SLATE

General Discussion

As in other parts of Tasmania, the regionally metamorphosed schist and quartzite in the Zeehan Quadrangle appear to be overlain unconformably by a thick sequence of quartzite and slate which was defined as the Oonah Quartzite and Slate by Spry (1958), after work NW of Zeehan and along the Pieman River. Similar rocks at Zeehan, Dundas, Renison Bell and near Trial Harbour were correlated on structural and lithological evidence in a brief note by Blissett and Gulline (1961a). The formation is now believed to be Upper Proterozoic, possibly ranging up into the Lower Cambrian, but for many years its age and stratigraphical position were uncertain and controversial. The quartzite and slate north and NW of Zeehan and at Renison Bell were placed in the Silurian by Waller (1904) and Twelvetrees (1906), and in the Cambro-Ordovician by Twelvetrees and Ward (1910), Waterhouse (1915, 1916) and Conder (1918). After the discovery of Middle Cambrian fossils in the Dundas Group (Thomas and Henderson, 1945), all formations in Tasmania known to be older than Ordovician and apparently younger than the Older Proterozoic "Davey Group" were placed by Carey (1947) and Hills and Carey (1949) within the "Pieman Group" as a provisional measure pending further work. Further advances were made by the publication by Carey (1953) and Elliston (1954) of material from a thesis by Elliston (1951). The Pieman Group was replaced by two new groups. The Carbine Group was regarded as late Precambrian to Lower Cambrian, overlain unconformably by the fossiliferous Middle to Upper Cambrian Dundas Group. Elliston (1954) compared the quartzite and shale at Renison Bell with his Carbine Group at Dundas, but believed that similar rocks near Zeehan were part of the Dundas Group.

Taylor (1954d) placed schist, micaceous quartzite, shale and slate north of Zeehan and on the Pieman River in the Davey Group (i.e., Older Proterozoic) which he considered was overlain unconformably by the Success Creek Group correlated with Elliston's Carbine Group. It must be emphasized that Taylor did not see the Whyte Schist (Older Proterozoic) and that the formations he included in the Davey Group form part of the Oonah Quartzite and Slate defined by Spry (1958).

In Blissett and Gulline (1961a) it was suggested that the Oonah Quartzite and Slate may pass up into the finer Carbine Group, for example near Queen Hill, Zeehan and on the Trial Harbour road. However, further detailed mapping of the Oonah Quartzite and Slate has shown that though the upper part is generally finer, alternations of thin-bedded fine quartzite, siltstone and dark shale also occur throughout the sequence, and there is therefore little justification for dividing the Precambrian succession. Again, where there are no exposures, the shale disintegrates on weathering while the more resistant arenaceous beds or the

numerous veins of quartz form a widespread mantle of detrital quartzite and quartz, giving the impression that such bands are more abundant than is the case. Spry (1962a) commented that Elliston (1954) clearly defined the Carbine Group at Dundas but the area in question is small. The term "Oonah Quartzites" of Hills and Carey (1949), has priority and as defined by Spry (1958) the Oonah Quartzite and Slate covers at least 50 square miles NW of Zeehan. Spry's definition, as used in this report, also covers the Oonah Quartzites, Montana Melaphyre Volcanics and Nubeena Quartzites of Hills and Carey (1949), the Carbine Group of Elliston (1954) and the Success Group of Taylor (1954d).

Lithology

The Oonah Quartzite and Slate consists of alternating white-weathering pale grey saccharoidal quartzitic sandstone or quartzite, thin-bedded micaceous quartzite and siltstone, and laminated hard greenish, grey or black shale. The coarser sandstone beds may contain fragments of kaolinized feldspar and subgreywacke grit is not uncommon. Golden-weathering muscovite is abundant on bedding planes in the finer quartzite and scattered as flakes up to about 3 mm across throughout black and dark grey siltstone. Dark grey limestone and dolomitic limestone are developed locally north and west of Zeehan and in the Dundas district. Spilitic lava flows and pyroclastic bands occur near Zeehan also in the upper part of the sequence.

In contrast with the Older Proterozoic, the Oonah Quartzite and Slate has suffered little dynamic metamorphism. Schistosity is developed locally at North Heemskirk and near the Comstock mines. The formations are commonly cleaved and shale or siltstone has been converted to slate or phyllite, but bedding is usually visible.

Age and Correlation

The Oonah Quartzite and Slate is apparently unfossiliferous. Indistinct casts of brachiopods, crinoids and gastropods reported by Waller (1904, map) and Twelvetrees and Ward (1910, pp. 37-38) on Queen Hill have not been confirmed, and a close examination of the area was unsuccessful in finding any. Cross sections of minute quartz veins and pits or cavities attributed to the weathering out of feldspathic material or shale flakes occasionally resemble organic fragments or casts.

The oldest fossiliferous rocks in Tasmania are represented by the Middle Cambrian *Ptychagnostus gibbus* Zone of the Dundas Group at Dundas, which is underlain by the unfossiliferous Crimson Creek Formation, believed to range from Lower to Middle Cambrian. The Oonah Quartzite and Slate is older and is accepted by most authors as Upper Proterozoic to Lower Cambrian. It may be entirely Lower Cambrian as suggested by Campana *et al.* (1960) but there is no supporting evidence.

Rocks shown as the Oonah Quartzite and Slate on the Zeehan Map Sheet are correlated on structural position and lithological similarity. A useful field guide is the abundance of yellowish-weathered muscovite which occurs throughout the region. While similar mica is present in Permian formations, these rocks are usually fossiliferous and there are no barren milky quartz veins which are common in the Proterozoic or Lower Cambrian.

Distribution

The Oonah Quartzite and Slate is probably at least 7000 feet thick and is exposed within a complex faulted anticlinorium which occupies much of the north and NW portion of the quadrangle. At Zeehan and Renison Bell, anticlinal folds plunge SE below Cambrian and younger formations. The upper part of the sequence near Zeehan was called the "Montana Melaphyre Volcanics" by Hills and Carey (1949) and includes dark grey and black shale or slate, grey micaceous siltstone and fine quartzite, while massive pale grey quartzite or subgreywacke is subordinate. Bedded limestone and dolomitic limestone occur near the Comstock and Oonah mines, and have been described near the Zeehan-Western mine, and Zeehan-Montana mine and the No. 4 Queen shaft by King (1961). Also in the higher measures are interbedded flows of spilitic or keratophyric lavas and beds of allied pyroclastic rocks ranging from tuffs to agglomerates. There are numerous exposures of these in the curving belt 4 miles long between the Comstock mine in the west and a point about 1 mile NE of the Montana Silver-Lead mine in the east. Petrographic descriptions of the volcanic rocks have been recorded by Twelvetrees and Ward (1910, pp. 15-18) and King (1961). Most of the lavas and pyroclastics appear to be concordant with the sediments though the relationship is frequently obscured by intense folding, faulting and shearing.

On the Pieman River, west of the mouth of the Wilson River, and in Western Hills, the coarser quartzites are again subordinate to dark shale and micaceous siltstone in the upper part of the formation (Success Creek Group of Taylor, 1954c). The region was investigated from a camp in Western Hills and no evidence was found for an unconformity between these beds and the coarser underlying series. Linear features on aerial photographs are due to large-scale folding of the relatively incompetent upper beds of shale and siltstone, and interbedded pale micaceous quartzite is indistinguishable from that typical of the Oonah Quartzite and Slate throughout the district. Similar rocks were mapped at Renison Bell, where they are admirably exposed in road and rail cuttings between the Argent Dam and the mill.

At Dundas the sequence was described in detail as the Carbine Group by Elliston (1954), and it resembles the upper part of the succession near Zeehan, except that lavas appear to be absent. Near the base is the impersistent Maestries Dolomitic Conglomerate consisting of rounded quartz pebbles in a dolomitic matrix. Beds of dolomitic limestone occur, though dolomite has also been formed by the dolomitization of serpentinite sills or dykes. The formation is about 2000 feet thick in the Dundas district.

Alternations of pale quartzite, laminated siltstone, and dark shale or slate were mapped across the North East Dundas Tram SE of Colebrook Hill, and also SW of Mt Dundas. They resemble the upper horizons in the Oonah Quartzite and Slate near Zeehan, and are overlain by Cambrian greywacke and siltstone.

At Granville Harbour, north of the Heemskirk Granite, quartzite, laminated siltstone and schist or phyllite have been partly recrystallized or hornfelsed by contact metamorphism, but they are probably a continuation of the Oonah Quartzite and Slate exposed north of the granite about 2 miles to the east. East of

Trial Harbour on the southern flank of the granite, indurated quartzite and laminated siltstone dip southwards below Cambrian greywacke and cherty siltstone and are also correlated with the Oonah Quartzite and Slate.

A short distance beyond the north-eastern boundary of the Zeehan Quadrangle, micaceous quartzite, siltstone and shale similar in lithology to the Oonah Quartzite and Slate outcrop east of Rosebery golf course and west of Rosebery.

CAMBRIAN SYSTEM

(See Figure 14)

Introduction

The red, purple, green and grey turbidites now placed in the Cambrian and assigned either to the Crimson Creek Formation or the overlying fossiliferous Dundas Group have posed problems of correlation since exposures were described at Dundas by Montgomery (1890). Twelvetrees (1901) believed that the beds at Zeehan and Dundas were Middle to Upper Silurian. The problem was confused by a note by Hall (1902) who accepted a report by G. Thureau that he had found *Diplograptus* near Strahan. Hall also claimed to have identified ? *Callograptus* and dendroids among specimens collected by G. A. Waller from the North East Dundas Tram in 1902, and later authors accordingly placed the rocks in the Cambro-Ordovician, though Waller (1904) thought that at Zeehan they were younger than the Silurian. Keble (1928) re-examined the specimens from the North East Dundas Tram and proposed a Lower Ordovician or lower Upper Ordovician age for this part of the succession, based on his identification of *Tetragraptus*.

Much of the confusion was cleared up by Thomas (1945) who criticized Hall's acceptance of the *Diplograptus* from Strahan in 1902. The specimens collected by Waller were scrutinized by W. J. Harris who found no recognizable graptolites. Proof that part of the sequence is Middle Cambrian was submitted by Thomas and Henderson (1943; 1945). Dendroids collected at the Razorback mine, Dundas are identical with species in Victoria, including *Archaeolafoea serialis* Chapman and Thomas, *Archaeocryptolaria skeatsi* Chapman, *Protohalecium hallianum* Chapman and Thomas, *Sphenoecium filicoides* (Chapman) and *Mastigograptus* sp.

Banks (1956) noted that in 1950, J. Elliston, B. G. May and others found trilobites near Dundas; B. L. Taylor and Elliston collected dendroids and agnostids on the Huskisson River, while others were found by Banks and R. J. Cooper in the Leven Gorge in North West Tasmania. According to Opik (1951 a, b, c), the fossils range from Middle to Upper Cambrian, and on the Huskisson River they included the important Upper Cambrian zone fossil *Glyptagnostus reticulatus*. The Dundas Group was defined by Elliston (1954), based on Opik's determinations. Elliston's definition included only Middle Cambrian formations but he added (p. 167) "more recent discoveries in other areas have extended the time range of the group into the Upper Cambrian". In recent years, Cambrian fossils have also been found near Smithton, Ulverstone, Beaconsfield and Adamsfield, thus allowing correlation

with the Dundas Group (Banks, 1956; 1962a). But in some parts of Tasmania the turbidites are apparently unfossiliferous and correlation has been made on lithological similarity and structural position, for instance at Queenstown, south of Macquarie Harbour, the West Coast Range, Sheffield and Deloraine.

At the same time, the underlying Carbine Group of Elliston (1954) or the Oonah Quartzite and Slate (Spry, 1958) have been widely regarded as Upper Proterozoic or Lower Cambrian and consequently a major unconformity has been inferred below the Dundas Group. Unconformities below Dundas-type sediments have been described in the Sticht Range by Carey and Banks (1954) and by Campana *et al.* (1960) at Bulgobac Siding, about 14 miles north of Rosebery. However, it has been shown by Blissett and Gulline (1961a) that in the Pieman River-Dundas-Zeehan region there may be a passage from the Oonah Quartzite and Slate up into the Crimson Creek Formation, believed to be Lower to Middle Cambrian, which closely resembles the overlying fossiliferous Dundas Group.

Banks (1956) commented that the name "Dundas Group" was introduced in 1905 by Waller, but the rocks have also been called "Dundas Slates" and "Dundas Series". It is clear from early literature that the term "Dundas" originated, not at Dundas, designated the type area by Elliston (1954), whose definition is in current use, but in the district round Renison Bell which was formerly known as "North Dundas". For example, Smith (1898, p. 10) described typical breccia-conglomerate in the Ringville area (between Renison Bell and Williamsford); Twelvetrees (1906) discussed the Renison Bell tinfield; Ward (1909) and (1911) reported on the "North Dundas" (Renison Bell) tinfield and the Exe River region; Waterhouse (1916) compared similar rocks south of Mt Heemskirk with "North Dundas". The name was afterwards applied to rocks in other parts of Tasmania, as in Nye (1928) and later authors. Thomas and Henderson (1945), who discovered Middle Cambrian dendroids at Dundas, remarked that "as the Razorback area is included in Ward's (1909) original plan of the North Dundas tinfield, the fossils described were found in the type area and thus fix the age of what is undoubtedly the Dundas Series".

In Taylor (1954) and Blissett and Gulline (1961a) it was demonstrated that the rocks in the Renison Bell area probably belong to the older Crimson Creek Formation and that the Dundas Group, as defined, may be absent. Unfossiliferous Dundas-type beds may therefore be correlates, not of the Dundas Group, but of the underlying Crimson Creek Formation.

Stratigraphy

(1) CRIMSON CREEK FORMATION

GENERAL DISCUSSION

B. L. Taylor and D. Burger mapped a thick series of purple and green mudstone, greywacke and slate along the Pieman River between the Wilson River and the Exe River, and also near Renison Bell (Taylor, 1954 a, c, d.). The beds were named the Crimson Creek Argillite. Taylor noted that on the Huskisson River the formation is overlain by the sequence of dark slate or shale, greywacke and conglomerate in which he and Elliston had collected

agnostids and dendroids in 1951, called by him the "Huskisson Group" and correlated with the Dundas Group. He suggested that the Crimson Creek Argillite may range from Lower to Middle Cambrian because there is apparently a passage down into the Lower Cambrian "Success Creek Group" (i.e. the upper part of the Oonah Quartzite and Slate), and it is followed conformably by the Middle to Upper Cambrian Dundas Group. Taylor believed that the formation is equivalent to part of the Carbine Group of Elliston (1954), presumably because it lies below a sequence correlated with the Dundas Group. Banks (1956) pointed out that the rocks resemble the Dundas Group rather than the Carbine Group. To conform with the Australian Code of Stratigraphic Nomenclature, (third edition), the sequence was termed the Crimson Creek Formation in Blissett and Gulline (1961a) and it was shown that in a number of localities in the Zeehan Quadrangle, the Oonah Quartzite and Slate is overlain, apparently conformably, by the Crimson Creek Formation which in turn passes up into the lithologically similar Dundas Group. The sequence was therefore considered as ranging from Lower to Middle Cambrian.

DISTRIBUTION AND LITHOLOGY

Pieman River-Renison Bell Area

The Crimson Creek Formation outcrops in a belt three miles wide east of the confluence of the Wilson River and the Pieman River. The outcrop extends eastwards as far as Rosebery golf course and swings SW beyond Renison Bell to the faulted junction with the northern end of the Zeehan Syncline.

On the north bank of the Pieman River, about $\frac{1}{4}$ mile south of the mouth of the Wilson River, indurated quartzite and siltstone pass northwards up into laminated siltstone and fine quartzite typical of the upper beds of the Oonah Quartzite and Slate. On the east bank of the Wilson River, the rocks are overlain by chocolate coloured mudstone, greywacke and blue-grey calcareous shale, followed by a monotonous succession of red, purple, green and grey mudstone or argillite with characteristic thin bands or partings of greywacke; flaggy and laminated purple, green, grey or black shale and siltstone; and beds of yellowish-brown weathered greywacke. The mudstone and argillite are typically massive and dense with a roughly cuboidal or conchoidal fracture. About $\frac{1}{4}$ mile west of the mouth of the Ring River, thin bands of coarse conglomerate were mapped by B. L. Taylor and D. Burger. Rounded pebbles of quartzite, schist and tuff up to 6 inches in diameter with an ill-sorted matrix occur within laminated brown argillite. Volcanic rocks are uncommon, though a flow of vesicular basalt about 30 feet thick was described by Taylor (1954d) on the north bank of the Pieman River, $\frac{1}{4}$ mile west of the mouth of the Huskisson River. The succession is about 10,000 feet thick along the Pieman River.

At Renison Bell, the Oonah Quartzite and Slate is exposed in the core of a SE plunging anticlinal fold. Dips are not steep and the Crimson Creek Formation overlies the Proterozoic or Lower Cambrian with structural conformity. At the base is 80 feet of the "Red Rock" of Conder (1918), consisting of red chert, coarse chert and quartz grit and conglomerate, overlain by distinctive

thick red, purple and green argillite or mudstone, siltstone greywacke and dark shale, making a total thickness of about 8000 feet. In the Renison Bell workings, pebbles of granite have been found in conglomerate by P. A. Hill and M. Solomon (pers. com.).

Similar beds can be seen south and SE of Renison Bell as far as the intrusive contact with serpentinite, pyroxenite and gabbro between the Argent tunnel and the Ring River. SW of the Argent tunnel, there are scattered outcrops of greywacke, purple and red siltstone and mudstone, and black shale in the Cuni District, where exposures are frequently obscured by swampy recent gravel, sand and alluvium.

Dundas District

Mapping round Dundas is complicated by the complex faulting, poor exposures and thick scrub. The Oonah Quartzite and Slate is overlain by deeply weathered red, purple and green mudstone, shale or slate, greywacke and conglomerate which were subdivided and defined as the Dundas Group by Elliston (1954). Elliston remarked (p. 166) "The succession in the Dundas Group is clearly established in the type section [in Dundas Rivulet] from the Misery Conglomerate down to the fossiliferous Hodge Slates, but the lower limit of this section is in contact with the intrusive serpentinite The mapping and comparison of the lithology to some extent justify the placing of the Hodge Slates towards the base of the Dundas Group However, the basal tuff [Judith Slate and Tuff] on the South Comet Creek contains trilobites and the fauna is thought to be very much lower than that found in the Hodge Slates. Therefore a section extending upwards to the Hodge Slates is proposed. The section on the upper end of Spur Track II is chosen as the type section for the part of the Dundas Group below the Hodge Slates. An approximate 1300 feet thickness of sediment occurs in this section from the Hodge Slates to the unconformity".

The position of the Judith Formation, correlated by Opik with the *Ptychagnostus gibbus* Zone is discussed on p. 32. The Severn Slate described by Elliston (p. 167) on the upper part of Spur Track II was regarded by Blissett and Gulline (1961a) as part of the Crimson Creek Formation, and thus older than the Dundas Group, for the following reasons. The track runs from Dundas eastwards to Moores Pimple and crosses the Older Proterozoic inlier. East of the Montezuma Fault, dolomitic conglomerate, laminated siltstone, and quartzite forming part of the Oonah Quartzite and Slate is exposed along the track for about $\frac{1}{4}$ mile. The rocks are succeeded further east by purple or fawn siltstone, shale or slate, greywacke and dolomite siltstone which can be traced as far as Moores Pimple. The boundary between the Oonah Quartzite and Slate and the Crimson Creek Formation is not visible, and could be gradational. In any event, there is structural conformity, and changes of dip are due to the influence of minor plunging folds. Again, structures in the Oonah Quartzite and Slate are no more complex than those in fossiliferous Dundas Group beds at Bonnie Point (North East Dundas Tram) where the author mapped a synclinal fold plunging at 60° to the south. Thus, there is no evidence for an angular unconformity above the Oonah Quartzite and Slate. Elliston did not find fossils in what he believed was

the equivalent of the Judith Formation on Spur Track II, and correlation over several miles on lithological grounds alone is unreliable in turbiditic sediments.

A similar relationship was mapped in Mariposa Creek, on the rugged western slopes of Mt Dundas. Oonah-type pale quartzite, siltstone and shale riddled with barren quartz veins form a prominent spur on the NW slope below the summit. A tributary flowing south along the strike of the Proterozoic rocks was followed to the confluence with Mariposa Creek along which a traverse was made westwards. About $\frac{1}{2}$ mile downstream, the Oonah Quartzite and Slate is overlain by greywacke conglomerate, khaki and brown weathered laminated siltstone and greywacke regarded as part of the Crimson Creek Formation. The strike of both formations varies a few degrees west and east of north, and dips are comparable, so that an unconformity is unlikely.

This evidence, and the passage from the Oonah Quartzite and Slate into the Crimson Creek Formation on the Pieman River and at Renison Bell was used to indicate in Blissett and Gulline (1961a) that the Dundas Group is not unconformable on the Oonah Quartzite and Slate at Dundas as suggested by Elliston (1954), but that it overlies the Crimson Creek Formation conformably. The highly faulted area south of Godkin Ridge and along Wallace's tram was visited by the author and A. B. Gulline and no evidence of unconformity was found. Near the south end of the track on the west side of Godkin Ridge, intensely puckered and deformed incompetent shale is interbedded with less altered pale grey Oonah-type quartzite or subgreywacke so that a small exposure might give the impression of unconformity. SW of the Junction with Wallace's tram, the Carbine track crosses dolomitic siltstone, siltstone, greywacke and chert conglomerate which appear to rest conformably on the Oonah Quartzite and Slate west and north of the North Comet mine. Elliston remarked that bedded dolomite is not found in the Dundas Group, nor is purple slate found in the Carbine (Oonah) rocks. However, both are characteristic of the Crimson Creek Formation.

On the North East Dundas Tram, north of Moores Pimple, purple, red, green and brown siltstone, dolomitic siltstone, cherty mudstone and slate, and greywacke outcrop on each flank of the inlier of Oonah Quartzite and Slate, and similar rocks occur north of Mt Dundas. East of a line from Moores Pimple to Mt Dundas, there is a considerable thickness of green and grey shale, siltstone, greywacke and greywacke conglomerate with interbedded volcanic and pyroclastic rocks which are tentatively correlated with the Crimson Creek Formation. They may be related to the Mount Read Volcanics and are discussed on p. 42.

Zeehan District

The Cambrian rocks at Zeehan were discussed at length by Waller (1903, pp. 5-9) though he correlated them with beds now known to be Silurian or Devonian. Waller noted the Y-shaped outcrop centred on Manganese Hill, the arms of which stretch north across the Argent Flat east of Queen Hill, west to the Sylvester mine and SE along the Austral Valley to the Smelters road. The rocks were described as grey or reddish fine-grained "melaphyre" (spilitic) tuffs ". . . interbedded with fine-grained black or dark chocolate-coloured slates into which they appear to

pass over by intermediate types". Twelvetrees and Ward (1910, p. 18) referred to the formation as the "Keratophyric Tuffs and Breccias", a name which has been used with various modifications by later workers. That part of the sequence is equivalent to the Dundas Group is indicated by the presence of *Diplagnostus* sp. in the Summit cutting on the Comstock tram, correlated by Opik (1951b) with the Hodge Slate. Part of the succession lies below this horizon, and there appears to be a passage from the Oonah Quartzite and Slate up into the Crimson Creek Formation which is now described.

Waller (1904, p. 8) considered that near the Sylvester mine, the beds are conformable "with the strata to the north and south" (the Oonah Quartzite and Slate). Exposures are poor and there is a thick cover of vegetation, but east and south of the mine, mineralized fine quartzite, siltstone and hard dark shale form a synclinal structure and pass up into deeply weathered red, purple and green greywacke, siltstone, chert and shale with occasional bands of tuff and flows of keratophyre or spilitite. The syncline is faulted north and south against Oonah Quartzite and Slate, but it is estimated that at least 1000 feet of beds lie below the shale and greywacke containing *Diplagnostus* sp. and above the Oonah Quartzite and Slate. The fossiliferous beds (?Hodge Slate) are overlain by conglomerate which may be equivalent to the Razor-back Conglomerate. If the Hodge Slate is low in the Dundas Group (see p. 33), then much of the succession below must be placed in the Crimson Creek Formation.

In the Austral Valley NE and east of the Spray mine, the Oonah Quartzite and Slate is overlain by brownish-weathered dolomitic siltstone, greywacke and shale. Exposures are generally poor and there has been intense faulting and close folding but there appears to be a passage near the remains of the Spray mill. Lithology resembles that in the Crimson Creek Formation elsewhere, and the rocks are apparently unfossiliferous.

In the highly disturbed area round the Austral Flat north of Manganese Hill, scattered exposures of weathered greywacke, siltstone and shale overlain by superficial deposits outcrop east of the upper beds of the Oonah Quartzite and Slate on Queen Hill. Evidence at the surface and in underground workings (e.g., Taylor and Burger, 1951a) suggests that the junction is a faulted one to the south, while further north there may be a passage. The question is complicated by the presence of sheared black slate in the upper part of the Oonah Quartzite and Slate and also in the lower horizons of the Crimson Creek Formation. No fossils have been found.

Along Dunkley's tram, about 3 miles north of Zeehan, several outcrops of red and green mudstone, siltstone and greywacke scattered over about $\frac{3}{4}$ mile were mapped and interpreted as a thin outlier of the Crimson Creek Formation preserved in a shallow downfold in the Oonah Quartzite and Slate. Another small elongated patch occurs $\frac{1}{2}$ mile further north along the tram.

SW of Zeehan, an outcrop over one mile wide of red and green mudstone, siltstone, greywacke and greywacke conglomerate with a number of interbedded keratophyre flows extends from the Tasmanian tram SW for at least 4 miles. Grey and green chert, siltstone and greywacke with sills of gabbro were mapped by R. P. B. Pitt in a south-flowing tributary of Comstock Creek, about one

mile SE of the Heemskirk Granite. In Bridge Creek, about $\frac{1}{2}$ mile SE of the Orient mine, A. B. Gulline noted purple and green greywacke conglomerate with chert pebbles, purplish and grey laminated chert and hard siltstone. It is suggested that these rocks are part of the Crimson Creek Formation indurated by the effects of contact metamorphism. The conglomerate was described by Waterhouse (1916, pp. 101-102) who compared it with rocks at North Dundas.

Trial Harbour District

On the coast, the relations between the Oonah Quartzite and Slate and beds correlated with the Crimson Creek Formations are obscured by the intrusion of a serpentinite mass. The whole district was later affected to some extent by the Heemskirk Granite. About $\frac{1}{4}$ mile south of Trial Harbour, fine-grained chilled pyroxenite is in contact with indurated fine grey and purplish cherty quartzite which is faulted to the south against altered Silurian Amber Slate. Inland, laminated greenish siltstone and mudstone, grey slate, greywacke and chert were examined south of the serpentinite while north of it there are fine-grained hornfelsed siltstone and laminated chert. In the Little Henty River, east of Trial Harbour there is a variable succession of green, purple and grey hornfels, chert, chert grit and pebbly conglomerate, and laminated indurated siltstone with thin intercalations of greywacke. A distinctive conglomerate was mapped in the river about $\frac{3}{4}$ mile SSE of Mayne's mine. The rock is a hard silicified formation at least 50 feet thick of rounded pebbles of quartz and chert up to about 4 inches in diameter in an ill-sorted matrix of greywacke and pebbly grit.

About $\frac{1}{2}$ mile south of Mayne's mine, quartzite and slate correlated with the Oonah Quartzite and Slate are overlain by the sequence described above, with no evidence of unconformity. The formations are structurally conformable and it is difficult to fix the boundary. It is considered that here quartzite and slate pass up into the Crimson Creek Formation which has been subjected to contact metamorphism. The presence of calc-silicate hornfels in the Little Henty River, as well as altered impure limestone described by Waterhouse (1916) invites comparison with dolomitic rocks in this series elsewhere. The formation is probably at least 1500 feet thick, though faulting and minor folding make accurate measurement difficult.

(2) DUNDAS GROUP

GENERAL DISCUSSION

The oldest fossils identified in Tasmania came from the Judith Formation at Dundas (Elliston, 1954) and were correlated with the lower Middle Cambrian *Ptychagnostus gibbus* Zone by Opik (1956, p. 251). The youngest Cambrian rocks appear to be those at Adamsfield containing an Upper Dresbachian or Lower Franconian fauna described by Opik (in Banks, 1962a), but correlated with the lower part of the June Group which is mainly Ordovician. Elsewhere in Tasmania, the highest known horizon in the Cambrian is the *Glyptagnostus reticulatus* Zone on the Huskisson River referred to the Lower Dresbachian (lower Upper Cambrian) by Opik (1951b). Though the *Ptychagnostus gibbus* Zone and the *Glyptagnostus reticulatus* Zone have yet to be found outside the Zeehan Quadrangle, the use of the term Dundas Group, as defined, should be restricted to units which can be placed with certainty

within this time range, as proposed by Campana *et al.* (1960). There are rapid changes of facies, both vertically and laterally, in the Cambrian sedimentary and volcanic rocks, and Banks and Solomon (1961) commented that definite correlation can only be made on palaeontological grounds.

Owing to complex faulting and folding, there is some doubt about the position of the Judith Formation in which the *Ptychagnostus gibbus* fauna was found by Elliston. The beds lie below a conglomerate which may be the Red Lead Conglomerate of Elliston (1954), but no other fossils have been discovered at higher horizons in this locality. The question is discussed below.

The detailed succession in the Dundas district is only of local significance and the conglomerates in particular cannot be traced for more than a few miles. They are subordinate to mudstone and greywacke on the Huskisson River, and are rare in the SE portion of the Quadrangle.

DISTRIBUTION AND LITHOLOGY

Dundas District

Dundas Group

Top	Formation	Thickness (ft)
	Misery Conglomerate (See Mt Zeehan Conglomerate) .....	.....
	Climie Formation	1500
	Fernflow Formation	500
	Comet Formation	500-1000
	Fernfields Formation	?0-1950
	Brewery Junction Formation	2000
	Razorback Conglomerate	250-750
	Hodge Slate	500-600
	Red Lead Conglomerate	150-400
	Judith Formation	200
	Total	5600-8900

Judith Formation

The basal member of the Dundas Group was named by Elliston (1954) after Judith Creek, a small tributary of Comet Creek, but it is possible that the beds here may be part of the Crimson Creek Formation. The only locality in which fossils were found is about $1\frac{1}{2}$ miles to the SW, in South Comet Creek 400 feet upstream from the confluence with Stichtite Creek. The fauna includes *Lorenzella*, *Pachyaspis*, *Peronopsis*, *Ptychagnostus*, *Pagetia* and *Triplagnostus*, correlated with the *Ptychagnostus gibbus* Zone (Opik, 1951 a, b; 1956, and Banks, 1956). A. B. Gulline mapped thin-bedded pale yellowish or cream shale and greywacke overlain by greenish-grey micaceous siltstone with partings of greywacke in which fossil fragments were found. The fossiliferous horizon lies below at least 100 feet of sheared greywacke conglomerate with rounded and angular chert pebbles. The conglomerate was named the South Comet Grit by Elliston, though it resembles closely the Red Lead Conglomerate exposed near the junction of South Comet Creek and Adelaide Creek about $\frac{1}{2}$ mile SW, and also conglomerate mapped

below the Hodge Slate near the Razorback mine by Blissett and Gulline (1961b). Westwards, the Judith Formation may be faulted against serpentinite along the line of Stichtite Creek, but the boundary is obscured by deep weathering and downwash.

In South Comet Creek, the conglomerate is overlain by brown weathered greenish and grey shale, siltstone and greywacke and in the lower part of Adelaide Creek by poorly exposed yellowish-brown weathered siltstone. Further east, the succession is confused by faulting, folding and the lack of fossiliferous horizons.

It appears possible that the *Ptyagnostus gibbus* Zone lies below the Red Lead Conglomerate, which is succeeded by the Hodge Slate.

Red Lead Conglomerate

Purplish-red, grey and greenish greywacke conglomerate and pebbly grit, containing rounded, subangular and angular pebbles and cobbles of chert and quartzite are set in a matrix of greywacke grit. The formation is about 250 feet thick in South Comet Creek, but may be as much as 400 feet thick north of the Razorback mine. The prominent outcrop of conglomerate on the ridge south of the South Comet mine may be equivalent as suggested by Elliston (1954) though no fossils have been found in the overlying hard dark grey and grey siltstone and fine quartzite towards Adelaide Creek. The conglomerate is poorly sorted and includes rounded to subangular fragments of chert, quartzite and siltstone up to about 12 inches in diameter, with impersistent bands of khaki-weathered greywacke and green subgreywacke.

The formation resembles the Razorback Conglomerate and certain horizons in higher conglomerates in the Dundas Group so that correlation by lithology alone is not conclusive.

Hodge Slate

The type area is near the Razorback mine where dendroids and fragments of trilobites were first discovered (Thomas and Henderson, 1945). The sequence is about 600 feet thick and includes hard grey to black laminated micaceous shale, flaggy siltstone and silty mudstone, with numerous partings of pale greywacke which becomes more abundant towards the top below the Razorback Conglomerate. Similar beds were mapped north of the Grand Prize mine and along the North East Dundas Tram east of Kapi Creek, though no fossils were found. Hereabouts, the Hodge Slate is in contact with deeply weathered pyroxenite and though the boundary is rarely visible, it is faulted in part near Kapi Creek.

Near the Razorback mine, Elliston (1954) recorded cystoid ossicles and a trilobite pygidium within the succession, and on the North East Dundas Tram west of Bonnie Point he collected *Solenoparia* sp., Bathyriscids and ?*Homagnostus* (Banks, 1956). In a personal note to Banks (1956), Opik correlated the assemblage with the upper part of the *Ptyagnostus atavus* Zone or the *P. punctuosus* Zone.

Razorback Conglomerate

The formation resembles the Red Lead Conglomerate and is about 250 feet thick on the summit of Mt Razorback. It includes massive grey, greenish and purplish-red greywacke-conglomerate

and chert breccia-conglomerate which form prominent craggy outcrops. The inclusions are of subangular to rounded pebbles and cobbles of pale grey and pale green chert, red jasper, black siltstone or slate and pale quartzite. There may be impersistent bands of buff-weathering greywacke and siltstone interfingering with conglomerate or pebbly greywacke grit as on the ridge NE of the Grand Prize mine.

The formation was mapped NE across the North East Dundas Tram near Confidence Saddle as far north as the Ring River where indurated chert- and greywacke-conglomerate is injected by tongues of fine-grained pyroxenite above the main intrusion.

The stratigraphical position of the conglomerate on Moores Pimple is uncertain. It contains distinctive rounded to subangular pebbles of green and pink chert, red jasper, and pink and milky quartz in an ill-sorted matrix of pebbly greywacke-grit and may be equivalent to the Razorback Conglomerate as suggested by Elliston (1954). However, it appears to overlie dolomitic siltstone and chert correlated in this report with the Crimson Creek Formation, in a similar manner to conglomerate in the Little Henty River. It may be the continuation of the sheared fuchsitic conglomerate in Natone Creek near Rosebery Cemetery.

There are a number of conglomerate bands in the complex region near Godkin Ridge and Montezuma Falls but correlation with the Razorback Conglomerate and higher formations is problematical. The formation was not found west or north of Mt Dundas.

West of the Grand Prize Mine, the Queenstown-Rosebery road has been cut through a ridge of pale green conglomerate with purple and red fragments of chert, jasper, quartzite and pale cream or milky quartz. The inclusions are chiefly subangular, with a small proportion of rounded green and cream greywacke grit.

Brewery Junction Formation

This is a variable succession of grey, green and purple siltstone, slate or shale with frequent alternations of yellowish-brown weathered greywacke. Purple and green greywacke-grit and breccia-conglomerate are common, and increase in thickness in the upper part of the formation, which passes up into the Fernfields formation. A bed of keratophyric tuff was mapped near the base of the succession by Banks (1956) and a similar band was noted by A. B. Gulline north of the Dundas Rivulet on the southern slopes of Mt Razorback. In the type area along the Dundas Rivulet, the formation is about 2000 feet thick. Banks (1956) recorded trilobites and cystoids just below the top of the succession on the South Comet tram but they were distorted and Opik was able to recognize only *Agnostus* (or *Homagnostus*?) and *Ptychagnostus*? In brown micaceous siltstone about $\frac{1}{4}$ mile NW of the Adelaide mine, A. B. Gulline discovered agnostids including *Oedorhachis* and *Clavagnostus* (M. R. Banks, pers. comm.).

SW of Montezuma Falls and on Godkin Ridge is a sequence of laminated grey and green siltstone, greywacke and greywacke-grit with bands of greywacke- and chert-conglomerate. Interbedded porphyritic basalt and allied pyroclastic rocks have been described by Scott (1954) but they are subordinate to the sedimentary rocks.

Banks (1956) correlated these with the Brewery Junction Formation which they resemble. East of Confidence Saddle and in the Ring River, similar rocks succeed the Razorback Conglomerate, but because of close folding and intense faulting the succession is difficult to work out east of Great Northern Creek. The beds are placed tentatively in the Brewery Junction Formation. Gatehouse (1961) identified *Nepea* among specimens collected by R. P. B. Pitt in brown weathered thinly-bedded siltstone about $\frac{1}{4}$ mile west of Montezuma bridge. The age is thus upper Middle Cambrian or lower Upper Cambrian, suggesting that here the succession may range up to the horizon of the Comet Slate.

On the tram near a spur west of Great Northern Creek, about $\frac{1}{2}$ mile SE of Confidence Saddle, A. B. Gulline found fragments of trilobites in brown stained greywacke and grey siltstone.

Fernfields Formation

On the old tram from Dundas to the Adelaide mine, bands of greywacke-grit and conglomerate become more abundant in the upper part of the Brewery Junction Formation and pass up into the Fernfields Formation which is about 1950 feet thick in the Dundas Rivulet. The sequence is mainly rudaceous and consists of coarse purplish-red conglomerate with bands of interbedded purple mudstone, siltstone and weathered greywacke up to at least 30 feet thick. The conglomerate is variable in facies, and contains rounded pebbles or cobbles of chert, green and purple siltstone and quartz up to about 6 inches in diameter, in a matrix of purplish greywacke grit. At some horizons, a few large pebbles or cobbles are scattered throughout a gritty matrix. Toward the top, the conglomerate is very coarse with boulders of quartzite up to about 12 inches across. Elliston (1954) compared it with the Owen Conglomerate.

East of the Grand Prize mine, the formation is about 1000 feet thick and was described by Blissett and Gulline (1961b). A number of conglomerate bands were mapped in the closely-folded and faulted country east of Confidence Saddle on the North East Dundas Tram. Though they are often chert-conglomerate similar to the Razorback Conglomerate, greywacke-conglomerate does occur, for example on the abandoned transmission line 1 mile east of Confidence Saddle on a spur leading north from Godkin Ridge. The conglomerate is less than about 200 feet thick and is overlain by greywacke and siltstone in which *Nepea* was found by R. P. B. Pitt about $\frac{1}{4}$ mile to the south. It may therefore be equivalent to the whole or part of the Fernfields Formation, or may be an imper-sistent bed within higher formations.

Comet Formation

In Dundas Rivulet near the confluence with South Comet Creek, the formation is about 1000 feet thick. It is conformable on the Fernfields Formation and consists of purple, green and grey siltstone, mudstone and shale, with scattered bands of greywacke-conglomerate and greywacke-grit. The shale or siltstone is locally highly cleaved and slaty, though bedding is usually visible.

Some horizons are highly fossiliferous. In Barkers Creek, west of Carbine Hill, Elliston (1954) discovered trilobites, including agnostids, amongst which Opik identified *Blackwelderia* cf. *biloba*

Kobayashi, *Conocephalites?*, *Oidalagnostus* and *Anomocarella?* (Banks, 1956). About $\frac{1}{4}$ mile north of the junction of the Dundas and Queenstown-Rosebery roads, and 100 yards east of the power line east of the road, A. B. Gulline found well preserved trilobites including *Damesops bilobus* in pale purplish-grey slaty siltstone. He also discovered sheared and distorted trilobite remains in brown weathered siltstone and fine greywacke in a tributary of Nevada Creek, $\frac{1}{4}$ mile south of the Grand Prize mine. About $\frac{1}{4}$ mile further east, about 50 feet above the south bank of the same stream, the author uncovered small weathered crags of khaki-coloured siltstone crowded with well preserved trilobites with some agnostids. Specimens from these localities were examined by Gatehouse (1961) who identified *Lejoppe*, *Doryagnostus*, *Cyclagnostus*, *Pseudagnostus Clavagnostus*, *Amphoton (Sunia)*, *Nepea*, *Agraulos* and *Damesops bilobus*. He also recognized *Cyclagnostus*, *Eodiscus*, *Dolichometopus*, *Nepea* and *Agraulos* amongst fossils collected by A. B. Gulline about 200 yards SE of the Grand Prize mine so that the rocks here appear to belong to the Comet Formation, and not the Brewery Junction Formation as indicated by Blissett and Gulline (1961b).

It appears likely that part of the confused succession on the North East Dundas Tram west of Bonnie Point may be equivalent to the Comet Formation. In a note to Banks (1956), Opik recorded *Coosia*, *Pseudagnostus* and *Aphelaspis* (?) among specimens collected by Elliston in 1951 about 1000 feet east of Bonnie Point. In the vicinity, A. B. Gulline and D. I. Groves obtained several trilobites which M. R. Banks (pers. comm.) believed may be upper Middle Cambrian or lower Upper Cambrian.

Fernflow Formation

The formation is about 500 feet thick and resembles the Comet Formation, but beds of massive coarse purple or green conglomerate are more abundant. As in the Fernfields Formation, boulders of quartz, quartzite and siltstone may be scattered throughout a matrix of purplish greywacke grit.

Climie Formation

The Fernflow Formation passes without a break up into the Climie Formation which is about 1500 feet thick in the Dundas Rivulet. There are bands of conglomerate in the lower part, which become fewer and thinner upwards. The apparently unfossiliferous sequence is composed mainly of purple and green greywacke, siltstone and highly-cleaved slate. Downstream, towards the bridge, the beds have been overturned and sheared.

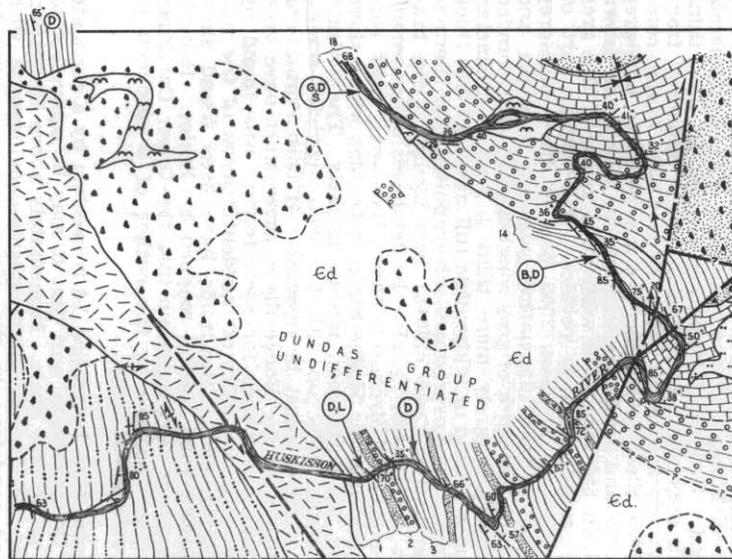
Misery Conglomerate

This formation resembles the Ordovician Owen Conglomerate, but was regarded by Elliston (1954) as part of the Dundas Group because of a probability that there is a faulted contact with the overlying Ordovician Gordon Limestone. In this report, the conglomerate is correlated with the Mt Zeehan Conglomerate and its relations with the Dundas Group are discussed in the section on the Junee Group.

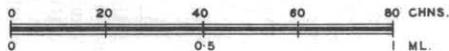
Huskisson River District (See Figure 4)

The detailed stratigraphy has been described by Taylor (1954d) and Banks (1956). Lithology is comparable with the Dundas area, but there are important differences. The succession is generally

FIGURE 4.



DUNDAS GROUP - HUSKISSON RIVER

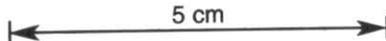


LEGEND

- | | | |
|------------|--|-------------------------------------|
| QUATERNARY | | ALLUVIUM |
| | | OLDER ALLUVIUM, MARSH DEPOSITS ETC. |
| | | MORAINE. |
| SILURIAN | | CROTTY QUARTZITE. |
| ORDOVICIAN | | GORDON LIMESTONE |
| | | MT. ZEEHAN CONGLOMERATE. |
| CAMBRIAN | | SHALE & SILTSTONE |
| | | GREYWACKE & SANDSTONE. |
| | | CONGLOMERATE |
| | | TUFF. |
| | | SERPENTINITE |
| | | CRIMSON CREEK FORMATION |
-
- | | | | |
|--|------------------------|--|--------------------------|
| | FAULT POSITION APPROX. | | FAULT INFERRED. |
| | STRIKE & DIP OF BEDS. | | VERTICAL BEDS. |
| | VERTICAL SHEARING. | | STRIKE & DIP OF CLEAVAGE |
-
- (DL) FOSSIL LOCALITIES :-
- B - BRACHIOPODS
 - D - DENDROIDS.
 - G - *GLYPTAGNOSTUS RETICULATUS*
 - S - SPONGE SPICULES.
 - L - LINGULID.
- NUMBERS REFER TO FORMATIONS OF TAYLOR (1954).

A. H. BLISSETT,
SEN. GEOLOGIST 1962

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finer than in the type area and there is little purple, red or green mudstone and siltstone which is characteristic elsewhere. There are a number of massive conglomerate bands, but they are usually thinner and finer than at Dundas and Zeehan. True greywacke is comparatively rare. Not more than 4000 feet of beds lie below the *Glyptagnostus reticulatus* shale and above the serpentinite intrusion which is provisionally taken as the base of the Dundas Group in this report, following Taylor (1954d) who subdivided the succession on the Huskisson River into Formations 1-19. The whole of the river section was not re-examined during the present survey, but an investigation was made of the base and upper part of the succession.

About 1½ miles upstream from the mouth of the Huskisson River, a sill-like mass of serpentinite and pyroxenite has intruded dark laminated slaty shale which has been altered at the contact to mottled pale grey and greenish chert. About 80 yards upstream, the author found dendroids and a lingulid in hard, black, faintly laminated slaty shale (Formation 1 of Taylor 1954d). A poorly-preserved dendroid was also found at a similar horizon about 1½ miles NW. Eastwards, the beds are overlain by indurated black slate and siltstone with bands of greywacke and fine conglomerate locally feldspathized. The next formation consists of fine, thin-bedded, hard, dark grey shale from which Taylor obtained fragments of dendroids (Formation 3). The beds which Taylor compared with the Hodge Slate at Dundas are succeeded by blue-grey sandstone, grey shale and mudstone, overlain by a grey or brown shale formation about 350 feet thick with three bands of fine grey conglomerate with rounded quartz pebbles. The higher part of the succession consists of at least 2000 feet of hard blue-grey shale with sandstone partings, alternating with subgreywacke, and several bands up to 160 feet thick of grey conglomerate with rounded quartz and chert pebbles rarely more than ½ inch in diameter. The sequence includes a band of feldspathic tuff about 90 feet thick (Formation 10). Fossils from overlying black graphitic slate (Formation 14) were examined by Opik (1951b) who identified the brachiopods *Protorthis* and *Otusia* (?), also the dendroids *Sphenoecium* Chapman and Thomas, and *Archaeolofoaea* Chapman. Opik correlated the formation with the Hodge Slate at Dundas where these dendroids occur, but this correlation appears unlikely. The problem was discussed by Banks (1956, pp. 191-192) who suggested several possibilities, most of which must be rejected. If both Formations 3 and 14 are equivalent to the Hodge Slate, there must have been isoclinal folding but no evidence for such folding was found by the author. There is no possibility of misidentification of the fossils in the lower formation as dendroids have been found since below the lowest fossiliferous horizon mapped by Taylor. Banks's suggestion that dendroids may range up into the Upper Cambrian was confirmed by the discovery by the author of a specimen in the *Glyptagnostus reticulatus* shale.

Mapping indicates that Formation 14 is overlain by a correlate of the Mt Zeehan Conglomerate, and that it may be equivalent to the *Glyptagnostus reticulatus* shale. Immediately above Formation 14, Taylor recorded 120 feet of chert breccia-conglomerate with bands of shale and sandstone in the upper part, succeeded by about 450 feet of coarse, faintly pink stained, grey conglomerate forming a steep gorge (Formation 16). The pebbles are up to 4

inches in diameter and are mainly well-rounded. Taylor observed "apart from the colour, the general aspect of this conglomerate is remarkably similar to that of the West Coast Range [Owen] Conglomerate". The author has examined the field notes of Taylor and D. Burger. There are a number of small, tight bends in the river imposed by the resistant conglomerate. Upstream, the conglomerate is overlain by coarse brown sandstone with thin alternations of fine conglomerate near the base, which may be equivalent to the Moina Sandstone, but it is probably less than about 50 feet thick (Formation 17). The next formation is of fine limestone passing up into coarsely crystalline limestone with calcite veins which is certainly the Gordon Limestone as Taylor (1954d) mapped overlying Eldon Group rocks to the north. The Huskisson River flows SSE across the dip and the lower 400 feet of the limestone is exposed in the river before its course turns westwards across the strike of the weathered limestone and an underlying conglomerate (Formation 19). The formation is somewhat finer than Formation 16 and consists of rounded pebbles of quartzite and chert in a sub-greywacke matrix, but exposures are not continuous. At the top, Taylor noted banded fine conglomerate and sandstone (Moina Sandstone?) overlain by thin-bedded brownish-green mudstone which probably marks the base of the Gordon Limestone; the succession is thus similar to that described downstream.

Further west, and stratigraphically below the conglomerate, is the *Glyptagnostus reticulatus* shale in which Taylor and Elliston found fossils in 1951. The zone fossil and spicules of cf. *Protospongia* were identified by Opik (1951b) who welcomed the discovery in Tasmania of this Upper Cambrian marker band of world-wide distribution. The locality was visited during the recent mapping programme and R. P. B. Pitt obtained several specimens of *G. reticulatus*. A few feet above the zone, the author found a small bifurcating dendroid. The sequence includes hard black carbonaceous shale or slate and laminated silty mudstone, and is probably about 300 feet thick though outcrops are not extensive.

The author would suggest that an exhaustive search be made for *G. reticulatus* in the black shale $\frac{3}{4}$ mile to the SE (Formation 14). The apparent passage into a correlate of the Mt Zeehan Conglomerate is discussed in the section on the Ordovician System.

Zeehan District (See Figure 15)

Only in two sections have fossils been found near Zeehan. In the Summit cutting on the Comstock tram, about $\frac{1}{4}$ mile east of the junction with Grubb's tram, Opik (1951c) identified *Diplagnostus* sp. and cystoids in sheared grey slate, interbedded with siltstone, and yellowish-brown weathered greywacke. Opik's correlation with the Hodge Slate is supported by the fact that the beds are overlain by shattered greenish-grey greywacke-conglomerate with some rounded chert fragments which resembles the Razorback Conglomerate.

About 2 miles SW, at least 500 feet of green and purplish greywacke, siltstone and mudstone exposed in the middle reaches of McLean Creek are correlated with the Dundas Group though only a few indeterminate fossil fragments and ?*Hyolithes* were seen. Southwards the beds may pass up into the Mt Zeehan Conglomerate and the boundary is described in the section on the Ordovician June Group.

Trial Harbour

The only rocks which at present can be correlated with the Dundas Group are about 2 miles SE of Trial Harbour on a ridge $\frac{1}{2}$ mile SE of the Little Henty River. D. I. Groves discovered a fragment of a trilobite in cleaved greenish siltstone and silty mudstone associated with grey subgreywacke. The specimen was examined by Gatehouse (1961) who commented that it consisted only of a few unidentifiable thoracic segments. At this point, the beds are probably faulted to the south against Mt Zeehan Conglomerate.

Farrell Rivulet-Henty River

In the SE portion of the Zeehan Quadrangle, rocks correlated with Dundas Group outcrop over at least 15 square miles but are partly blanketed by Pleistocene moraine of fluvio-glacial deposits. On the eastern limb of the Zeehan Syncline, red, purple and green shale, greywacke and greywacke-conglomerate continue south of Misery Hill in a continuous but faulted outcrop. No fossils were found, but the sequence lies with structural conformity below the Mt Zeehan Conglomerate. North of the lower reaches of Farrell Rivulet, the beds are locally overturned to the east, and they are faulted to the south against Devonian Bell Shale by the Little Henty Fault. East of the Queenstown road, about $\frac{1}{2}$ mile up Tom Creek, A. B. Gulline collected agnostids in grey laminated siltstone in a sequence which also includes green and purple siltstones, greywacke grit and conglomerate. Gatehouse (1961) concluded that the rocks are upper Middle Cambrian or lower Upper Cambrian.

About $\frac{1}{3}$ mile south, Howard's timber tram turns eastwards off the Queenstown road near the bridge over Farrell Rivulet. The tram is more than 5 miles long and winds across a long wooded southern spur of Mt Dundas. The first $\frac{1}{2}$ mile crosses rocks resembling the Moira Sandstone which may be faulted against a folded sequence at least 2 miles wide of ubiquitous greenish grey laminated mudstone and shale, siltstone and fine greywacke, with scattered beds of tuff or agglomerate. The characteristic coarse conglomerate bands are absent, though the type area of the Dundas Group is only one mile to the NW. One mile NE of the Moira Sandstone junction an exposure of fine green quartz conglomerate was mapped which consists of subangular quartz and greywacke pebbles, mainly less than $\frac{1}{2}$ inch in diameter, in a greenish greywacke matrix. A few fragments of brachiopods were collected by the writer from green mudstone along a disused southern branch of the tram, $2\frac{1}{2}$ miles due east of the Queenstown road, and some 250 yards west of an outcrop of gabbro within the sequence. The fossil fragments are too poorly-preserved for identification but they are presumably from the Dundas Group.

The rocks strike south and are probably continuous beyond the southern boundary of the Quadrangle, but are obscured by glacial deposits, except in the valley of the Henty River and in a few places on the Queenstown road east of the Henty Bridge. The succession is similar to that along Howard's tram and in a small north flowing tributary of the Henty River, $1\frac{1}{2}$ miles NE of the bridge, the author found fossils at two horizons within hard pale green and grey mudstone and siltstone. A. R. Palmer (pers. comm.) identified spicules of the hexactinellid sponge *Chancelloria* sp. and suggested that the formation is upper Middle Cambrian or lower Upper Cambrian. The sequence is therefore part of the Dundas Group.

(3) MT READ VOLCANICS

In the Zeehan Quadrangle, the Mt Read Volcanics (Banks and Solomon, 1961) or "porphyroids" of many early authors are exposed on the Read-Dundas Plateau, east of Mt Dundas. The age and origin of these rocks have been major problems since Rosenbusch (in Twelvetrees and Pettard, 1900) compared quartz-keratophyre and allied rocks from Mt Read with certain porphyritic lavas in Europe. The formation was usually regarded as a thick sequence of extrusive lava flows interbedded with pyroclastic and sedimentary rocks, with some intrusive igneous rocks though Finucane (1932) thought that at Rosebery the porphyroids were Devonian intrusions into Cambro-Ordovician rocks. A detailed critical study was made by Carey (1947) who found abundant evidence of pyroclastic and extrusive rocks within sediments along the Emu Bay Railway north of Farrell Siding (5 miles north of Rosebery). Several authors considered the possibility that the Volcanics might be altered Cambrian rocks. Carey (1953) suggested that they may be lavas and sediments hydrothermally altered in the Devonian, while according to Scott (1954) they are sheared, silicified and albitized Cambrian spilitic rocks. Bradley (1954) put forward the hypothesis that the formation is metasomatized Cambrian greywacke and greywacke-conglomerate, and that it is therefore a metamorphic suite. Elliston (1954) thought that NE of Moores Pimple, the beds are hydrothermally altered conglomerate.

Jennings (1958, p. 28) and Solomon (1960) recorded the presence of the high-temperature form of quartz within porphyroids, indicating that they are volcanic in origin. Spry (1962b) and Campana and King (in Banks, 1962a) believed that they may be ignimbrites, or welded tuffs.

The age of the Mt Read Volcanics was also controversial. Some authors concluded that they are younger than the Dundas Group, for example Hills (1915b), Carey (1947) and Campana *et al.* (1958). Twelvetrees and Ward (1910) assumed that the volcanics were Cambro-Ordovician and part of the succession then correlated with the "Dundas Slates". Banks (1956) and Wade and Solomon (1958) placed the rocks in the Dundas Group. At Bulgobac, Campana *et al.* (1960) postulated that sedimentary rocks correlated with the Dundas Group rest with an angular unconformity upon the Mt Read Volcanics which they suggested are therefore Lower Cambrian. In reply, Banks and Solomon (1961) argued that the contact may be a disconformity of only local significance and that the stratigraphical position of the two formations is not precisely known. The disconformity may thus represent local erosion at any time during the deposition of the Dundas Group. Lavas and tuffs interbedded with the Dundas Group *sensu stricto* have been described by a number of authors, including Elliston (1954) and Banks (1956), and similar rocks have been recorded in the present work. Though the presence or absence of volcanic or pyroclastic beds is not in itself sufficient evidence to place formations at a definite horizon in the Proterozoic-Upper Cambrian succession, the author agrees with Campana *et al.* that at least part of the Mt Read Volcanics is older than the Dundas Group. However, it is likely that part may be equivalent in age to the Dundas Group.

The spilitic and keratophyric lavas and pyroclastic rocks in the upper part of the Oonah Quartzite and Slate, and in the Crimson Creek Formation at Zeehan have already been discussed. Hills and

Carey (1949) considered that quartzite and slate at Nubeena Hill, Zeehan (correlated in this report with the Oonah Quartzite and Slate) ". . . are also well-developed in the Read-Rosebery area where they are in the form of quartzitic schists and slates which occur in the lower workings of the Hercules mine and to the west of the main workings at Rosebery". The same authors described the Mt Read Volcanics along the West Coast Range and remarked that "At Zeehan, . . . 10 miles to the west of the main axis of vulcanism, a series of keratophyre tuffs outcropping on Argent . . . and . . . Austral Flats . . . appear to represent the same formation . . . In the Read-Rosebery area argillaceous and calcareous sediments and tuffs have been schisted". Earlier in this chapter, part of the keratophyre tuffs was placed within the Crimson Creek Formation which is probably conformable upon the Oonah Quartzite and Slate. Both formations contain dolomitic or calcareous beds. The author considers therefore that part of the Mt Read Volcanics at Rosebery may be equivalent to the upper horizons of the Oonah Quartzite and Slate and to the Crimson Creek Formation, which range in age from Upper Proterozoic to possibly Middle Cambrian. The fact that the volcanics may extend up into the Dundas Group *sensu stricto* is not disputed.

East of Moores Pimple on the track to Mt Read, fine chert breccia-conglomerate and greywacke pass eastwards into a thick variable assemblage of hard laminated greenish cherty siltstone or siliceous ash and slaty shale, greywacke and fine greywacke-conglomerate. There are many bands of interbedded pale green and pink agglomerate or tuff containing fragments of dark quartzite and silty slate, cream, green and pink feldspathic porphyry, and white-weathering rhyolite or keratophyre. The beds strike north and dip steeply to the east, though there has been minor close folding within the sequence. Similar rocks were mapped east of Mt Dundas, and in the Zeehan Quadrangle they are provisionally correlated with the Crimson Creek Formation. If the correlation is correct, it indicates that from the time during which the upper part of the Oonah Quartzite and Slate was deposited, vulcanism was concentrated chiefly along the West Coast Range with minor activity in the Zeehan district. In the Pieman River-Huskisson River region lavas or pyroclastic rocks are uncommon and scattered.

(4) PROBABLE CAMBRIAN ROCKS WEST OF HENTY BRIDGE

In the SE corner of the Quadrangle, west of the Queenstown road, a sequence of pale grey quartzite, green and purple shale, siltstone and greywacke or greywacke-grit has been folded along NNW axis into long angular anticlinal and synclinal structures plunging northwards. The succession is different from that east of the road, and resembles to some degree the Crimson Creek Formation elsewhere so that it may be Cambrian. To the north, the beds appear to be faulted against Moina Sandstone. Structures are similar in the latter formation and it is possible that the Cambrian rocks here plunge below the Moina Sandstone.

Cambrian Sedimentation

The problem of the provenance of Cambrian sediments was first studied by Carey (1953) who envisaged deposition in a eugeosynclinal trough between two Precambrian elements: the Tyennan Block to the east and the Rocky Cape Geanticline to the NW. A Middle Cambrian uplift (the Porphyroid Anticlinorium) formed a chain of volcanic islands supplying pyroclastic and volcanic

detritus to the trough. Most later authors have accepted the idea of a volcanic accumulation on the edge of depositional basins, though Banks (1956) pointed out that vulcanism was not confined to the margins. Campana *et al.* (1958) suggested that the Mt Read Volcanics are Lower Cambrian and were related to a system of faults near the edge of the trough. Banks and Solomon (1961) visualized a volcanic accumulation during part or all of Dundas deposition. Evidence which shows that vulcanism may have started in the Upper Proterozoic and continued throughout the Cambrian was described earlier in this chapter.

At Dundas, Elliston (1954) noted that the Cambrian formations tend to be impersistent, and postulated cycles of deposition which he related to periods of volcanic activity followed by long periods of sedimentation during which the finer beds were laid down. Banks (1956) concluded that at Dundas, there are at least 8 cycles each grading from coarse subgreywacke-conglomerate to slate or mudstone. He showed that the volcanic rocks are associated with the finer deposits and suggested that each cycle started with an orogenic uplift. An important contribution was made by Wells (1957) who described slump structures and graded bedding in the Cambrian rocks at Deloraine. He suggested that the absence of current-bedding, the presence of coarse graded deposits and clay pellets, textural variations and poor sorting are typical of high density currents. Wells assumed rapid deposition in shallow water of detritus from nearby high mountain ranges. At Queenstown, Wade and Solomon (1958) noted wide variations in lithology laterally and vertically and suggested that particular formations were rock units with little time significance. Solomon (1960) visualized sedimentation in impermanent basins and considered that contemporaneous deposition of any particular rock type was unlikely.

Apparent unconformities in a turbidite succession do not necessarily imply sub-aerial erosion as Crook (1959) demonstrated. Crook showed that both unconformities and para-unconformities may be due to scour by turbidity currents and that neither tectonic movement nor sub-aerial erosion may have taken place. He suggested that younger rocks containing inclusions of older mudstone or argillite could be derived by submarine erosion entirely within the depositional trough.

Heesen (1959) thought that depositional breaks might also be caused by the scouring effects of deep currents. The Blake Plateau, which covers 60,000 square miles at depths of 400-700 fathoms east of Florida and Georgia, has been swept clear of Recent and Pleistocene deposits by the Gulf Stream.

In the Zeehan Quadrangle, the Cambrian formations appear to have been deposited in a tectonically unstable trough bounded to the east by an off-shore belt of volcanoes, into which unsorted detritus, both sedimentary and volcanic, was poured rapidly. North and west of a line from Zeehan to Dundas, the sediments are generally finer and may indicate a relatively undisturbed environment in which thick mudstone and siltstone accumulated, with scattered intercalations of greywacke and conglomerate. The deepest part of the trough was along the Pieman and Huskisson Rivers where about 14,000 feet of Cambrian rocks are preserved. The rare lava flows are probably of submarine origin. The deposition of a number of conglomerate bands in Middle to Upper Cambrian

times may imply intermittent changes in sea level, or uplift of the source area to the east. Further to the SE, the Dundas district was probably nearer the shoreline and disturbed by frequent tectonic movements. Greywacke, greywacke-grit and conglomerate are abundant and may reflect changes in the volume and type of detritus flooding into the trough. On the other hand, they may represent sediment carried into deeper water by turbidity currents, as suggested by Wells (1957). It is possible that bands of pale impure quartzite within the Dundas Group were formed by the winnowing-out of clay material from unconsolidated graywacke by underwater currents. The lower horizons in the conglomerates are polymictic with a matrix of greywacke, sometimes passing up into siliceous conglomerate with boulders of quartz or quartzite in a quartz grit cement, as in the Fernfields Formation, Fernflow Formation and Misery Conglomerate. One possible explanation is that the lower beds were derived from erosion in the source area of Lower Cambrian siltstone, jasper and chert of which many of the pebbles are formed while during the deposition of the upper beds, the Cambrian rocks had been stripped off to expose Precambrian rocks which supplied detritus consisting mainly of quartzite and quartz. Another hypothesis is that the greywacke-conglomerate originated entirely within the eugeosynclinal trough, as suggested by Wells (1957) and Crook (1959), and that the siliceous beds were produced by sub-aerial erosion of a Precambrian terrain bordering the basin.

Cambrian Ultrabasic and Basic Intrusions

GENERAL DISCUSSION

Serpentine was noted on the West Coast by Sprent (1878). Montgomery (1890) recognized the basic and ultrabasic rocks near Trial Harbour, and Waterhouse (1915) compared gabbro at North Heemskirk with the large exposure west of Zeehan on the road to Trial Harbour. Most early workers assumed that the intrusions were an early differentiate of the Devonian Heemskirk Granite; for example Waller (1904), Twelvetees and Ward (1910) and Waterhouse (1916). But Carey (1947) noted the association of the ultrabasic rocks with Cambrian sediments and Hills and Carey (1949) argued that the intrusions are mainly sills and most abundant in Cambrian bedded rocks in a manner which suggests that they were intruded before folding. That they may be Cambrian is supported by the discovery of detrital osmiridium in the Owen Conglomerate at Adamsfield where further evidence was provided by Carey (1953) and Carey and Banks (1954). In 1943, D. E. Thomas had collected trilobites from the beds immediately above the serpentine in the Adamsfield area, though the contact was taken as a fault. Carey and others obtained other fossils in 1952 and it was shown that the serpentine was overlain conformably by conglomerate with pebbles of serpentine, and that there were also sedimentary concentrations of magnetite and probably chromite which might be marine placer deposits. The fossils were a few feet above the conglomerate and were succeeded concordantly by normal Owen Conglomerate. The specimens were examined by Opik (in Banks, 1962) who reported the presence of trilobites, both inarticulate and articulate brachiopods including *Eoorthis billingsella*, and gastropods such as *Scaevogyra*. According to Opik the fauna is younger than the Lower Dresbachian *Glyptagnostus reticulatus* Zone on the Huskisson River, and may range from Upper Dresbachian to Lower

Franconian. Thus at Adamsfield, the ultrabasic rocks must be older than Upper Cambrian. At Queenstown, Wade and Solomon (1958) recorded detrital chromite in the Upper Owen Conglomerate which is probably Lower Ordovician, though there is no known serpentine mass in the vicinity.

Taylor (1954d) considered that in one locality the Wilson River-Huskisson River serpentine complex is in contact with Ordovician Gordon Limestone, but Banks (1959) suggested that the junction is a faulted one.

The serpentinite at Dundas was taken as Upper Cambrian by Elliston (1954) because it apparently transgresses beds at the top of the Middle Cambrian and was displaced by Devonian faulting.

The gabbro at North Heemskirk and a small patch of dolerite on Eureka Plains are injected into the Upper Proterozoic Oonah Quartzite and Slate. The ultrabasic intrusions at Trial Harbour and west of the Comstock mine are thick sill-like or laccolithic masses near the boundary of the Oonah Quartzite and Slate and the overlying Crimson Creek Formation, and the serpentinite SE of Dundas may be at a similar horizon. On the Huskisson River, near Serpentine Hill, Pine Hill and east of Mt Razorback, pyroxenite, gabbro and serpentinite lie between the Crimson Creek Formation and the Dundas Group. There are many minor sills or dykes within the Crimson Creek Formation, but they are less common in the Dundas Group. The youngest rocks intruded appear to be the upper Middle Cambrian or lower Upper Cambrian beds along Howard's tram and near the Henty River, which contain gabbroic sills or dykes.

DISTRIBUTION

Trial Harbour

The rocks at Trial Harbour are peridotites and dunites which have been extensively converted to serpentinite (Waterhouse, 1916; Spry, 1962b). Crystals of magnetite are disseminated throughout the intrusion or are present as irregular bands, particularly near the chilled margins to the north and south. Minor segregations of nickel minerals occur, including pentlandite, heazlewoodite and zaratite. The northern margin with the sedimentary rocks is only about 200 yards south of the Heemskirk Granite and is an irregular injection zone rather than a sharp contact, with bands of dark hornfels and cherty siltstone included between tongues of chilled peridotite. The southern margin is irregular, and fine peridotite is in contact with indurated banded quartzite.

The intrusion which is about $\frac{1}{2}$ mile wide on the coast appears to wedge out about 2 miles south of east and may be a discordant sill.

Comstock District

West of the Tenth Legion Fault, hornblende-gabbro is exposed for at least $2\frac{1}{2}$ miles to the SW. The petrology of the rocks was described at length by Waterhouse (1916, pp. 32-40). The main mass of the intrusion is coarse grained and composed of plagioclase, including labradorite with a little albite and orthoclase, abundant prismatic crystals of hornblende and some pyroxene. Accessory minerals include apatite, magnetite and ilmenite extensively altered

to leucoxene. In places, feldspar has been converted to granular epidote and fibrous actinolite, while the hornblende has been chloritized.

The eastern end of the intrusion is faulted against Oonah Quartzite and Slate. At the Tenth Legion mine in the north, the gabbro has been partly serpentinized and dolomitized. Magnetite occurs in large irregular lenses and segregations within serpentinite or calc-silicate hornfels formed by the contact metamorphism of dolomitized serpentine by the Devonian Heemskirk Granite (Hughes, 1959). Along the southern margin the chilled edge of the intrusion is in contact with indurated Cambrian grit, chert and laminated hornfelsed siltstone. Exposures are poor, but the strike of the boundary is similar to that in the Cambrian Crimson Creek Formation and therefore the contact may mark the top of a thick transgressive sill or laccolith. The base of the intrusion is poorly exposed to the west and NW, but the gabbro becomes finer and basaltic near the junction with indurated quartzite and hornfels which form a narrow strip between the gabbro and the Heemskirk Granite.

The intrusion becomes thinner to the SW and appears to wedge out in dense scrub about 1 mile east of the Orient mine. There is no connection with the peridotite mass near Trial Harbour, 2 miles to the south-west, though Waterhouse (1916, p. 103) recorded thin dykes or sills of gabbro-amphibolite in Bridge Creek within beds correlated in this report with the Crimson Creek Formation.

North Heemskirk

Waterhouse (1915) noted an outcrop of gabbro about 1½ miles north of Donellys Lookout, which resembles the larger body in the Comstock district. Coarse gabbro is exposed on a low scrub-covered hill about ¼ mile across, and is overlain to the west by Tertiary basalt. A specimen was examined by G. Everard, Department of Mines petrologist, who reported that in thin section the rock consists of hypidiomorphic augite and labradorite, with a little accessory ilmenite partly altered to leucoxene. The labradorite has been extensively converted to kaolin and sericite while chlorite and felted needles of actinolite have been formed by the alteration of augite. Thus the rock is a uralitized gabbro. An analysis made by the Department of Mines Laboratory, Launceston, is given below:—

	%
SiO ₂	46.60
Al ₂ O ₃	14.30
Fe ₂ O ₃	3.04
FeO	12.87
MnO	0.08
TiO ₂	2.69
P ₂ O ₅	0.04
CaO	7.64
MgO	5.73
Na ₂ O	3.42
K ₂ O	0.36
H ₂ O—	0.40
H ₂ O+	3.20

(Reg. No. 840)

100.37

Dundas

The ultrabasic rocks east of Mt Razorback were described by Taylor (1955) and Blissett and Gulline (1961b). The intrusion is a sill-like body which appears to have been intruded at the base of the Dundas Group, and consists of pyroxenite which has been almost completely serpentinized except for craggy masses of pyroxenite near the Razorback asbestos prospect. Disseminated magnetite, chromite and traces of osmiridium occur throughout the intrusion and thin irregular veins of chrysotile asbestos were formerly worked about one mile NW of the Razorback mine. At the mine, slickensided serpentine which has been extensively dolomitized or converted to talc is faulted against the Hodge Slate.

SE of Dundas, bands and patches of mauve coloured stichtite ("chrome serpentine") are present in serpentinite near the Adelaide and Red Lead mines.

Melba Flat-Ring River

The ultrabasic rocks form a broad, irregular sill at least 4 miles long from SW to NE, which was intruded at the base of the Dundas Group. A detailed study of the complex was made by Ward (1909) who recognized two chief types of rock: gabbro and norite; pyroxenite and peridotite. The intrusions were also described at length by Taylor (1955). Spry (1962b) considered that the predominant rock is pyroxenite (enstatolite) which grades into saussurite norite near the Argent tunnel. The pyroxenite has been serpentinized locally, for example south of the Argent tunnel and in the Ring River, but serpentinite is subordinate, in contrast to the ultrabasic intrusions at Dundas. Below the Dundas Group, the upper part of the pyroxenite is relatively fine and has been almost completely decomposed by weathering.

To the west, the base of the sill is faulted, but it appears to follow the strike of the underlying Crimson Creek Formation which swings to a N-S trend west of the Melba Flat. The sill has thus been warped in company with the enclosing sediments.

Asbestos was worked at one period on Serpentine Hill, where chromite and magnetite are also disseminated through the rock. Low grade nickel deposits occur in the lower part of the intrusion in the Cuni district, as well as in thinner sills of pyroxenite or dolerite further west.

Colebrook Hill

An intrusion of partly serpentinized pyroxenite up to about 200 yards wide extends from the Pieman River south along the western flank of Colebrook Hill for at least $2\frac{1}{2}$ miles. Two miles south of the river, a branch of the intrusion strikes NW for $\frac{3}{4}$ mile and lenses out in the Exe River. Near the mouth of the Exe River about $\frac{1}{2}$ mile to the north, the southern extremity of the Wilson River-Huskisson River sill appears to be faulted off.

The Colebrook intrusion may therefore be a branching dyke within the Crimson Creek Formation.

Asbestos is developed locally near the old Olympic mine and on the north west flank of Colebrook Hill.

Wilson River-Huskisson River

Serpentinized banded pyroxenite forms a transgressive sill at least 1000 feet thick injected near the boundary of the Crimson Creek Formation with the overlying Dundas Group. In the Huskisson River, both the base and top have chilled margins and the surrounding sediments have been altered to chert or hornfels impregnated with magnetite. Taylor (1955) recorded small deposits of asbestos in banded pyroxenite on Rileys Knob. Osmiridium was formerly produced in the Wilson River field, in the NW extension of the ultrabasic intrusion north of the Zeehan Quadrangle.

SE of the Huskisson River, the sill can be followed across the Pieman River as far as the mouth of the Exe River, where it becomes thinner and has been intensely faulted.

There are many minor sills or dykes of fine grained pyroxenite, dolerite and serpentinite in the Zeehan region, especially in the Crimson Creek Formation. The highest beds intruded are upper Middle Cambrian or lower Upper Cambrian Dundas Group in the Henty River, upstream from the Queenstown road, so that intrusion of ultrabasic rocks in the area probably took place after about middle Upper Cambrian time.

Conclusions

Towards the end of Upper Proterozoic times or early in the Lower Cambrian, miogeosynclinal deposition characterized by abundant orthoquartzite was replaced by eugeosynclinal conditions during which many thousands of feet of fine mudstone, greywacke and conglomerate were deposited accompanied by the extrusion, and minor intrusion, of sodic lavas and tuffs of the spilite-keratophyre suite. In the north and west of the Zeehan region, conditions were relatively undisturbed and thick deposits of finer material were laid down, with rare lava flows. East of Zeehan towards the Read-Dundas Plateau on the unstable eastern margins of the trough, volcanic rocks are more abundant and include andesite, basalt, quartz-keratophyre and rhyolite flows. In Middle to Upper Cambrian times, periods of vulcanism appear to have alternated with periods during which large volumes of detritus were poured into the trough and locally redeposited by turbidity currents. In the late Upper Cambrian widespread ultrabasic or basic sills and dykes were intruded. They are thus later than the spilitic extrusive rocks though they may be genetically related as indicated by Turner and Verhoogen (1951, pp. 201-202; 240-241).

ORDIVICIAN SYSTEM (JUNEE GROUP)**Introduction**

Thureau (1888a) regarded the ore-bearing rocks of the Zeehan field as Silurian because of the fossils he found in them. It should be remembered that he wrote before the concept of the Ordovician System was established and the term "Silurian" covered what is now known as the Silurian proper and the Ordovician. Etheridge (1896) examined a collection of fossils from Zeehan which he regarded as having Lower Silurian (now Ordovician), Upper Silurian (now Silurian) and even Siluro-Devonian affinities. He wrote: "I think it is not impossible that they represent a series of beds homo-

taxially equivalent to the lower portion of the Upper Silurian". This opinion influenced subsequent writers though, as Banks (1962b) pointed out, the fossils did, in fact, come from Ordovician, Silurian and Devonian rocks.

Waller (1904a) correlated the red siliceous conglomerate on Mt Zeehan and the Professor Range with the prominent outcrops capping mountains in the West Coast Range about 15 miles to the east, believing that it lies at the base of the Silurian. At Zeehan, Twelvetrees and Ward (1910, p. 34) supposed that the conglomerate and overlying sandstone (Moina Sandstone) were Cambrian because to the east of the Denison Range (Central Tasmania), similar conglomerate was overlain by "the Ordovician limestone of the Gordon River", but the limestone at Zeehan was still regarded as Silurian. At Maydena, Koboyashi (1940) showed that the "June Series" of Lewis (1940) is Ordovician and Thomas (1945a) proved that the succession at Adamsfield is equivalent to it, but the conglomerate and limestone on the West Coast were thought to be Silurian or possibly Lower Devonian. The basis of the present classification was laid by Carey (1947) who placed the post-Dundas Group conglomerates throughout Tasmania in the basal Tremadocian. The June Group was eventually defined by Gill and Banks (1950) and recent work on its time range by Hill (1955) and others has been discussed by Banks (1957; 1962b).

Succession in the Zeehan Region June Group

Formation	Thickness (ft)
Top	
Gordon Limestone	1000-2000
Moina Sandstone	120-2000
Mt Zeehan Conglomerate	0-1500

The Mt Zeehan Conglomerate has been generally accepted as being equivalent to the Owen Conglomerate of the West Coast Range, and as unconformable upon the Cambrian. The formation, together with the overlying Moina Sandstone, occupies a similar position below the Gordon Limestone as does the Owen Conglomerate defined by Bradley (1954), or the Lower, Middle and Upper Owen Conglomerate of Wade and Solomon (1958). M. R. Banks (pers. comm.) remarked that there is no evidence that the conglomerate at Zeehan was continuous with that exposed on the West Coast Range and therefore the name Mt Zeehan Conglomerate (Waller, 1904) is used in this report. The conglomerate resembles the Roland Conglomerate defined by Jennings (1958) near Round Mount in North West Tasmania. The sandstone, grit and quartz-conglomerate resting conformably on the Mt Zeehan Conglomerate are similar to the Moina Sandstone which succeeds the Roland Conglomerate and the name is therefore appropriate. The Moina Sandstone may be equivalent to the Caroline Creek Sandstone. It will be demonstrated that the massive conglomerates may be impersistent facies within an arenaceous and rudaceous succession, and that in at least three localities (Misery Hill, the Huskisson River and McLean Creek) there may be a passage up from the Middle to Upper Cambrian Dundas Group.

DISTRIBUTION

(a) Zeehan District

On Mt Zeehan, the *Mt Zeehan Conglomerate* is exposed in a warped and faulted anticline which plunges towards the SE. The formation is apparently conformable on the Cambrian in McLean Creek, about 2 miles west of the Oceana mine.

Hard thin-bedded grey siltstone, fine quartzite, and yellowish-brown greywacke containing ?*Hyolithes* pass up into greywacke- and chert-conglomerate and pebbly grit. The conglomerate consists of many rounded pebbles of chert and jasper up to 6 inches in diameter resembling conglomerate in the Dundas Group. The formation becomes coarser and more siliceous upwards, passing into boulder conglomerate with bands of pebbly grit similar to the Owen Conglomerate in the West Coast Range. The strike of both the Cambrian rocks and the Mt Zeehan Conglomerate is E-W, with southerly dips ranging from about 40° to 65°. The relationship thus bears a striking resemblance to the passage from the Dundas Group to the Junee Group on Misery Hill. About 1500 feet of coarse Mt Zeehan Conglomerate is exposed for about $\frac{1}{2}$ mile southwards in McLean Creek.

West of the creek, the higher beds include purplish-red conglomerate with boulders up to 12 inches in diameter. To the east, coarse red conglomerate with bands of pebbly grit passes up into the Moina Sandstone.

North and NW of Mt Zeehan, the lower beds include coarse purplish-red conglomerate with well rounded cobbles and boulders predominantly of quartz and quartzite up to about 6 inches in diameter, in a reddish matrix of quartz grit. About $\frac{3}{4}$ mile south of the summit of Mt Zeehan and $\frac{1}{4}$ mile north of the Little Henty River, the formation includes many rounded boulders of quartzite and a few of pale chert, partly jasperized, up to 18 inches in diameter, in an unsorted matrix of pebbly grit. Irregular tongues and bands of purplish grit with clusters of pebbles interfinger with the massive conglomerate.

West of the railway bridge 5 miles SE of Zeehan, the Little Henty River flows west for about $\frac{3}{4}$ mile through Devonian rocks. Crossing the Little Henty Fault, the river winds through folded NW striking interbanded coarse conglomerate and laminated greenish-grey siltstone and subgreywacke near the junction with the overlying Moina Sandstone. Further downstream coarse conglomerate is exposed which has been sheared along NW and NE trends.

North of Zeehan, the Mt Zeehan Conglomerate is absent, leading previous workers, for example Bradley (1954) and Campana *et al.* (1958), to the conclusion that the Gordon Limestone overlaps and rests unconformably on Cambrian or Proterozoic rocks. However, the Moina Sandstone is present and is described below.

The *Moina Sandstone* is about 1200 feet thick on the flanks of the Mt Zeehan Anticline. On the eastern limb, near the Oceana mine, the Mt Zeehan Conglomerate is succeeded by pale grey, thin-bedded, quartzose, pebbly grit and grit in which the author found a poorly-preserved and unidentifiable trilobite pygidium. The sequence includes bands of pink-stained coarse quartzite, and, in

the upper part of the succession, distinctive bands up to 10 feet thick of quartzose grit or sandstone crowded with *?Scolithus* vertical to bedding. West of the Smelters road, $\frac{1}{2}$ mile north of the Oceana mine, the higher beds include pale grey pebbly grit, and conglomerate consisting mainly of subangular and subrounded pebbles of quartz up to about 2 inches in diameter. Rounded pebbles are uncommon. About $\frac{1}{4}$ mile west of the Oceana mine, pink and purplish conglomerate with pebbles of quartz and quartzite in a matrix of siliceous pebbly grit at the top of the Mt Zeehan Conglomerate is overlain by pale grey pebbly grit which passes up into subgreywacke grit with small chert fragments, and hard sandstone with interbedded pebbly grit.

East of McLean Creek, on the western limb of the anticline, red boulder conglomerate and pebbly grit are succeeded at the base of the Moina Sandstone by banded pink pebbly grit and conglomerate which is overlain by pebbly grit and coarse sandstone or quartzite. At about the middle of the succession further south on the northern slope of the Little Henty River there are massive purplish grit and pebbly grit, and faintly pink siliceous quartzite with *?Scolithus* normal to bedding. South of the Little Henty *?Scolithus* is present in massive and thin-bedded pale quartzite and pebbly grit. On a ridge south of the river about $1\frac{1}{4}$ miles west of the railway bridge, similar rocks north of the Little Henty Fault have been brought in contact with Devonian Florence Quartzite.

West of Dunkley's tram, about 2 miles north of Zeehan, Moina Sandstone is exposed in two outcrops which are probably faulted to the west against the Oonah Quartzite and Slate, and it is overlain to the east by weathered Gordon Limestone. The largest exposure is $\frac{3}{4}$ mile SE of the Montana Silver-Lead mine and is about $\frac{1}{4}$ mile across. It consists of pale-weathering quartzose conglomerate with some rounded pebbles up to about 2 inches in diameter, as well as pale coarse quartzite cut by barren quartz veins. The smaller outcrop is about $\frac{1}{2}$ mile further north.

The Gordon Limestone in the Zeehan region generally is rarely exposed and has decomposed into black, dark grey and blue-grey clay or soft shale which form swampy button-grass flats near the water-table. It is probably about 900 feet to 1000 feet thick. A few blocks of dark arenaceous limestone were noted near the old Despatch mine, about $\frac{1}{2}$ mile north of Zeehan post office. Small outcrops of massive dark grey to black limestone occur below the remains of Heberlein's house near the junction of the Oceana mine road with the Smelters road. Banks (1957) described light-grey recrystallized limestone in Fox's open-cut, and in the Smelters Quarry impure limestone overlain to the east by interbedded limestone and dark siltstone. Hill (1955) noted blue-grey to black impure limestone with grey-black argillaceous bands in cores from a borehole at the Oceana mine. Also in the mine, Jack (1961) described medium to dark grey finely crystalline limestone, partly dolomitic, with argillaceous, siliceous and carbonaceous horizons.

The base of the Gordon Limestone is rarely exposed, but at several points along the Smelters road and south of the Oceana mine, pebbly grit and sandstone (Moina Sandstone) are overlain by a few feet of greenish shale or rotten arenaceous limestone and calcareous sandstone.

(b) *Professor Range*

Four miles SE of Mt Zeehan, *Mt Zeehan Conglomerate* strikes NW and dips SW at angles between about 35° and 60° at the western end of the Professor Range. To the east, the formation is folded into a NNW trending and plunging syncline, and to the north the sequence is faulted against scree-covered Gordon Limestone. In the west, medium pink conglomerate with thin bands of pebbly grit passes up into coarse cobble conglomerate. The highest beds are of bleached conglomerate composed of pebbles of quartz, quartzite and chert up to about 3 inches in diameter. In the centre of the hill, sheared pale conglomerate with pebbles of quartz, quartzite, jasper and grey and pink chert are overlain by massive pink siliceous conglomerate containing thin interbedded bands of fine conglomerate or pebbly grit. At the eastern end of the hill, variable red and pink conglomerate includes rounded pebbles and cobbles up to at least 6 inches in diameter of rounded quartz and quartzite and subrounded to subangular jasper and chert.

The Mt Zeehan Conglomerate is about 1000 feet to 1200 feet thick.

The *Moina Sandstone* is from 1750 feet to 2000 feet thick and follows the Mt Zeehan Conglomerate conformably. At the base in the west, pale grey quartz conglomerate or siliceous pebbly grit passes up into cross-bedded, pale grey, quartzose, pebbly grit and sandstone, with bands of ?*Scolithus* above the middle of the succession. East of the Professor Range, similar rocks with ? *Scolithus* are folded into a NNW plunging anticline.

The *Gordon Limestone* is poorly exposed. On the railway line, one mile west of the Professor Range, a small outcrop of disturbed thin-bedded fine grey quartzite, siltstone and silty shale was mapped at about the middle of the formation. Near Grieve Siding, black pug is exposed in an old mining prospect and similar decomposed outcrops may be seen westwards along the railway. Gill and Banks (1950) noted that here the base of the limestone is argillaceous and arenaceous. NE of the Professor Range, the valley of Amber Creek is cut in decomposed Gordon Limestone which is blanketed by recent gravels and sands. The thickness of the Gordon Limestone is about 1750 feet to 2000 feet.

(c) *Little Henty River*

Mt Zeehan Conglomerate two miles SW of Mt Zeehan has been briefly described by Blissett and Gulline (in Banks, 1962b). It is exposed on a peneplaned and faulted NW trending plateau about 3½ miles long and ¾ mile wide, separated from Mt. Zeehan by the Little Henty Syncline. The formation is probably at least 1500 feet thick though except in the larger creeks, outcrops are poor. The chief rock is coarse pink or red conglomerate with cobbles and boulders of quartz and quartzite up to at least 9 inches in diameter which passes up into red pebbly grit. The formation occurs in two main outcrops separated by a down-faulted block of sheared conglomerate and poorly exposed Silurian Crotty Quartzite or *Moina Sandstone*. Within the central block, conglomerate with boulders up to 2 feet across forms a steep ridge overlooking Fen Creek. The western block is probably faulted against the Dundas Group to the NE. No definite *Moina Sandstone* was seen and it may have been faulted out. *Gordon Lime-*

stone is not exposed, but it probably underlies superficial deposits on the swampy flat in the middle reaches of Fen Creek north of the Plateau.

(d) *East limb of Zeehan Syncline (North)*

A button-grass flat east of the syncline probably obscures *Gordon Limestone*. The NNW lineation of the flat is interpreted as marking the faulted junction with the Cambrian Crimson Creek Formation west of the Cuni area. At the Leslie prospect, near the Rosebery road about 500 yards north of the Dundas turn-off, an old shaft and trenches have been cut in black limestone pug which is faulted to the east against the Cambrian Dundas Group. A few small outcrops of fine dark grey impure limestone were noted in Leslie Creek, about $\frac{1}{4}$ mile north west of the prospect. No *Moina Sandstone* or *Mt Zeehan Conglomerate* was seen north of Misery Hill.

(e) *Misery Hill*

(See Figure 5)

The apparent passage from the Dundas Group into the Junee Group on Misery Hill has aroused interest for some years. The conglomerate was regarded as the basal member of the Junee Group (Jukes Conglomerate) by Hills and Carey (1949). It was named the Misery Conglomerate by Elliston (1954) and placed at the top of the Dundas Group. He thought that the *Gordon Limestone* is either faulted against the conglomerate or that it is transgressive, and suggested that higher Cambrian beds than the conglomerate continue in the Dundas Rivulet. Bradley (1954, p. 218) placed only about 100 feet of sandstone and grit (*Moina Sandstone*) within the Junee Group.

In view of its importance, the area was mapped in detail. Though there has been faulting, the position of the *Gordon Limestone* is clear. The conglomerate is overlain conformably by pebbly grit and pale sandstone in which a poorly preserved trilobite pygidium was found. South of the summit of Misery Hill, the latter formation is overlain by decomposed *Gordon Limestone*, followed by the Silurian-Devonian *Eldon Group* so that it is equivalent to the *Moina Sandstone*. West and NW of Misery Hill, the boundary between the conglomerate and the *Moina Sandstone* strikes obliquely to the trend of the limestone flat, and thus the junction with the *Gordon Limestone* is probably a fault (See Figure 5). Faulting near the quarry and to the NE is within conglomerate or interbedded and underlying greywacke and mudstone. No fault contact was seen between the conglomerate and the *Moina Sandstone* or *Gordon Limestone*.

In Dundas Rivulet, north of the bridge, sheared conglomerate and the underlying *Climie Slate* (*Dundas Group*) have been overturned and there are no Dundas-type beds above the conglomerate. Downstream, south of the bridge, the rivulet flows across an alluvial flat resting on decomposed *Gordon Limestone* and then through Silurian and Devonian formations.

From the above evidence, the conglomerate is correlated with the *Mt Zeehan Conglomerate*. On Misery Hill the formation is about 500 feet thick, and follows conformably upon green and

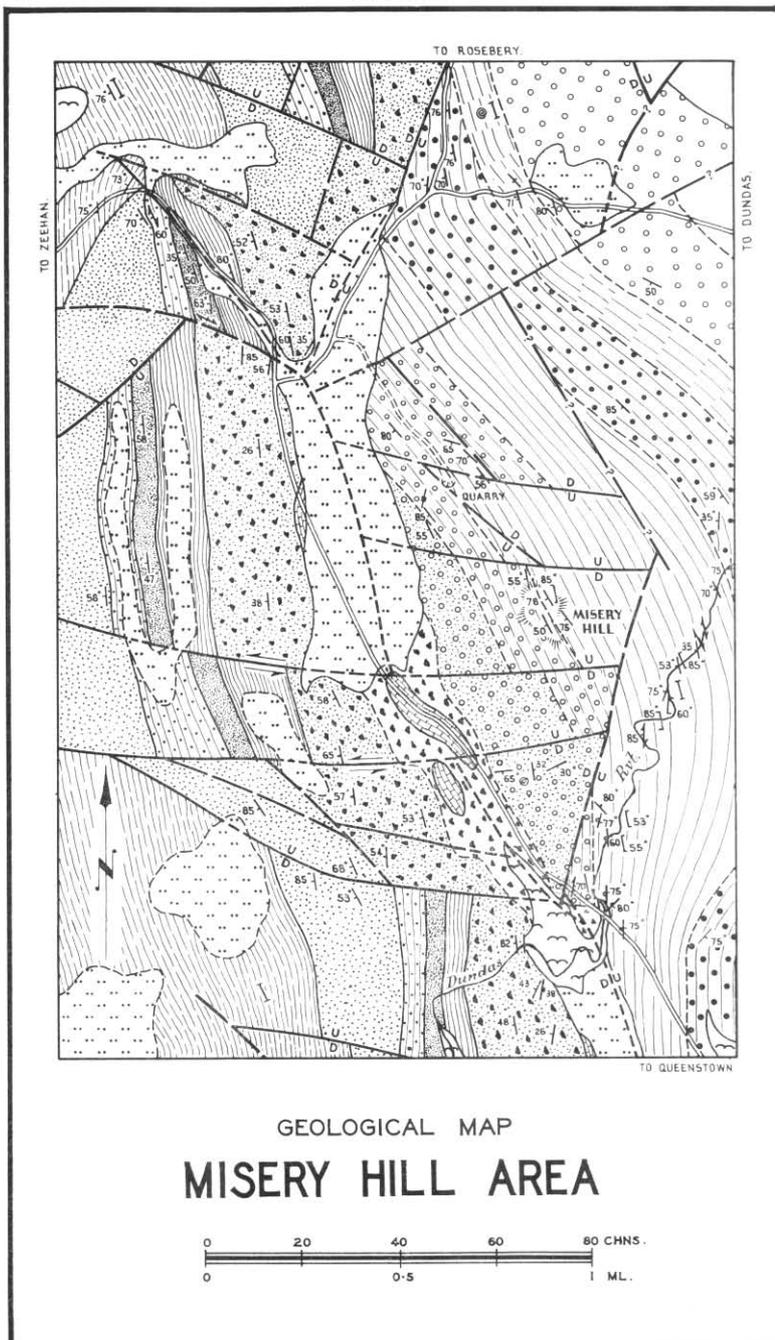
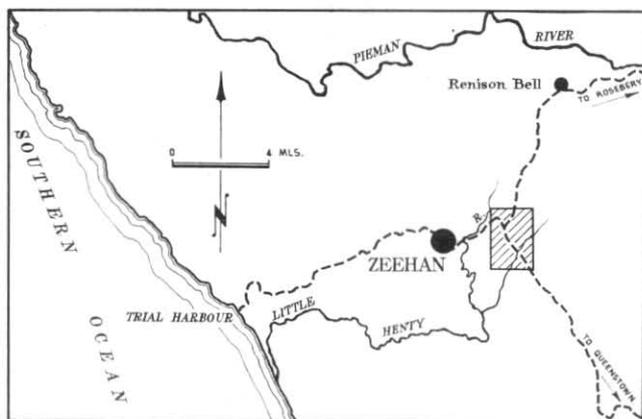
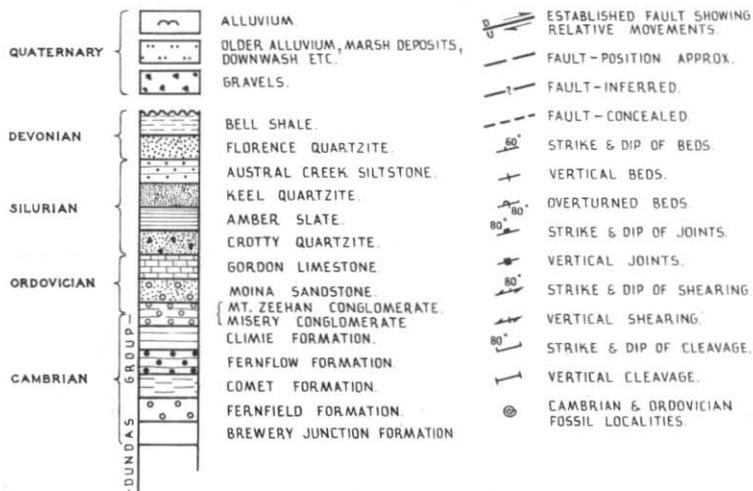


FIGURE 5.

**LOCALITY MAP****LEGEND**

A. H. BLISSETT,
SEN. GEOLOGIST 1962

WITH ACKNOWLEDGMENT TO A. B. GULLINE

5 cm

purple greywacke, siltstone and mudstone in the upper part of the Climie Slate. In the quarry at the north end of the hill, jointed and slickensided bands of hematitized conglomerate are interbedded with red and purple pebbly grit. The conglomerate includes many rounded cobbles and boulders up to 1 foot long of purple quartzite, purple, grey and green chert, pink quartz, and hematitized siltstone in a matrix of pebbly grit formed of similar material. On the top of Misery Hill, coarse cobble and boulder conglomerate in the middle of the succession consists chiefly of rounded hematitized quartzite, chert and pink stained quartz in an ill-sorted chert and quartz matrix. The higher beds include purple conglomerate with well-rounded pebbles of quartzite, chert, jasper and quartz in a gritty matrix.

The *Moina Sandstone* is about 900 feet thick and the base is marked by a change in colour to grey though there may be pink staining locally. Pale grey conglomerate with bands of pebbly grit containing rounded pebbles of bleached quartzite and quartz pass up into pale grey saccharoidal grit, arkose and quartzite alternating with siltstone and greenish shale.

The *Gordon Limestone* is about 900 feet thick though part of the succession may have been cut out by faulting. The junction with the *Moina Sandstone* is not exposed and the limestone has weathered into a buttongrass flat blanketed by alluvium and gravels. Patches of dark pug may be seen in cuttings along the road, and in Black Jack's prospect.

(f) *East limb of Zeehan Syncline (South)*

For $1\frac{1}{4}$ miles south of Misery Hill, the *Gordon Limestone* is the only formation in the June Group exposed, though it is largely obscured by superficial deposits. About $\frac{1}{2}$ mile south of the Little Henty bridge decomposed calcareous shale, dark arenaceous limestone with thin veins of calcite and indurated calcareous quartzite near the top of the formation may be seen in cuts at the old Mariposa mine. About 200 yards to the east, a NNW trending line of quartz and pyrite outcrops may mark the faulted contact with the Dundas Group.

Three-quarters of a mile further south, Mt Zeehan Conglomerate and *Moina Sandstone* are exposed on a prominent hill, west of the Queenstown road and east of the Dundas Rivulet, and faulted outcrops extend for 2 miles SSW as far as the Little Henty Fault. At the north end of the outcrop, the *Mt Zeehan Conglomerate* consists of pink conglomerate with pebbles of quartz and quartzite up to at least 4 inches in diameter, with interbedded pebbly grit. A band of conglomerate 10 feet thick was noted containing rounded boulders up to 9 inches in diameter. Further south, A. B. Gulline mapped less than 300 feet of conglomerate which, though overturned, appears to be in structural conformity with the Dundas Group to the east.

The *Moina Sandstone* is about 1200 feet thick, consisting of white and pale grey feldspathic grit and coarse quartzose sandstone, with bands of pink conglomerate and pebbly grit towards the base.

To the west, the *Gordon Limestone* is poorly exposed in the valley of the Dundas Rivulet.

Along the Queenstown road south of the Dundas Rivulet, there are a number of exposures of decomposed Gordon Limestone as far as the Henty River. The Moina Sandstone is exposed east of the road and north of the junction with Howard's tram, and includes pale weathering quartzose conglomerate with rounded pebbles of quartz generally less than 3 inches in diameter, pebbly grit and sandstone, and thin-bedded fine sandstone.

(g) *Duck Creek*

Ordovician rocks are exposed on the coast 2 miles north of Granville Harbour, on the southern limb of the Duck Creek Syncline. The coarse conglomeratic facies is absent and 120 feet of beds correlated with the *Moina Sandstone* appear to rest unconformably on Proterozoic schist. The contact is exposed only at the water line and must be examined when the sea is calm. The junction could be a fault, but away from the water line, the rocks are obscured by beach deposits and sand dunes. At the base of the succession is about 10 feet of hard purplish grit with many sub-angular and a few rounded pebbles of quartz. The basal beds are overlain by 30 feet of banded purplish-red grit and quartz breccia-conglomerate, which pass up into coarse, faintly purple quartzite with bands of conglomerate up to about 4 feet thick. The upper beds consist chiefly of massive coarse quartzite which is cross-bedded in places. The Moina Sandstone strikes easterly and dips to the north at about 50°.

The *Gordon Limestone* follows conformably and is represented by about 300 feet of black and dark grey, hard, flaggy calcareous siltstone and silty shale with bands of argillaceous limestone. The rocks are honeycombed and fretted by the weathering out of calcareous material. The only fossils found were a few poorly-preserved ? bryozoa.

The northern limb of the syncline has been intensely disturbed and the Moina Sandstone has been faulted out. The Gordon Limestone is represented by cleaved grey to dark grey calcareous siltstone with traces of crinoid ossicles, calcareous slate and argillaceous limestone. Near the faulted junction with Proterozoic schist, the beds have been folded into an asymmetrical anticline which plunges NE with the axial plane dipping SE at about 80°.

(h) *Upper Duck Creek*

About 4 miles east of the mouth of Duck Creek, A. B. Gulline mapped Mt Zeehan-type conglomerate across the old Corinna track east of the Granville Estate. The rocks are poorly exposed in low hills projecting through a cover of swampy Tertiary and Quaternary deposits, and may be unconformable on the Onah Quartzite and Slate. The beds are at least 500 feet thick and strike NW with NE dips of about 65° to 75°. The lower part of the sequence includes conglomerate containing pebbles of quartz up to about 2 inches in diameter, with bands of interbedded pink and white siliceous quartzite. At a higher horizon is conglomerate with rounded cobbles of quartzite and bands of finer conglomerate or pebbly grit. Further north, in Duck Creek, cobble-conglomerate was mapped with rounded inclusions of pale quartzite, quartz and dark siltstone in a matrix of smaller sub-rounded or rounded pebbles. A small exposure of faintly pink coarse quartzose sandstone and pebbly grit resembling the Moina Sandstone was noted in the creek about

$\frac{1}{2}$ mile further east. The Gordon Limestone was not seen but it may be blanketed by superficial deposits, or faulted out. Deeply weathered Silurian or Devonian formations were mapped further north along the Corinna track.

(i) *Healy Creek*

About $2\frac{1}{2}$ miles east of Upper Duck Creek, poorly exposed Ordovician rocks were found by A. B. Gulline in a small tributary of Healy Creek, $1\frac{1}{2}$ miles south of its confluence with the Pieman River. A thin bed of red conglomerate rests unconformably upon the Oonah Quartzite and Slate and passes up into alternating thin-bedded fine reddish quartzite and conglomerate. The Moina Sandstone is about 175 feet thick. The overlying Gordon Limestone consists of about 350 feet of dark grey to black argillaceous and arenaceous limestone or calcareous siltstone. The beds strike NW and dip NE at about 60° .

(j) *Huskisson River*

Above the shale of the *Glyptagnostus reticulatus* Zone is about 400 feet of conglomerate consisting of rounded pebbles of sandstone and grey chert up to about $\frac{1}{2}$ inch in diameter in a yellowish-brown subgreywacke matrix. Exposures are poor and the formation passes up into alternating grit and sandstone overlain by thin-bedded weathered mudstone which appears to mark the base of the Gordon Limestone. Taylor (1954d) estimated the thickness of the Gordon Limestone as about 1100 feet. It consists of hard bands of crystalline limestone with softer intercalations of argillaceous limestone, and following conformably upstream beyond the northern margin of the Zeehan Quadrangle, Taylor mapped all the overlying formations of the Silurian-Devonian Eldon Group. The Gordon Limestone appears to rest on the conglomerate and sandstone conformably, though a disconformity is possible either at this horizon or above the Upper Cambrian *G. reticulatus* Zone.

The apparently conformable relations to the SE between Mt Zeehan-type conglomerate, thin Moina Sandstone and Gordon Limestone have already been discussed in the Cambrian section. The relationship may also be examined about $\frac{1}{2}$ mile to the southeast, where the formations have been shifted south on the eastern side of a tear-fault (See Fig. 4). Here, the large bend in the Huskisson River reaches furthest east, and the river flows for about 150 yards NNW along the boundary between Mt Zeehan Conglomerate and Gordon Limestone. The conglomerate includes rounded pebbles of quartzite, quartz and chert and is apparently faulted off to the west. To the SE, a few weathered exposures of greywacke-conglomerate with rounded cobbles of quartzite up to about 4 inches in diameter are obscured by glacial deposition.

The Mt Zeehan Conglomerate is overlain in the river by dark blue-grey argillaceous limestone. Upstream, scattered small outcrops of impure blue-grey and black limestone and flaggy calcareous mudstone are exposed through thick alluvium. Only a few poorly-preserved crinoid columnals were found.

Age of the Junee Group

The oldest known fossils in the Junee Group are those at Adamsfield in the basal Jukes Conglomerate described by Opik (in Banks, 1962a) as Upper Dresbachian to Lower Franconian forms. In the Zeehan region, the Mt Zeehan Conglomerate is apparently unfossiliferous. The Moina Sandstone contains ?*Scolithus* and obscure

organic remains of undeterminable age and trilobite pygidia found by the writer on Mt Zeehan and Misery Hill were too poorly-preserved and incomplete for identification though they show that the formation was marine. The Moina Sandstone may be equivalent to the Caroline Creek Sandstone in North West Tasmania the age of which was discussed by Banks (1957, 1959). Near Railton it contains trilobites including *Etheridgaspis*, *Asaphellus lewisi* and *Carolinites* which are probably of Upper Arenig (Upper Canadian) age. At Maydena, in south Central Tasmania, the beds lie below the Florentine Valley Mudstone which is Middle Arenig so that here the Caroline Creek Sandstone is older than at Railton (Banks, 1959).

The age of the Gordon Limestone near Zeehan was discussed at length by Banks (1957). Fossils were described by Etheridge (1896), Chapman (1919) and Hill (1955), including *Tetradium dendroides*, *T. tasmaniense*, *T. conjugatum* ?*Lichenaria* and ?*Protaranea*, as well as rhynchonellids, gastropods and echinoderms. Many fossils were obtained in cores from a borehole at the Oceana mine and Hill (1955) concluded that the limestone at Zeehan was at least older than Lower Trentonian as the hole drilled to 938 feet did not reach the base of the limestone. According to Banks (1957), the base of the Gordon Limestone at Adamsfield is Upper Canadian and contains *Manchuroceras*, *Suecoceras*, *Piloceras*, *Utoceras* and *Allocotoceras*. He concluded that the base of the limestone in Tasmania is not younger than Lower Trentonian nor older than Upper Canadian. In this report, an apparent passage from the Middle to Upper Cambrian rocks up into the Junee Group has been described in three localities. Near Misery Hill, the youngest Cambrian in the Dundas Group is the Comet Formation. Between this formation and the Gordon Limestone, the higher Cambrian beds together with the Mt Zeehan Conglomerate and the Moina Sandstone do not exceed a total thickness of 3500 feet. If the limestone is not younger than Upper Canadian, and if the Comet Formation is Lower Dresbachian (Banks, 1962a), then this thickness of beds apparently occupied most of the Upper Cambrian and Canadian times. It appears possible that the Mt Zeehan Conglomerate may be Upper Cambrian, in which case the Moina Sandstone would represent part of the Lower Ordovician below the Upper Canadian. The boundary between the Moina Sandstone and the Gordon Limestone is not visible so that there could be a disconformity at this horizon.

On the Huskisson River, the Mt Zeehan Conglomerate appears to rest conformably upon the shales with *Glyptagnostus reticulatus* which may be basal Franconian (Opik, 1951b) or upper Dresbachian (Opik, in Banks, 1962a), so that here also, the Mt Zeehan Conglomerate may be Upper Cambrian. The Moina Sandstone is thin and the possibility of a disconformity below the Gordon Limestone cannot be discounted.

Banks (1957) suggested that at Zeehan, beds as young as Richmondian occur about 500 feet below the top of the Gordon Limestone, which on the Gordon River may range up into the Lower Silurian. In the Linda Valley near Queenstown, Banks (1959) noted that the Gordon Limestone is followed by fossiliferous siltstone ("Fenestella Shale") which grades up into the overlying Eldon Group.

Deposition of the Mt Zeehan Conglomerate

In a controversial paper, Campana *et al.* (1958) postulated that the Owen Conglomerate along the West Coast Range is a continental deposit laid down in a rift valley. The outcrops of Mt Zeehan Conglomerate lie about 15 miles west of the Range and may have been a separate deposit. In this report, only the deposition of the Mt Zeehan Conglomerate and the Moina Sandstone is discussed, though certain conclusions reached may be pertinent to the main problem in the West Coast Range (See Fig. 6).

In The Zeehan region, a number of facts appear to be important.

(a) It has been shown that on Misery Hill, in McLean Creek and on the Huskisson River, there is apparently a passage from Cambrian beds into the Mt Zeehan Conglomerate. The Cambrian rocks contain marine fossils and in the first two localities, the conglomerate is overlain by thick Moina Sandstone in which fragments of trilobites were found. Therefore the Mt Zeehan Conglomerate is probably also a marine formation though laid down in shallower water, and it resembles bands of conglomerate in the Dundas Group lying between fossiliferous formations whose marine origin is indisputable.

(b) Similar conglomerate in the Dundas Group is impersistent and variable in facies. As indicated in the section on the Cambrian system it may have been formed by turbidity currents. These variations are also typical of the Owen Conglomerate in the West Coast Range which Hills and Carey (1949) regarded as a shoreline deposit varying greatly in thickness over short distances. Bradley (1954) described slump structures which he suggested are typical of active orogenic belts, believing that deposition took place in erosional or fault troughs. In the Queenstown area, Wade and Solomon (1958) also described wide variations in thickness and facies.

In the Zeehan region, the Mt Zeehan Conglomerate varies in thickness and lithology over short distances. For example, on Mt Zeehan and to the SW, it is about 1500 feet thick, but is reduced to about 300 feet, 3 miles east of Mt Zeehan and to 500 feet on Misery Hill, $4\frac{1}{2}$ miles NE. On the Professor Range, 4 miles SE of Mt Zeehan, the conglomerate is about 1200 feet thick but finer. In the Huskisson River, 10 miles NNE of Misery Hill, the conglomerate includes only about 400 feet of variable fine to medium conglomerate.

The Moina Sandstone follows conformably. On the Huskisson River it is thin, but in the Zeehan area, the formation is from 1200 feet to 2000 feet thick. Conglomerate usually occurs in the lower horizons and bands of conglomerate or pebbly grit alternate with quartzose or arkozic sandstone throughout the succession, and therefore the Mt Zeehan Conglomerate may be a rudaceous facies of variable thickness within an arenaceous sequence. It may be significant that where the Mt Zeehan Conglomerate and the Moina Sandstone together reach their maximum development, the overlying Gordon Limestone is also thick. Thus the central region round Mt. Zeehan and the Professor Range may represent the area of maximum subsidence within a depositional trough, while thinner deposits near Misery Hill and on the Huskisson River would indicate the margins of the basin.

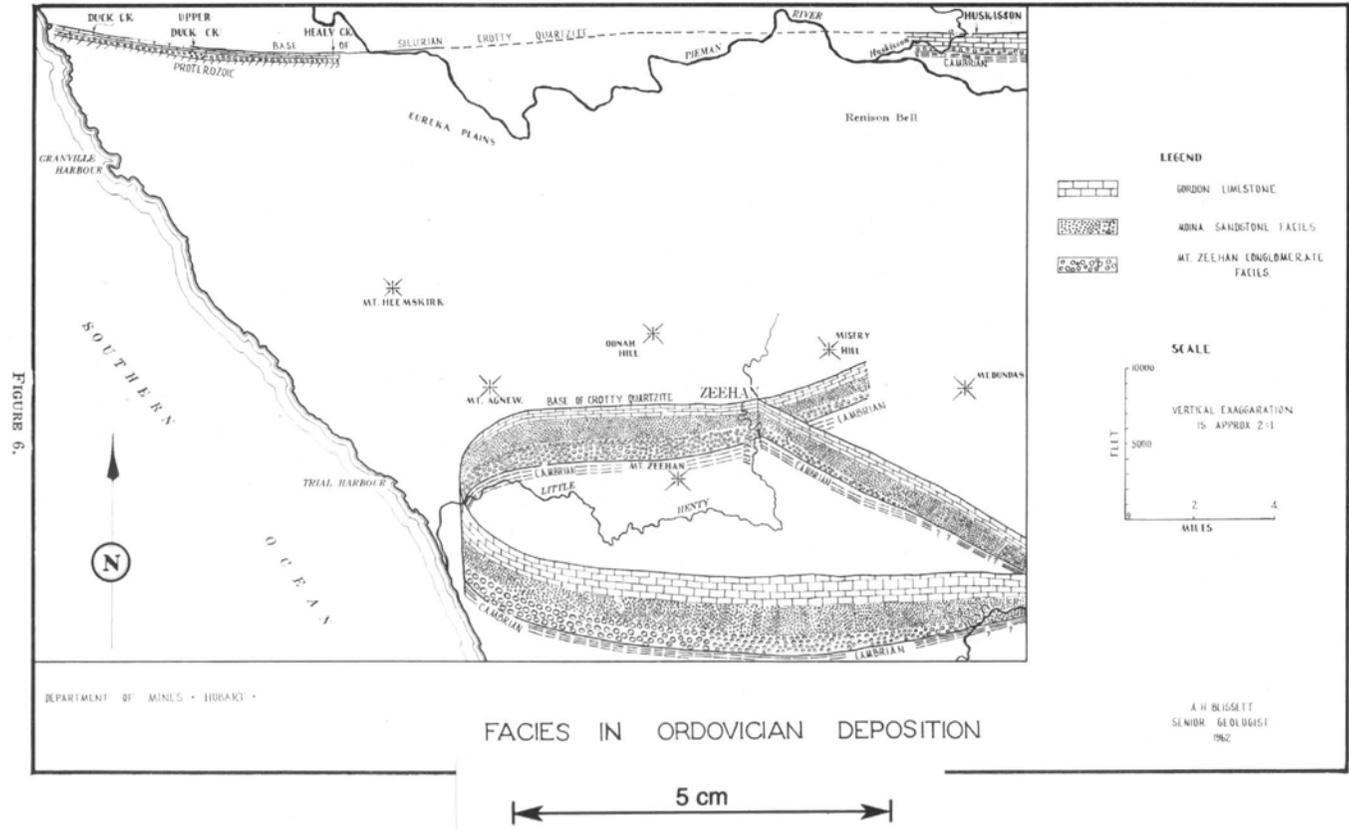


FIGURE 6.

(c) In the NW, the Junee Group is probably unconformable on Proterozoic rocks. On Healy Creek and Upper Duck Creek, Mt Zeehan-type conglomerate not more than about 500 feet thick rests on deformed quartzite and slate, while on the coast south of Duck Creek, the conglomerate is finer and is only 120 feet thick, resembling the Moina Sandstone facies rather than the Mt Zeehan Conglomerate. In each case, the formations are overlain by Gordon Limestone which is much thinner than in the centre of the basin. It is suggested that at some stage during the deposition of the Mt Zeehan Conglomerate, or the Moina Sandstone the sea transgressed to the NW, possibly over a fault-line coast. The fine conglomerate and grit below the Gordon Limestone at Duck Creek may either be a finer facies of the Mt Zeehan Conglomerate, or it may represent a later and more extensive transgression not long before the time during which the Gordon Limestone was deposited.

(d) The widespread red and purple colouration of the Mt Zeehan Conglomerate may be due to the presence of detrital hematite (cf. Solomon, 1959) and is not necessarily characteristic of continental deposits as suggested by Campana *et al.* (1958). Much of the Dundas Group which contains numerous fossiliferous horizons is also extensively oxidized. There is widespread pink and red colouration in the marine Moina Sandstone near Mt Zeehan, and also in the Silurian Keel Quartzite.

SILURIAN AND DEVONIAN SYSTEMS (ELDON GROUP)

Fossiliferous Silurian rocks were first recognized on the West Coast by Gould (1862) who later referred to the "Eldon beds" (Gould, 1866). Similar beds were described near Zeehan by Thureau (1888a). Johnston (1888) used the name "Queen River Group" which persisted for many years until Thomas (1947) re-introduced Gould's name in its present form of Eldon Group. Thomas, (1945a) and Gill (in Carey, 1947), working independently claimed a Devonian age for part of the sequence, based on the presence of *Pleurodictyum* and certain chonetid brachiopods. Hills and Carey (1949) established a provisional Silurian to Devonian succession, and the Eldon Group was finally defined by Gill and Banks (1950) after work in the Zeehan district. Taking the base of the Devonian as the base of the Ludlow Bone Bed (or the base of the Gedinnian in continental Europe), Gill (1950) showed that the Bell Shale, and possibly the underlying Florence Quartzite is Lower Devonian:—

Eldon Group

Formation		Thickness in Type Area (Feet)
Lower Devonian	{ Bell Shale	Over 1400
	{ Florence	
	{ Quartzite	1600
Silurian	{ Austral Creek	
	{ Siltstone	200
	{ Keel Quartzite	200
	{ Amber Slate	800
	{ Crotty Quartzite ...	1600

Crotty Quartzite

Near the Zeehan smelters, R. P. B. Pitt (pers. comm.) found rolled fragments of *Tetradium* from the Gordon Limestone in the lower part of the Crotty Quartzite, indicating that here there may be a disconformity at the base. Though the boundary between them can rarely be seen, the formations are structurally concordant elsewhere in the region so that erosional intervals or non-sequences are not great.

The Crotty Quartzite was described in detail by Gill and Banks (1950). Like the Florence Quartzite, the sandstone and grit may have been originally calcareous, but deep weathering has leached out the calcareous material. The formation includes coarse pale quartzose sandstone, grit and pebbly grit or fine conglomerate, which are often cross-bedded. Bands of interbedded greenish shale or slate resembling the Amber Slate form depressions within the broad rounded ridges characteristic of the Crotty Quartzite.

Fossils are not common, except in a number of distinct horizons. According to Gill (1950), the coarse-ribbed brachiopod *Camarotoechia synchrona* is diagnostic. Moulds of large crinoid ossicles were noted in a number of places. Near Eden Siding, Gill and Banks (1950) described tubicolar structures (? *Scolithus*) normal to bedding planes similar to those in the Moina Sandstone, as well as branched polyzoa, and straight or curved organic structures parallel to bedding.

The ridges of Crotty Quartzite can be traced round the faulted Zeehan and Little Henty Synclines. Waterhouse (1916) thought that sandstone and grit on a hill one mile SE of Trial Harbour might be Silurian and his opinion was confirmed recently. Numerous *Tentaculites* found by M. R. Banks in 1959 (pers. comm.) in the overlying cherty siltstone suggest that these belong to the Amber Slate and that the ridge is formed of Crotty Quartzite. The formation here includes pale grey pebbly grit and coarse sandstone with faintly pink staining in places. A mould of ?*Camarotoechia* was found on the southern slope of the hill.

In Healy Creek, A. B. Gulline mapped many boulders of pink-stained coarse Crotty Quartzite though none was seen in situ.

In the Duck Creek Syncline, the Crotty Quartzite follows the Gordon Limestone conformably and is represented by about 80 feet of hard massive pale grey quartzitic sandstone with bands of fine pebbly grit and quartzose conglomerate.

The Crotty Quartzite is probably of Llandovery age (Opik, 1951a; Banks, 1962c).

Amber Slate

The sequence which is about 800 feet thick follows the Crotty Quartzite conformably and includes greenish-grey shale or slate, siltstone and bands of fine quartzite. Along the railway line south of Austral Siding and near the Zeehan smelters, the beds are intensely cleaved and sheared. The shale and slate are usually deeply weathered and give rise to marshy buttongrass flats between the Crotty and Keel ridges.

On the coast one mile SE of Trial Harbour, thin-bedded and flaggy shale, calcareous siltstone and fine quartzite have been altered by contact metamorphism by the Heemskirk Granite into hard compact chert and calc-silicate hornfels. Waterhouse (1916, p. 119)

regarded them as "pre-Silurian" but the abundance of *Tentaculites* found by Banks indicates that the rocks are probably part of the Amber Slate. Many fragments of brachiopods and crinoid stems are visible on some bedding planes. The beds strike NW and dip steeply to the SW, with a number of minor folds (See Plate 3).

On the southern limb of the Duck Creek Syncline, the Amber Slate is partly represented by about 200 feet of sheared greenish-grey shale and flaggy siltstone which succeed the Crotty Quartzite conformably and contain crinoid ossicles and *Tentaculites*. The next 750 feet of the succession which is obscured by beach sands may also be part of the formation.

Opik (1951a) recorded ostracods, chiefly *Gillatia*, in the lower part of the Amber Slate which he correlated with the Upper Llandovery "*Iliaenus* band" of Victoria. *Tentaculites* is common at some horizons and Banks (1959) has noted *Monograptus* and *Cyrtograptus* near Frenchmans Cap. Gill (1950) described rhynchonellids, *Loxonema* and bryozoa.

Keel Quartzite

The characteristic sinuous steep and narrow hogback ridges of Keel Quartzite noted by Gill and Banks (1950) clearly mark the broad plunging folds in the Eldon Group and are a valuable guide to mapping. The formation consists of about 200 feet of white-weathering quartzite which follows the Amber Slate concordantly. It is hard and usually fine-grained though coarser bands are present. Faintly pink or purplish stained medium to fairly coarse quartzose sandstone forms a narrow ridge east of the railway line south of Austral Siding.

Fossils are not common but Banks (1962c) believed that the Keel Quartzite may be of upper Wenlock or lower Ludlow age.

Near Duck Creek, about 50 feet of cross-bedded coarse purple-stained grey quartzite with bands of purplish grit are correlated with the Keel Quartzite.

Austral Creek Siltstone

Gill and Banks (1950) described shaly quartzite in the upper part of the Keel Quartzite forming a depression between the Keel and Florence ridges. On the Huskisson River, Taylor (1954d) mapped thin-bedded grey-green shale about 700 feet thick at this horizon, calling it the "Hill Shales". Mapping has shown that the formation is persistent throughout the Zeehan region. It is therefore defined as that sequence of greenish-grey and bluish-grey laminated silty shale, siltstone and fine quartzite resting conformably upon the Keel Quartzite and overlain conformably by the Florence Quartzite. The type area is on the lower reaches of Austral Creek near its junction with the Little Henty River, half a mile east of the Oceana mine and 3 miles SE of Zeehan, between co-ordinates 341400E, 838800N and 341700E, 838100N.

The beds are about 200 feet thick and some bands are indurated and cherty. The sequence is regarded as passage beds between the paucifossiliferous Keel Quartzite and the Florence Quartzite in which fossils are abundant. A number of bands crowded with crinoid ossicles were noted but were not studied in detail. It is suggested that in view of its position between probable Silurian beds below and lower Devonian rocks above, a comprehensive palaeontological examination would be instructive. If the Keel Quartzite is lower Ludlovian, the Austral Creek Siltstone may be upper Ludlovian or Devonian.

On the east south of Duck Creek, about 80 feet of beds above the Keel Quartzite are covered by beach sand. A few feet of thin-bedded grey and greenish-grey siltstone and fine quartzite, are exposed, but the next 100 feet is also obscured. Probably the section all belongs to the Austral Creek Siltstone which would be therefore about 200 feet thick here.

Florence Quartzite

The formation was regarded by Gill and Banks (1950) as a highly fossiliferous calcareous sandstone which has been leached so that the organic remains are usually preserved as moulds. Gill (1950) listed the prolific fauna. The index fossils are *Notoconchidium florencensis*, *Protoleptostrophia plateia* Gill and *Eatonia* (*Eatonia*) *pleonecta*. The sequence was placed tentatively in the Lower Devonian by Gill because of the number of genera of that age present, including *Maoristrophia*, although *Encrinurus* also occurs. Gill (in Banks, 1962c) pointed out that *Protoleptostrophia* is known only from the Lower and Middle Devonian, and that *Eatonia* is a Lower Devonian genus.

Outcrops of Florence Quartzite form prominent broad rounded ridges rising above the undulating topography developed on the overlying Bell Shale. The sequence is about 1600 feet thick and includes thin-bedded and flaggy greenish or grey siltstone, and fine to fairly coarse sandstone or quartzite with interbedded massive coarse sandstone. Fossils are scattered throughout the formation and there are many richly fossiliferous bands packed with moulds of brachiopods, crinoid stems and a few fragments of trilobites.

Rocks correlated with the Florence Quartzite occupy the core of the Duck Creek Syncline, but are partly blanketed by beach sands. At the base is about 60 feet of massive pale grey calcareous quartzite with bands of pale flaggy quartzite in the upper part. The beds are overlain by 120 feet of thin-bedded or flaggy pale grey quartzite and laminated siltstone, followed by 80 feet of more massive rusty-weathering grey medium-grained quartzite which has been highly cleaved and sheared (See Plate 4). A long beach covers the next 1000 feet of the succession, which is followed by at least 350 feet of hard, cleaved, thin-bedded and flaggy, grey or greenish-grey, fine to medium quartzite, siltstone and silty slate. Fossils were discovered by the author here in 1959. They included moulds of *Notoconchidium florencensis*, polyzoa and crinoid stems, which occur in thin crowded bands or are scattered throughout the sequence.

Bell Shale

The Bell Shale was defined by Gill and Banks (1950) as the formation including at least 1400 feet of siltstone, often shaly, and interbedded quartzite, which is terminated above by erosion following the Tabberabberan Orogeny. These authors described the abundant fauna including *Pleurodictyum*, *Chonetes ruddockensis* Gill, *Eospirifer parahentius* Gill, *Plectodonta bipartita* (Chapman) and *Leptocoelia polyspera* sp. nov. Land plants were found at some horizons. Gill and Banks also commented on the presence of crinoid ossicles with scalloped edges, a useful field guide. Other typical Lower Devonian genera such as *Maoristrophia*, *Australocoelia* and *Notoleptaena* have been noted by Gill (in Banks, 1962c).

The Bell Shale is preserved in the cores of the Zeehan and Little Henty Synclines. It is a variable succession of grey or greenish-grey to black shale or soft slate, laminated siltstone and thin-bedded to flaggy fine quartzite which are frequently micaceous. Highly cleaved slate was mapped SE of the railway bridge over the Little Henty River (4 miles SSE of Zeehan). The shale and slate are generally deeply-weathered to pale yellowish-brown and cream-coloured clay soils, while the harder siltstone and quartzite form low ridges and hummocks.

Deposition of the Eldon Group

Gill (1950) showed that alternations of coarse and fine deposits may be traced over a wide area in Tasmania, though there appears to be an overall reduction in grain size in the upper beds. Gill thought that changes were due to geosynclinal movements rather than local coastal changes, and in general deposition took place near the shoreline. Opik (1951a) suggested that the Crotty Quartzite was formed by erosion of rising early Silurian mountains on the mainland. Uplift might be connected with the Benambran Orogeny in New South Wales (Banks, 1959). Banks (1962c) concluded that the sediments were unstable shelf-type deposits with the coarser facies being laid down in disturbed near-shore conditions in fairly deep water. The finer sediments accumulated in a deeper and less-disturbed environment, but from time to time turbidity currents brought in coarser sediments and shallow water fossil remains, as in the Bell Shale.

TABBERABBERAN OROGENY

Waller (1904) recognized that in the Zeehan district there had been violent earth movements and he described the anticlinal structure of Mt Zeehan. He considered that the orogeny took place after the Upper Silurian and before the Permian, but attributed the movements to the intrusion of first the ultrabasic rocks and then the emplacement of the granite. Hills and Carey (1949) suggested that orogenesis occurred at some time between the Lower Devonian and the Lower Carboniferous. As Banks (1959) pointed out, the movements in Tasmania have usually been correlated with the Middle Devonian Tabberabberan Orogeny in Victoria, but there is no conclusive evidence for this. However, recent work has now provided a convincing argument for correlation. Burns and Banks (in Banks, 1962c) demonstrated that at Euganana in northern Tasmania, movements took place before late Middle Devonian. Banks (1962c) proved the movement at Point Hibbs to be later than upper Lower Devonian, and Evenden and Richards (1962) showed that the granite which followed the folding is probably Middle Devonian.

On the West Coast, the orogeny brought to a close a long period of sedimentation ranging from Younger Proterozoic or Lower Cambrian to Lower Devonian, during which at least 30,000 feet of eugeosynclinal and miogeosynclinal sediments were deposited. Although possible unconformities resulting from Cambrian movements in West Central and Central Tasmania may be represented in the Zeehan-Huskisson basin by changes in deposition or local disconformities, as shown earlier in this report, sedimentation in these areas was more or less continuous.

The Tabberabberan Orogeny produced a series of NW trending synclinoria and anticlinoria with extensive E-W cross-folding, accompanied by a complex fault system along NNE and NNW trends.

The Zeehan Syncline was separated from the Huskisson Syncline by cross-folding and faulting, and from the Little Henty Syncline by the warped Mt Zeehan anticline. The structural pattern played an important part in the control of mineralization which took place in the later stages of the granitic intrusions at Mt Heemskirk and Pine Hill.

Devonian Granitic Intrusions

In the Zeehan region, important mineralization accompanied the granitic intrusions which, though they were mapped first in 1876, when cassiterite was discovered, have been studied chiefly in their role of host rocks for orebodies. The intrusions include the Heemskirk Granite Complex and the quartz-porphry sills and dykes on Pine Hill and near Renison Bell. Most early workers, for example Ward (1909), Twelvetrees and Ward (1910) and Waterhouse (1916), thought that the granitic rocks were later acid differentiates of the same magma which gave rise to the ultrabasic rocks. Carey (1947) showed that the latter were not Devonian but late Cambrian intrusions.

(1) HEEMSKIRK GRANITE COMPLEX

The complex covers about 35 square miles west of Zeehan and forms the nucleus of the Heemskirk Range. The outcrop is roughly circular, but is cut off to the west by the NW trending coastline. The intrusion is a large stock or boss emplaced near the southern limb of an anticlinorium of Proterozoic quartzite and slate which to the south are overlain by Cambrian formations. Though discordant, the north and south margins of the intrusion may have been partly controlled by the grain of the country rock.

Mineralogy

The rock has been described invariably as a granite, but CIPW norms calculated by M. Longman from three specimens analysed by the Department of Mines Laboratory, Launceston show that these are adamellites in which alkali-feldspar and plagioclase each range between $\frac{1}{3}$ and $\frac{2}{3}$ of total feldspar (Table 2).

Table 2

<i>Analyses</i>			
	1	2	3
SiO ₂	73.58	73.70	75.20
Al ₂ O ₃	12.39	14.31	13.32
Fe ₂ O ₃	0.72	0.78	0.42
FeO	2.12	1.40	0.83
MnO	0.04	Tr.	Tr.
TiO ₂	0.30	0.17	0.13
P ₂ O ₅	0.06	0.10	0.04
CaO	1.64	0.96	0.60
MgO	0.65	0.46	0.32
Na ₂ O	2.80	3.18	2.19
K ₂ O	5.04	3.69	6.04
H ₂ O—	0.17	0.17	0.30
H ₂ O+	0.66	0.98	0.50
	100.00	99.90	99.89

Norms—CIPW Classification

	1	2	3
Quartz	33.18	37.86	37.32
Orthoclase	29.47	21.68	35.58
Albite	23.58	27.25	18.34
Anorthite	6.67	3.89	3.06
Corundum	.....	3.77	2.04
Hypersthene	4.14	2.68	1.72
Diopside	0.46	.....	.....
Magnetite	0.93	1.16	0.70
Ilmenite	0.61	0.46	0.15
Apatite	1.01	0.34	.....

Niggli Values

Si	406.6	424.9	472.9
al	40.4	48.4	49.1
fm	17.5	14.2	9.4
c	9.6	5.9	4.2
alk	32.5	31.5	37.4

1. Adamellite. NE of Trial Harbour. Photo-location Z4/619/3. Lab. Reg. No. 1165.
2. Adamellite. Tasman River. Photo-location Z7/569/13. Lab. Reg. No. 838.
3. Adamellite. Granville Harbour. Photo-location Z8/581/21A. Lab. Reg. No. 839.

The petrology of the rocks was described in detail by Waterhouse (1916) upon whose report the following account is based. The most abundant variety is a coarse holocrystalline pink adamellite composed of pink orthoclase, quartz and albite or oligoclase, with some biotite. Accessory minerals include apatite, zircon, magnetite and a little secondary muscovite. Black tourmaline is usually present, especially with quartz in poorly defined aggregates. The pink adamellite merges gradually into belts of white or cream-coloured adamellite which is finer and lacking in pink orthoclase. Tourmaline is more abundant in this variety and quartz tourmaline nodules are characteristic. In the past the white adamellite has been called the "tin granite" because it contains most of the cassiterite-bearing orebodies, particularly in the south.

The adamellites are cut by numerous dykes and irregular masses of white "tourmaline-microgranite" formed of orthoclase, albite, oligoclase and quartz.

The minor intrusions carry many quartz-tourmaline nodules up to about 6 inches in diameter, some of which contain fine crystals of cassiterite. Tin is also associated with dykes and veins of porphyritic "microgranite", aplite and greisen. A number of thin veins of pegmatite were noted consisting of coarse orthoclase, quartz and black prismatic tourmaline.

Waterhouse (1916) described a "basic dyke" within the adamellite, on the cliffs about one mile NW of Trial Harbour. It varies in width from about 3 inches to 4 feet and is made up essentially of monoclinic pyroxene together with axinite in calcite, idocrase and sphene. There are irregular bands of quartz up to about 2 feet wide. M. Solomon (pers. com.) suggested that the vein may have originated from the contact metamorphism of remnants of the country rock. It is noteworthy that the axinite veins on Colebrook Hill, east of Renison Bell, may be metasomatic fissure replacement veins due to the pneumatolytic or hydrothermal alteration of calcareous rocks (p. 243 and Waller, 1902b).

Structures

Though the adamellite is rarely porphyritic, platy flow-structures have given rise to layering. Tension joints or fissures have played an important part in the subsequent mineralization. They trend chiefly between NW and NE and provided zones of weakness along which the late-stage mineralizing fluids were injected. In some areas there has been extensive greisenizing along fissures, forming irregular pipes or masses which may be highly mineralized, as in the old Federation mine.

Metamorphism

On the north and NW flanks of the intrusion, thermal metamorphism is relatively low grade. The margins have been somewhat chilled, and the quartzite was indurated and partly recrystallized, with widespread tourmalinization of interbedded slate. Fragments of dark chialstolite-siltstone and hornfels were noted in St Dizier Creek, but they do not constitute a well-defined zone.

Contact metamorphism in the south and south-east is more advanced and is emphasized by the alteration of calcareous or dolomitic sedimentary rocks and dolomitized serpentinite into calc-silicate hornfels. The effects were studied by Waterhouse (1916, pp. 111-143).

Near Trial Harbour, quartzite has been recrystallized with the development of secondary biotite, hornblende, magnetite and garnet. Calcareous bands in formations now known to be Cambrian and Silurian, together with dolomitized serpentinite, were converted into calc-silicates, including abundant diopside, as well as actinolite, idocrase, epidote, tremolite and magnetite. Flaggy laminated shale in the Amber Slate south of Trial Harbour was indurated into tough flinty chert, and decomposed andalusite slate was described by Waterhouse (1916, p. 121) NE of Trial Harbour. In contrast the quartzose grit and sandstone in the Crotty Quartzite were subjected to only slight induration.

(2) QUARTZ-PORPHYRY AT PINE HILL

Ward (1909) discussed the intrusions on Pine Hill and near Renison Bell. Quartz-porphyry on Pine Hill is partly obscured by talus but it is probably a complex sill with associated irregular veins of quartz carrying cassiterite and green tourmaline. Phenocrysts are chiefly of quartz or orthoclase in a quartz-feldspar groundmass. The main intrusion has thrown off quartz- or feldspar-porphyry dykes trending NW. The groundmass of the dykes is cryptocrystalline, so forming a finer facies of the quartz-porphyry. Several parallel dykes cross Renison Bell Hill and outcrop at the roadside near a quarry a short distance due south of the mill (P. A. Hill and M. Solomon, pers. comm.).

On the North East Dundas Tram, about $\frac{1}{4}$ mile SE of Confidence Saddle, a poor exposure of yellowish-weathered quartz-porphyry bearing needles of black tourmaline was noted.

AGE OF THE GRANITIC INTRUSIONS

A Devonian age was proposed for the Heemskirk Granite by Twelvetrees (1901) and for the quartz-porphyry by Ward (1909); these opinions are shared by most later authors. Pebbles of granite were noted by Twelvetrees and Ward (1910) in the Permian deposits near Zeehan. A heavy-mineral separation was made by the writer from a specimen of subgreywacke grit collected by M. R. Banks from the Permian "Woodbridge" Group near Koyule, about 8 miles SE

of the Heemskirk massif. Heavy minerals include fresh crystals of zircon, tourmaline and some apatite. This evidence indicates that the Heemskirk complex had been unroofed and partly eroded before Permian sedimentation; an analogy can be drawn with North Eastern Tasmania where Permian formations rest unconformably upon the peneplaned Ben Lomond Granite (Blissett, 1959). It has long been recognized that Silurian and Devonian beds near Zeehan have been mineralized. Carey (1947), Hills and Carey (1949) and David (1950, p. 272) considered the possibility of two intrusive phases, one in the Devonian and a later, more "acid", episode in late Devonian or early Carboniferous times, by comparison with metallogenetic provinces in Victoria correlated with known Carboniferous granite in New South Wales. Carey (1953) thought that the various intrusions in Tasmania were probably phases of a single magmatic cycle and that mineralization took place in the Devonian.

As mentioned earlier, Banks found fossils near Trial Harbour proving that calcareous siltstone which had been contact metamorphosed by the Heemskirk mass is part of the Silurian Amber Slate. By radioactive dating methods, Evenden and Richards (1962) showed that the granitic intrusion is probably Middle Devonian.

There is no direct evidence for the dating of the quartz-porphry at Pine Hill. The intrusion is associated with quartz-cassiterite-sulphide mineralization which has been attributed to the Devonian metallogenetic period, and which Montgomery (1893a) compared with that near Mt Bischoff in North West Tasmania. Spry (1962b) pointed out that the quartz-porphry is less deformed than Cambrian intrusions which are usually albitic and often intensely sheared; it is probably also Middle Devonian.

PRE-PERMIAN EROSION SURFACE

Montgomery (1896) recognized that patches of Permian tillite at an altitude of about 3000 feet near Mt Read (five miles NE of Mt Dundas) rested on an old erosional surface. This stripped surface was described by Edwards (1941) who postulated post-Palaeozoic faulting to explain its lower level near Zeehan and also the fact that Mt Zeehan and the Heemskirk Range now rise well above the Zeehan Tillite. He correlated the Permian on Mt Sedgwick (at about 3500 feet above sea level) with that at Malanna (two miles SW of Firewood Siding) which is near sea level. Bradley (1954) suggested that the surface near Mt Read and south of the Hercules opencut was undulating with variations of up to about eighty feet in height. On the Read-Dundas Plateau, the exhumed pre-Permian peneplain now forms part of the Lower Plateau Surface (3000-3500 feet) of Davies (1959) and Scott (1960b), thought by them to be an Upper Tertiary level.

While the surface upon which Permian tillite was deposited was uneven and may have been tilted later, the present wide variations in altitude support the suggestion by Edwards (1941) that there was post-Palaeozoic faulting. In several instances, the Jurassic dolerite has also been faulted. The position of the erosion surface in different districts is discussed below.

Read-Dundas Plateau

The surface lies at about 3000 feet above sea level. Thin patches of tillite remain, and about one and a half miles SW of the Hercules opencut, one outcrop only a few inches thick was noted in a depression between ridges of Cambrian volcanics, greywacke and slate. The base of the dolerite on Mt Dundas is also at about 3000 feet.

Colebrook Hill

On the eastern spur, the peneplain is at an altitude of 1800 feet, or 1200 feet lower than on the Plateau, two and a half miles to the south and SE.

North of Zeehan

Near the old Montana Silver-Lead mine, the base of the tillite is 600 feet above sea level. The surface is irregular and several rounded hills of the Proterozoic basement rise up through the tillite. On the roadside east of the mine, Proterozoic beds have been thrust over the glacial formation from the NE and have formed topography at least 200 feet higher. The fault strikes NW with a NE hade of 45°, and as the Permian outlier is surrounded by hills of Proterozoic rocks, similar faulting may have taken place on the poorly-exposed eastern and western margins.

Oonah Hill

Two small outliers lie at an altitude of 1000 feet about $\frac{3}{4}$ mile south of the main outcrop. It is possible that the peneplain has risen in this distance but post-Permian faulting is likely.

Eureka Cone Sheet

Mapping is complicated by thick scrub, but the base of the tillite is apparently at about 600 feet on the north side of the cone-sheet, north of the Pieman River. A small outcrop at the confluence of Pine Creek and the Pieman River is 175 feet above sea level which may be explained partly by the southerly tilt of the erosional surface and partly by post-Permian faulting.

Swansea Mine

At least three minor outcrops of tillite rest on a surface at an elevation of about 800 feet. Proterozoic quartzite and slate which rise about 300 feet higher to the east may have been thrust over the dissected peneplain.

Firewood Siding District

The base of the Permian is not exposed, but in Shell Creek, three miles NW of the Siding, Permian beds outcrop as low as 200 feet above sea level. The Permian and intrusive dolerite have been downthrown by the NW trending Firewood Siding Fault against Ordovician and Silurian formations, so that faulting was post-Jurassic, probably Tertiary. The pre-Permian surface is tilted to the SW and is near or below sea level.

It is apparent that post-Permian faulting has taken place over much of the Zeehan region and it will be described at length in the section on structural geology.

PERMIAN SYSTEM

Permian beds lie unconformably on folded Proterozoic and Lower Palaeozoic formations and include glacial, freshwater and marine sediments. Scattered outliers of tillite remain in the Zeehan district and on the Read-Dundas Plateau, while about 750 feet of freshwater and marine beds are faulted against Ordovician or Silurian formations in the SW near Firewood Siding.

Zeehan Glacial Formation

Tillite covers about $2\frac{1}{2}$ square miles some 4 miles north of Zeehan, and it also outcrops round the northern margin of the Eureka dolerite cone sheet. There are a number of small patches north of Oonah Hill; north of Zeehan, about 1 mile SE of the confluence of the Stanley River with the Pieman River; and near the Swansea mine, 2 miles SW of the township.

Moore (1894) recognized the tillite as a Permian glacial deposit similar to that on the Read-Dundas Plateau, though Montgomery (1896) regarded that near Zeehan as a Tertiary marine formation. Later authors accepted a Permian age, but Hills and Carey (1949) placed it in the Proterozoic or Cambrian because it was apparently interbedded with quartzites and slates of their "Pieman Group" and it also resembled the tillite on King Island which was believed to be late Precambrian. This view was followed by Taylor and Burger (1951b) and by Elliston (1954) who thought that the tillite might be part of his newly-defined Dundas Group. However, Banks (1956, p. 193) commented on recent work by Spry which established that the tillite rests unconformably on pre-Dundas Group rocks, although its precise relationship with the Dundas Group was not known. Campana and King (1958) and Spry (1958) showed that the tillite includes boulders or blocks of fossiliferous Silurian quartzite, so that it is almost certainly Permian. The apparent interbedding with the Proterozoic or ?Lower Cambrian is caused by overthrusting of the latter from the NE. Spry (1958) correlated the tillite north of the Eureka Cone Sheet with the Zeehan Glacials and compared it with the Wynyard Tillite of North West Tasmania which is basal Permian.

The tillite is a stiff yellowish-weathering blue-grey or greenish-grey clay with unsorted fragments of quartz, quartzite or sandstone, sometimes striated, and occasionally shale. Some inclusions are rounded but the majority are subangular, ranging in size up to at least 1 foot across. Bedding is usually absent and when present is ill defined. Bands of greenish-grey micaceous sandstone, and of clay with few erratics were noted on Northridge Creek, north of the Pieman River. The clay matrix is easily weathered so that the tillite gives rise to subdued topography strewn with detrital gravel derived from the included fragments.

In the main outcrop, north of the Montana Silver-Lead mine, the tillite is less than 50 feet thick. It was deposited on an undulating surface and in places has been stripped off low hills of Proterozoic quartzite and slate. On the northern edge of the Eureka Cone Sheet, the formation dips gently southwards and is at least 200 feet thick.

North of Oonah Hill, a few feet of highly weathered tillite remains in two outliers about $\frac{1}{4}$ mile across, and several small patches occur near the Swansea mine.

The scattered remnants of tillite on the Read-Dundas Plateau also rest directly on folded and peneplained Proterozoic or Cambrian rocks and resemble the tillite near Zeehan. Moore (1894) recorded that E. J. Dunn had found Permian glacial beds east of Moores Pimple at an altitude of 3000 feet. Bradley (1954) noted tillite up to about 50 feet thick south of the Hercules open-cut (3 miles NE of Mt Dundas). Between the Pimple and the open-cut, outcrops are small and are frequently only a few inches thick. On the plateau NE and SE of Mt Dundas, angular gravel was noted which may be detritus from a thin bed of weathered tillite underlying the dolerite. Fragments include subangular or angular quartz, and pink or grey chert with occasional rounded cobbles or small pebbles or Permian pebbly grit. To the SE, there are a number of erratics of Ordovician conglomerate, believed to be Pleistocene glacial debris. Permian mudstone reported by Reid (1925a, pp. 7, 10) and by Elliston (1954) was not seen in traverses over the northern part of Mt Dundas.

On the top of the eastern spur of Colebrook Hill (between about 1600 feet and 1800 feet), a number of blocks and fragments of fossiliferous Devonian quartzite remain which are probably derived from weathered Permian tillite.

Firewood Siding District

Johnston (1892) described fossil plants collected south or SE of Firewood Siding by T. P. H. Jones. They included *Glossopteris browniana* and *Gangamopteris*, associated with spiriferids, *Fenestella* and *Stenopora*. The rocks were mentioned briefly by Twelvetrees (1901) but were first examined in detail by Gill and Banks (1950) who showed that the Permian beds are faulted against Ordovician and Silurian formations. Fossils include *Martiniopsis oviformis* McCoy, *Spirifer duodecimcostata* McCoy, *Merismopteria macroptera* (Morris), *Platyschisma oculus* Sowerby and *Conularia inornata* Dana. M. R. Banks (pers. comm.) has since correlated the succession near Firewood Siding with other parts of Tasmania, and the author has mapped Permian beds for about 4 miles NW of the siding. Near Shell Creek, a total of about 750 feet of Permian has been down-thrown by the Firewood Siding Fault, against Ordovician and Silurian rocks outcropping to the NE. The Permian beds dip SW at angles ranging generally between 30° and 50°. The pre-Permian surface is nowhere exposed.

The three divisions recognized by Banks are:—

3. Cygnet Coal Measures (Kazanian-Tartarian).
2. Fern-tree Group (Upper Kungurian).
1. Woodbridge Glacial Formation (Kungurian).

1. Woodbridge Glacial Formation

East of the siding Banks noted fossiliferous pebbly siltstone and sandstone, and coal seams in lower beds further south.

On the steep south slope of Shell Creek, about 3 miles NW of Firewood Siding, indurated grey siltstone and silty mudstone with spiriferids may be equivalent.

2. Fern-tree Group

In the same locality, massive dark grey sandy or gritty siltstone and sandstone with few pebbles were mapped, resembling those described by Banks near Firewood Siding.

Marine fossils are rare.

3. Cygnet Coal Measures

Banks noted *Glossopteris* and *Gangamopteris* in the succession of quartzose pebbly sandstone and siliceous or carbonaceous siltstone with coal seams near Firewood Siding.

Scattered outcrops of similar formations, including pale banded pebbly grit and coarse sandstone with beds of quartz conglomerate, were mapped on the higher slopes south of Shell Creek and the plateau further south. Some fragments are rounded, but the majority are subrounded or subangular and up to at least 2 inches long. Towards the base, there are bands of soft yellowish-brown weathered coarse grit with abundant muscovite and also weathered dark grey fine micaceous sandstone and siltstone. Similar rocks, intruded by dolerite, outcrop for about 4 miles between Firewood Siding and NW of Shell Creek.

JURASSIC DOLERITE

Dolerite resembling that covering much of Central and Eastern Tasmania outcrops in three localities round Zeehan:—

1. Eureka Cone Sheet.
2. Mt Dundas
3. NW of Firewood Siding.

Eureka Cone Sheet

Dolerite was noted by Waller (1902c) and the intrusion was recognized as a cone sheet by Spry (1958) who demonstrated its unusual form. It is an oval body about 6 miles long from NW to SE and some 3 miles wide. In the north, dolerite rests on Permian tillite which dips gently southwards and lies unconformably upon Oonah Quartzite and Slate (?Younger Proterozoic). Southwards, the Permian wedges out and dolerite was injected directly into the Proterozoic beds, which also occupy the core of the cone sheet where they are partly obscured by Tertiary gravels and a small exposure of basalt. The contact of the dolerite with the country rock is nowhere visible.

Mt Dundas

The prominent dolerite peak of Mt Dundas was described by Montgomery (1893b). About 700 feet of dolerite is preserved on the summit, where it rests on a pre-Permian erosional surface cut across steeply-dipping Proterozoic and Cambrian formations. The dolerite was probably intruded at or near the base of a bed of Permian tillite which has since been almost completely stripped off the erosion surface. It is generally coarse and steep angular crags displaying columnar jointing rise out of a talus slope of dolerite blocks littering the plateau.

Firewood Siding

Dolerite was discovered about one mile north of Firewood Siding by K. G. Brill in 1953 (Banks and Ahmad, 1959, p. 117). In early 1960, the unknown ground further to the NW was mapped. The remains of a faulted sill, which had been tilted gently to the SW, extend for about 4 miles NW towards the Little Henty River over a width of up to 2 miles. The sill was injected into Permian pebbly grit and coarse micaceous sandstone (Cygnet Coal Measures) and may be up to about 750 feet thick (See Fig. 16). The dolerite is fairly coarse, with fine-grained chilled margins, but contacts are invariably blanketed by soil and vegetation.

Age of the Dolerite

Hills and Carey (1949) showed that in Tasmania the dolerite is younger than the Upper Triassic-Lower Jurassic sedimentation and was subjected to widespread erosion before Lower Tertiary faulting. Banks (1958) suggested that by analogy with the chemically similar Karroo dolerite in South Africa, it might be Lower Jurassic. Recent age determinations made by Evenden and Richards (1962) place the age near the boundary between the Lower and Middle Jurassic.

CAINOZOIC ROCKS

Tertiary and Quaternary deposits rest upon peneplaned Mesozoic and older rocks. The beds are mainly unconsolidated and as they are chiefly non-marine formations, their ages cannot be determined accurately.

Tertiary Period

Sedimentary Deposits

Rocks shown as Tertiary formations are a variable assemblage of gravel, sand, silt and clay outcropping mainly in the NW and SW of the Quadrangle. Scattered outliers of gravel cap hills of Proterozoic quartzite and slate north of Zeehan.

About $2\frac{1}{2}$ miles east of Granville Harbour, A. B. Gulline discovered a small outcrop of thin silicified bryozoal limestone largely obscured by vegetation. It rests on Proterozoic quartzite and slate, and apparently is succeeded to the west by Tertiary sand and clay which are overlain by basalt further west. According to Banks (1957), basalt rests on limestone thought to be Upper Oligocene or Lower Miocene at Temma, 45 miles NNW, so that the limestone near Granville Harbour may be equivalent.

Sub-basaltic sand, silt and clay with a maximum thickness of about 200 feet outcrop over several square miles east of Granville Harbour and Duck Creek and extend for about 7 miles inland. In the upper reaches of Duck Creek the beds rest on weathered and peneplaned Ordovician, Silurian and Devonian formations, and are partly blanketed by Quaternary deposits. The sand is usually semi-consolidated and has weathered yellowish-brown, with bands of iron-pan which was probably formed by iron-rich solutions percolating down below the weathered basalt cover, now mainly eroded away. In places, the basalt has baked the underlying sand into hard sandstone.

In a small creek 2 miles north of Donnelly's Lookout, gravels containing rounded pebbles of quartz and quartz-tourmaline ("schorl") rock lie at the base of the Tertiary. Similar gravels which have been worked for cassiterite in the Tasman River and St Dizier Creek were described by Waterhouse (1915), though they may not be of the same age. Waterhouse found fragments of lignitized and silicified wood, and also impressions of Tertiary plant leaves in fine sandy beds associated with the gravels. He interpreted the deposits as fluvial. The beds lie within a shallow depression cut in peneplaned Proterozoic quartzite and slate, which is now occupied by the Tasman River, St Dizier Creek, and their tributaries and are partly masked by recent alluvial gravels. The gravels are probably late Tertiary or early Pleistocene fluvial deposits.

About 1 mile to the NE, Waterhouse described pale grey quartzose conglomerate and grit containing grains of tourmaline, small amounts of cassiterite and fragments of silicified wood. The present survey confirmed his opinion that the beds are indurated Tertiary gravel and sand originally overlain by basalt. The rocks outcrop for about 2 miles from NNW to SSE and are probably up to about 100 feet thick.

There are extensive spreads of gravels up to at least 50 feet thick on Eureka Plains within the dolerite cone-sheet. The base of quartz, quartzite and "schorl rock" which are chiefly subangular. Stream erosion has dissected the underlying Proterozoic quartzite and slate, so forming a number of flat-topped ridges and hills capped by gravels. The lower beds consist of pebbles or cobbles of quartz, quartzite and "schorl rock" which are chiefly subangular. In places, rounded fragments are common higher in the gravel.

Small outliers of gravel were also mapped south of the Pieman River about 3 miles east of Eureka Plains, east of Trial Harbour, and on the peneplaned seaward edge of the Heemskirk Range. It is possible that the deposits near the coast may be of marine origin.

The Tertiary rocks in the SW portion of the Quadrangle, west of Firewood Siding, were described in detail by Banks and Ahmad (1959). The deposits include more or less unconsolidated gravel, sand, clay and lignite from which Johnston (1892) recorded what is now known as *Notofagus cunninghami* and also *Acacia*. Banks and Ahmad suggested that the beds are possibly Upper Cainozoic because of the presence of cones of *Banksia* cf. *marginata* which resemble modern forms living in the area.

Basalt

Basalt was described by Waterhouse (1915) as a dense, fine-grained olivine-basalt, vesicular in places. The largest outcrop is that east of Granville Harbour, covering about 5 square miles. Smaller outcrops are scattered over the NW section of the Zeehan Quadrangle as far east as Eureka Plains.

A small patch of basalt was noted by Waller (1904) a short distance west of the bridge over Austral Creek on the road to the Zeehan smelters.

Quaternary Period

Pleistocene Deposits

During glacial times, the Zeehan region was an area of deposition rather than erosion. Moraine and fluvioglacial gravels occur north of Renison Bell on both sides of the Pieman River, and in the SE north and south of the Henty Valley.

In the NE, hummocky till extends from Rosebery westwards to within a mile of the mouth of the Wilson River. The moraine consists of gravels and clay with many boulders and erratic blocks up to at least 5 feet across of quartzite, porphyry, pink or red Ordovician conglomerate and occasional blocks of Jurassic dolerite. The base of the till is at altitudes ranging from about 450 feet to 600 feet above sea level. The Pieman River with its tributaries subsequently cut down to a least 200 feet below the glacial deposits. South and west of the morainal deposits, fluvioglacial sand and gravels are now being actively dissected north of Renison Bell. On the road-side, a short distance east of the Exe River bridge, sub-horizontal and contorted varved clay and silt were mapped by R. P. B. Pitt.

In the SE, the valley slopes of the Henty River are blanketed by moraine with many large erratics of Ordovician Owen Conglomerate, some of which are as large as a small house. The deposits range from an altitude of over 2000 feet above sea level down to only 400 feet in the valley of Ewart Creek. Northwards along the Queenstown-Rosebery road, the erratics are smaller and there are fluvio-glacial boulder beds and gravels between the Farrell Rivulet and Tom Creek.

Small outliers of moraine were mapped east of the summit of Mt Dundas, between about 2950 feet and 3050 feet. The deposits are of pale gravelly clay, with a few erratics of Owen Conglomerate, and they are not continuous with the lower till to the south, so that they were not necessarily products of the same ice-sheet.

Lewis (1934) postulated three phases of glaciation in Tasmania, but it has been proved recently that one of them, the "Malanna" Glaciation, is invalid. Banks and Ahmad (1959) found no evidence of glaciation in Lewis's type area at Malanna (west of Firewood Siding) and they concluded that the deposits were formed by Tertiary faulting and erosion. The moraine near the Henty River is correlated with the Yolande phase, though it is possible that the moraines on the West Coast were deposited by a single glaciation (Bradley, 1954; Jennings and Banks, 1958).

Recent Deposits

There are widespread deposits of older gravel, sand and clay which are now being stripped off by stream erosion. East of Zeehan, the Little Henty River has cut down through the older alluvium and is forming narrow alluvial flats while two miles SE of Renison Bell, the Ring River has cut down about 8 feet through older alluvium.

Of recent origin are the prominent talus slopes of dolerite, conglomerate and quartz-porphiry on Mt Dundas, Mt Zeehan, Pine Hill and NW of Zeehan.

On the coast, raised sand-beaches were mapped at 20 feet, 45 feet and 60 feet above present sea level near Duck Creek, and at 25 feet south of the Little Henty River. Sand-dunes up to 100 feet high fringe the coast north of Granville Harbour and south of Trial Harbour. Thin patches of fine blown sand were noted over a mile from the coast at an altitude of 350 to 400 feet on the basalt plateau SE of Duck Creek.

STRUCTURAL GEOLOGY

GENERAL DISCUSSION

In the Zeehan region, the major structures were produced by Tabberabberan movements and by post-Permian epeirogenic block-faulting. It has been shown in a previous section that there is probably a passage from the Proterozoic or Lower Cambrian Oonah Quartzite and Slate up into the Cambrian, and that in three localities the Junee Group follows conformably. There may be local disconformities or para-unconformities within the Upper Proterozoic to Devonian succession, but no evidence was found for major orogenic movements resulting in angular unconformities, except near Duck Creek and Healy Creek. Here, the Junee Group presumably rests unconformably upon deformed Proterozoic schist

and quartzite and the boundary may therefore be a Tyennan Unconformity as defined by Carey and Banks (1954). The problem was not studied in detail, but the Proterozoic rocks appear to have been re-folded by Tabberabberan movements near Duck Creek.

The area round Zeehan has been highly disturbed both by Tabberabberan folding and faulting and also by intense post-Permian thrusts and faults. Mapping, supported by evidence in less-disturbed districts, indicates that there is structural conformity between Proterozoic and Cambrian rocks, and that structures in Proterozoic formations can be explained by Tabberabberan movements. Though the pattern in the Dundas district is also complex, Tabberabberan structures were mapped in formations ranging from Proterozoic to Upper Cambrian. It is possible that at Renison Bell there may be a disconformity at the base of the Cambrian succession but there is structural conformity with the gently-folded underlying Proterozoic or Lower Cambrian quartzite and slate.

TABBERABBERAN STRUCTURES

The orogeny produced a series of major anticlinal and synclinal belts with variable trends, which have been influenced, in part, by earlier structural elements.

The main elements are:—

- Heemskirk Anticlinorium
- Little Henty Syncline
- Mt Zeehan-Professor Anticlinal Zone
- Zeehan Syncline
- Huskisson Syncline
- Duck Creek-Healy Creek Synclinal Zone
- Dundas Anticlinal Zone
- Westerway-Ewart Syncline

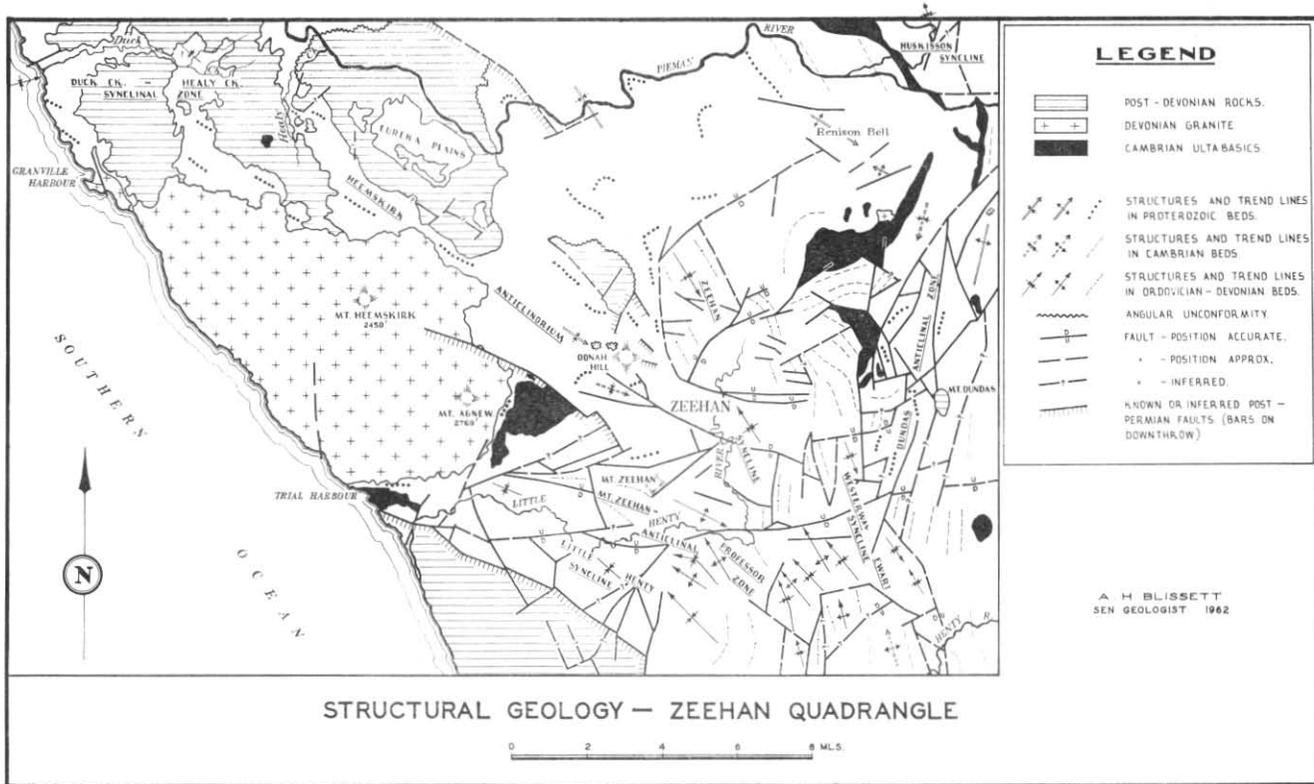
HEEMSKIRK ANTICLINORIUM

The structure was recognized by Carey (1953). Proterozoic or Lower Cambrian rocks are exposed over almost half the Zeehan Quadrangle and the SW flank of the anticlinorium was intruded by the Devonian Heemskirk Granite. The regional strike is NW with warping to an easterly alignment near Trial Harbour and Oonah Hill. Exposures are not good but there are many reversals of plunge of minor fold axes indicating easterly or NE cross-folding. SE plunging anticlinal noses at Zeehan and Renison Bell have separated the Little Henty, Zeehan and Huskisson Synclines. At Zeehan, near the faulted junction with Ordovician to Devonian formations, there has been close folding, shearing and local overturning on the the western margin of the Zeehan Syncline. Carey (1953) discussed this zone, the "Waller Upthrust" of Hills. The writer considers that the northern section of the zone is represented by the Despatch Fault, a north trending structure bounding the western margin of the Zeehan Syncline. North of the fault, Cambrian beds appear to be preserved in shallow downfolds in the Proterozoic rocks beyond the culmination of the Zeehan Syncline.

Between Montana Hill and Queen Hill, Zeehan, the fault zone has been dislocated by post-Permian thrusts or faults which are discussed later. On the west side of the Florence ridge Cambrian rocks are faulted against Silurian or Devonian formations, and south of Manganese Hill, the Oonah Quartzite and Slate is tightly folded on the south side of the SE trending Balstrup Fault. Further to the SE, the Proterozoic beds are thrown against Ordovician Mt Zeehan Conglomerate which, together with the overlying Moina Sandstone, has been overturned.

G.S.—4.

FIGURE 7.



5 cm

North of the Oceana mine, faulting associated with the NE striking Oceana Fault has dislocated mineralized veins in the workings and movement was therefore probably post-Permian. West of the mine, the zone of overturning continues SE for at least half a mile within Ordovician formations on the eastern limb of the Mt Zeehan Anticline.

LITTLE HENTY SYNCLINE

The syncline strikes NW but northwards it has been somewhat warped to a more westerly trend. The plunge from NW and SE has formed an elongated faulted basin, in the core of which Devonian Bell Shale is preserved. The SE end of the structure plunges NW at about 40°. The NW end is faulted against Cambrian formations some three miles east of Trial Harbour. SE of Trial Harbour, Mt Zeehan Conglomerate is exposed on the western limb as an anticlinal roll faulted against Permian beds. The Little Henty Syncline is separated from the south end of the Zeehan Syncline by the Professor Anticline which plunges to the NW. Along the anticlinal axis the Florence Quartzite has been arched up, isolating the Bell Shale to the centres of the synclines. Minor NE cross-folding has produced a shallow down-fold and a reversal of plunge immediately south of the Little Henty Fault.

MT ZEEHAN-PROFESSOR ANTICLINAL ZONE

On Mt Zeehan, Ordovician formations have been folded into a SE plunging anticline, noted by Waller (1904), which to the north has been warped to an E-W trend. In McLean Creek, the plunge of the fold has exposed Cambrian beds which pass up into the Mt Zeehan Conglomerate. The structure is therefore the down-faulted extension of the Heemskirk Anticlinorium. On the western limb, the Cambrian and Ordovician rocks strike E-W, with southerly dips of about 40°-65°. Overturning on the eastern limb has been described earlier.

Mt Zeehan Conglomerate is exposed in the Professor Anticline which plunges NW towards the Little Henty River.

ZEEHAN SYNCLINE

The structure was regarded by Carey (1953) as the trough of the Zeehan-Magnet Synclinorium, and it forms the southern section of the Zeehan-Railton Synclinorium of Banks (1959). The syncline is a complex NW trending faulted basin in the centre of which over 1400 feet of Devonian Bell Shale remains. Carey (1953) commented on the transverse faults which tend to step down the Bell Shale from north to south. The north end of the syncline is faulted against Proterozoic beds and plunges SSE as far as the Brickfield Fault NE of Zeehan, which throws down the formations to the south in the deepest part of the basin. SE of Zeehan and north of the Balstrup Fault, the plunge changes direction to the NW. South of the Balstrup Fault, the beds are upthrown and plunge NNW at about 25°, bringing up the Florence Quartzite and older formations. The Bell Shale has been downthrown once more south of the Little Henty Fault, and has been intensely cleaved along NW axes with steep easterly dips. North of the Professor Range, the Ordovician to Devonian succession plunges again to the NW. The changes in plunge in the Zeehan Syncline are probably due to E-W or NE cross-folding, and downwarping has been followed by faulting. Carey (1953) commented that the

structural axes cross the Little Henty Fault without offset and that there is therefore no transcurrent movement. The structural pattern supports his opinion, and the apparent eastward shift of the SE end of the Mt Zeehan Anticline north of the fault can be explained by the stripping-off by erosion of the upper part of an asymmetrical structure.

The eastern limb of the Zeehan Syncline has been affected by numerous faults and it has been overturned in places. The full sequence from Devonian formations down to the Proterozoic is exposed on the western flank of the Dundas Anticlinal Zone.

HUSKISSON SYNCLINE

The structure has been folded along a NW axis with a regional plunge of about 30° to 40° in this direction. Most of the syncline lies beyond the northern boundary of the Zeehan Quadrangle. To the south the structure is separated from the small Ring River Syncline by cross-folding and E-W faulting in the Cambrian Crimson Creek Formation.

The Huskisson Syncline is probably asymmetrical. On the western limb, thick Proterozoic to Upper Cambrian rocks outcrop below the Junee and Eldon Group beds in the centre of the syncline. The eastern limb has been dislocated by NNE trending transcurrent faults, and over the eastern boundary of the Quadrangle, part of the succession appears to have been cut out by a zone of shearing, tight folding and local overturning which strikes northwards along the Pieman River.

DUCK CREEK-HEALY CREEK SYNCLINAL ZONE

Near Duck Creek, over 3000 feet of Ordovician, Silurian and Devonian rocks have been preserved in an asymmetrical syncline whose main axis strikes and plunges a few degrees north of east. Minor folds trend and plunge slightly north and south of east with local reversal of plunge imposed by small scale NW cross-folding. North of the mouth of Duck Creek, the structures have formed a small basin with inwards dips of 15°-20°. Small symmetrical folds to the east of the cross-fold are developed in flaggy siltstone and shale (part of the Florence Quartzite) which are interbedded between more massive beds of quartzite. The folds plunge at about 15° to the SE in a similar direction to the general dip of the beds, and were probably formed by movement of the basement when cross-folding took place.

Though there are minor folds on the southern limb of the Duck Creek Syncline, the beds are relatively undeformed and they dip northwards at angles ranging between 50° to 60°. The core of the syncline has been sheared by NE faulting along Duck Creek. The northern limb has been intensely faulted and part of the succession cut out. Near the contact with Proterozoic schist, the Gordon Limestone has been folded into an asymmetrical E-W anticline whose axial plane has been overturned to the north. Drag-folding near the junction indicates that the north block moved west.

The Florence Quartzite in the centre of the syncline has been intensely cleaved, mainly along a trend north of east, especially on the northern limb. (See Plate 4).

East of Duck Creek, Junee and Eldon Group rocks are poorly exposed and are almost completely obscured by Tertiary and Quaternary deposits, but they appear to have been folded into a NW striking syncline. Three miles further east, the small exposure in Healy Creek is apparently faulted against Proterozoic rocks to the west, and is partly overlain unconformably by Permian beds. The Ordovician and Silurian formations strike NW with a NE dip.

DUNDAS ANTICLINAL ZONE

The zone was considered as part of the Bischoff Anticlinorium by Carey (1953) who also noted the Proterozoic inlier at Renison Bell, NW of the axis. Elliston (1954) recognized the domal structure at Dundas itself and described the reversals of plunge on the NE trending anticlinal axis which exposes the Proterozoic rocks in the Concliffe structural high, across the North East Dundas Tram. The following account differs in some essentials from the pattern drawn by Elliston, and in addition the extension of the axis north and south of the area mapped by him is now discussed. Close folding along NNW and NNE axes has affected Proterozoic beds and fossiliferous Middle to Upper Cambrian Dundas Group along the North East Dundas Tram. The Proterozoic and Cambrian formations dip off the domal high east of Dundas township, and northwards they plunge into the complex Ring River Syncline. The eastern limb of the syncline dips off the Concliffe anticlinal ridge in which the Oonah Quartzite and Slate is exposed. Dundas Group rocks occur within the Ring River Syncline, but part of the succession appears to have been cut out by NNW and NNE faulting. The beds have been thrown into tight folds with small-scale reversals of plunge over short distances. At Bonnie Point, a synclinal fold trending NNW and plunging SSE at 60° was mapped within fossiliferous siltstone and greywacke. Comparable folding was mapped over a wide area east of Mt Dundas and south as far as the Queenstown road near the Henty bridge. Close folding appears to be present to the north along Colebrook Hill and on the eastern limb of the Huskisson Syncline. Thus, east of a line from Great Northern Creek (on the North East Dundas Tram) to the Queenstown road, there appears to be a zone of close folding which trends a few degrees east or west of north (See Figures 7 and 16). Rocks from Upper Proterozoic to Upper Cambrian are involved, and as the Mt Zeehan Conglomerate on Misery Hill is conformable upon the Dundas Group, it is concluded that the structures are Tabberabberan. Folding was followed by much NNW and NNE faulting. The same trends have been mineralized in the Zeehan region generally. The writer supports the suggestion by Elliston (1954) that post-Permian movement may have taken place along existing faults, as will be discussed later.

NW of Dundas, Cambrian formations intruded by an ultra-basic mass form the faulted eastern limb of the Zeehan Syncline. The base of the Dundas Group has been repeated on Mt Razorback by complex strike faulting (Blissett and Gulline 1961b). In the Cuni district, the Crimson Creek Formation has been faulted against Dundas Group and Eldon Group rocks by a splay off the Brickfield Fault.

WESTERWAY-EWART SYNCLINE

The structure is a narrow faulted syncline about five miles long, trending NNW along the course of the Queenstown road. It is a shallow downfold in Ordovician and Lower Silurian formations

east of the Zeehan Syncline. The northern end plunges southwards towards the Little Henty Fault. South of the fault the syncline is a canoe-shaped closed structure which to the east has been brought into contact with Dundas Group rocks by the Ewart Fault. This dislocation is warped southwards from a NNW trend to a N-S alignment, reflecting the change in trend of the country rocks. To the NW, folds are predominantly NNW to NW; to the east is the zone of close folding described previously.

Analysis of Tabberabberan Structures

The first tectonic analysis of the West Coast generally was made by Carey (1953) who visualized major fold belts formed by E-W compression of the eugeosynclinal belt. Folding was followed by shearing due to movement west side north of the sediments relative to the Tyennan Block on the east, accompanied by some lateral compression of the trough. Differences in the pattern of deformation imposed by this movement were attributed to the increase of thickness in the sediments away from the Tyennan Block. In the Zeehan region, rotational strains were relieved by NNW folds and ENE tension faults.

Bradley (1956) believed that on the West Coast NE-SW compression produced a NW trending strain pattern influenced by earlier features. Solomon (1962) suggested that the major folds in Tasmania were formed by differential movements, agreeing with Bradley that pre-existing features played an important role, for example prominent fracture zones and the margins of depositional basins. NNW and NW minor folds and thrusts were apparently superimposed. Solomon suggested that the main structures are due to NE directed forces modified locally by lithological boundaries and earlier fractures.

In the Zeehan region west of the latitude of Dundas, the major folds strike NW. To the east the trend is distorted to N-S or NNE-SSW and there has been close folding so that warping may be due to compression against the Tyennan ridge as suggested by Solomon (1962). NE to SW and E-W cross-folding may have been contemporaneous with the main folding, and was responsible for the warping of the Mt Zeehan Anticline to an E-W trend near McLean Creek, as well as the separation of the chief structural features. At the same time, the northern culmination of the Little Henty Syncline was distorted slightly westwards from a NW strike. Though not mapped in detail, it appears that in the belt of broad NW trending folds, cross-folds are also of a similar order. On the other hand, in the tightly-folded zone along the North East Dundas Tram, there are rapid changes of plunge suggesting that cross-folding is also on a small scale. A zone of close folding and local overturning was formed on the western limb of the Zeehan Syncline which ruptured after continued stress. North of Duck Creek, pressure directed NE was responsible for north-facing asymmetrical folding of Gordon Limestone, later dislocated by a SW striking sinistral wrench fault. At Dundas, near the South Comet mine, SW to NE compression was relieved locally by a NNW dextral wrench fault which was later mineralized, and by a sinistral wrench fault striking south of west along South Comet Creek.

The NNE and NNW faults in the east were influenced by the trend of the earlier folds and, together with the numerous mineralized fissures or faults in the region which have a similar alignment, may have been formed, in part, by relief of compression.

In the Zeehan district, the major faults are in places associated with warping due to cross-folding. The Brickfields Fault has brought the SSE plunging northern sector of the Zeehan Syncline against the deepest part of the basin where the plunge is reversed north of the Pyramid Fault. Further south, the E-W Little Henty Fault cuts a downwarp between the Mt Zeehan and Professor Anticlines.

Thus, in the Zeehan region, the pattern described is in broad agreement with the conclusions of Solomon (1962) who suggested major NW folding warped to a NNE-SSW or N-S trend towards the east, due to compression from the SW. E-W or NE cross-folding may have been contemporaneous though it is not clearly demonstrated. NNE, E-W and NE faulting probably developed at a later stage.

POST-PERMIAN STRUCTURES

Banks (1958) showed that it is difficult to distinguish Tertiary faults from those associated with the intrusion of the Jurassic dolerite. Banks and Ahmad (1959) demonstrated that the Firewood Siding Fault and the Eden Fault are probably Upper Cainozoic, but precise dating of the numerous post-Permian dislocations in the Zeehan region is not possible. The majority strike NW or NE, though there has probably been renewed movement along NNW or NNE Tabberabberan faults near Colebrook Hill where the pre-Permian surface has been downthrown relative to the Read-Dundas Plateau. The NW trending Northridge Fault has downthrown Permian tillite to the SW, against Proterozoic rocks. The Tenth Legion Fault has a similar strike and may also be post-Permian. To the SE, Proterozoic rocks appear to have been thrust westwards over the remnants of the pre-Permian surface near the Tasmanian mine. At the Montana Silver-Lead Mine north of Zeehan, Campana and King (1958) showed that the Proterozoic rocks have been thrust over Permian tillite. East of the mine, along the Corinna road, the thrust strikes NNW with an easterly hade of 45°. Solomon (1962) suggested that the dislocation may be due to renewed movement along an older fault line. The adit crosscut west of the road crosses a NNE trending thrust having at 54° to the SE.

Most of the old workings in the Zeehan district are now inaccessible. The author has studied all available reports and mine plans and concludes that there is abundant evidence for intense post-mineralization, post-Permian faulting, particularly near the anticlinal nose of the Heemskirk Anticlinorium between the Montana Silver-Lead mine and Queen Hill. The evidence will be discussed at length in the description of the mines and is summarized below.

In the Zeehan-Western mine, Waller (1902) noted that ore-bodies were cut off by "slides". Waller (1904) described a slickensided fault trending NW and having at 28° to the NE. On No. 8 lode a NNE striking fault was crossed on which Waller calculated an eastern upthrow of 200 feet. The same author recorded a fault striking at N 75° W and having NE in the Oonah mine. Twelvetrees and Ward (1910, p. 128) commented that the N-S striking main orebodies bend to a NW alignment near the fault. The author suggests that the change in direction may be due to drag and that movement may have been north block up and west. In the No. 2 Argent mine, orebodies are dislocated by faulting (Waller, 1904). Twelvetrees (1901) remarked that veins in the

main crosscut in the Mt Zeehan mine were intensely faulted, and mine plans show that the Main lode has been displaced on the 60 foot level north drive. In the Florence mine, Waller (1904, pp. 34-35) described a loose open formation striking NNE in which a sudden inflow of water was encountered, carrying with it slurry, fragments of slate and galena. A man was drowned in a burst of water from the drive on Currie's lode which indicates that there may have been relatively recent disturbance. Similar evidence of probable post-Permian faulting striking E-W, NW or NNW was recorded by Waller, and by Twelvetrees and Ward (1910) in the Tasmanian Crown, Nubeena, Grubbs, Stonehenge, and South King mines. Jack (1961) showed that in the Oceana mine, orebodies may be displaced a few feet by low angle thrusts striking NNW. A water-bearing fault zone which is probably associated with the Oceana Fault was encountered in the north drive on the 420 foot level.

The author considers that much of the complex disturbance of Proterozoic to Devonian rocks in the vicinity of Zeehan must be attributed to post-Permian, possibly Tertiary, faulting which was partly controlled by Tabberabberan structures and zones of weakness.

EROSION SURFACES

The presence of peneplaned surfaces at different levels has been recognized for many years. On the Read-Dundas Plateau, the Lower Plateau Surface (3000-3500 feet) of Davies (1959) coincides with the stripped pre-Permian surface as was noted by Edwards (1941). This surface is probably Upper Tertiary (Davies, 1959; Scott, 1960b). Although the Heemskirk Range may be the remains of the St Clair Surface (1400-2700 feet) defined by Davies (1950) after work by Clemes (1925), there are many concordant heights between 2000 feet and 2300 feet which the author considers to represent the St Clair Surface, while Mt Agnew, rising to an altitude of 2769 feet, may be monadnock. It is possible therefore that the Range may be the downfaulted remnants of the higher Plateau Surface. Mt Zeehan, Carbine Hill, Commonwealth Hill and Colebrook Hill are all part of the dissected St Clair Surface, which is well-developed on the NW and SW foothills of the Read-Dundas Plateau.

The Higher Coastal Surface (1200-1500 feet) of Davies (1959) is represented by the Western Hills, Oonah Hill, Nubeena Hill, the Professor Range and other features. Hills west of Renison Bell up to 1800 feet above sea level and north of the Pieman up to about 1600 feet may be part of either this surface or an intermediate level above it.

The Lower Coastal Surface (300-900 feet) of Davies (1959), is the Henty Peneplain described by Gregory (1903). This is a striking feature over much of the Zeehan region, especially SW and south of Zeehan, where less-resistant formations in the June and Eldon Groups have been eroded below the curving truncated ridges of quartzite. The seaward margin of the Surface has been cut by more recent erosional levels, while inland it rises to about 850-900 feet near Mt Zeehan and the Professor Range. Plate 9 illustrates the surface SW of the Professor Range, which is a monadnock rising above it. Gill (in Scott, 1960a) showed that the level was formed after the Pliocene and Banks and Ahmad (1959) demonstrated that it is pre-Upper Pleistocene.

Banks and Ahmad described a surface between 350 feet and 400 feet worn across Cainozoic and Palaeozoic beds and named it the Firewood Siding Surface after the locality in which they studied the truncation of the Tertiary sediments. The surface is represented further north by isolated hills near the coast SE of Trial Harbour and by the low plateau of basalt capping Tertiary sediments east of Duck Creek and Granville Harbour. Twidale (1957) thought that the 400 foot level near Pieman Heads might have been a marine plain of erosion, but conclusive evidence is lacking.

North of Granville Harbour, and south of Trial Harbour, there is a well-marked change of slope at an altitude of 200 feet which might mark an old cliff line of a marine bench now blanketed by sand-dunes and swampy sand or clay. Raised beaches at 60 feet, 45 feet, 25 feet and 20 feet above present high-water mark reflect stages in recent emergence of the coast.

ECONOMIC GEOLOGY

MINERALIZATION AND ORE-GENESIS

Though there are low-grade deposits of asbestos and copper-nickel ores associated with the ultrabasic intrusion (?Upper Cambrian), the most important mineralization of the Zeehan region accompanied the Devonian granite intrusions. At Zeehan formations up to the Devonian Bell Shale have been mineralized. Between Zeehan and the outcrop of the Heemskirk Granite about 4 miles to the west, Twelvetrees and Ward (1910) recognized 4 main types of mineral assemblages. In the granite, cassiterite is the most important mineral and it is associated with tourmaline, pyrite, chalcopyrite and less abundant tetrahedrite, siderite and fluorite. Bismuthinite, wolfram and molybdenite are rare.

On the margins of the granite, cassiterite extends out into the contact-metamorphic zone. Further east, between the Comstock mines and Queen Hill, orebodies of galena, sphalerite and other sulphides occur in a pyritic gangue with subordinate siderite. The zone furthest from the Heemskirk Granite, in the east of the Zeehan district, is characterized by a sideritic gangue, and the siderite zone is also well shown in the Dundas area. The zones are not sharply defined and there is apparently a gradation from one type to another. No mineragraphic studies have been made, except by Stillwell (1930) on the unusual stannite ores in the Oonah mine. Stannite and fine cassiterite also occur in the Zeehan-Queen mine, and on Queen Hill.

The cassiterite-sulphide lodes at Renison Bell, Pine Hill, Exe River and near Mt Razorback were probably associated with the quartz-porphry dykes and sills, which may be apophyses of a granitic intrusion in depth.

The axinite-sulphide deposits on Colebrook Hill, and the complex "fahlore", chalcopyrite, galena and arsenopyrite ores at North Dundas with fine-grained cassiterite locally are probably also Devonian. Along the North East Dundas Tram, fossiliferous Upper Cambrian rocks have been mineralized so that mineralization was at least post-Upper Cambrian.

Structural Control

Most of the orebodies in the Zeehan Quadrangle strike between NNW and NNE and they appear to be fissure veins formed along zones of faulting, shearing and fracture resulting from the Tabberabberan movements. Orebodies in the Gordon Limestone are of the fissure-replacement type. At Zeehan, Dundas and Renison Bell, mineralization is most widespread in structural highs in the Oonah Quartzite and Slate, and the overlying Cambrian Crimson Creek Formation.

Post-Mineralization Effects

The orebodies were dislocated by post-Permian faults and thrusts. Near the Montana Silver-Lead mine, the orebodies were exposed by pre-Permian erosion and were blanketed by Permian tillite which is now being stripped off. The tillite may have extended originally over the whole of the Zeehan district and much of the mineralized area may have been subjected to weathering processes before the Permian. During the Cainozoic, a number of erosional surfaces were formed and consequently over a considerable period the orebodies were oxidized to gossan, with leaching of the more soluble minerals and probably secondary enrichment in depth. The processes of oxidization and enrichment in the Zeehan district should be more closely studied.

Future Exploration

The Zeehan district has been prospected and explored exhaustively for many years, and most of the orebodies found at the surface have long been worked out. The lode consists of relatively short but rich ore-shoots within a gangue of pyrite or siderite, and it is likely that in depth similar small lenses may be present. It is however, doubtful if there are any bodies larger than those worked in the old mines. Deposition of minerals depends on the temperature of mineralizing fluids, and of the host rocks and also on the speed of crystallization. If the volatile fluids moved quickly along planes of weakness and then cooled rapidly, there may be a barren zone below the mineralized zone. Thus it does not follow that workable veins join and become richer in depth. Not enough is known of the genesis of the ores in the Zeehan region and it is clear that much mineralogical work is necessary to throw light on the problem.

In the description of the mines and prospects, conclusions are drawn and in some cases recommendations are made for further testing and diamond drilling. Boreholes are suggested in the following cases:—

Ore	Mine
Cassiterite or Stannite	{ Oonah Zeehan-Queen Maynes
Silver-Lead	{ West of Montana Silver-Lead mine Mt Zeehan mine Comstock (N part of Main lode) Manganese Hill
Copper-Nickel	{ Nickel Reward area (Cuni) North Cuni

SUMMARY OF MINERALS IN THE ZEEHAN QUADRANGLE

METALLIC MINERALS

Lead Minerals

PRIMARY MINERALS

Galena.—Lead Sulphide, PbS (86.6% Lead when pure). Lead-grey colour with metallic lustre. Massive or cubic form. Often finely crystalline. The most important ore of lead; usually contains variable amounts of silver.

Hardness: 2.5-2.75.

Specific Gravity: 7.4-7.6.

Common in the Zeehan-Dundas area, where it ranks as a silver-lead ore.

Jamesonite.—Antimonial lead sulphide, $2PbS.Sb_2S_3$ (Up to about 50.8% lead; 29.5% antimony). Dull lead-grey colour. Usually fine-grained. May also contain silver.

Hardness. 2-3.

Specific Gravity: 5.5-6.0.

Occurs in the Zeehan district (e.g., Spray mine) and North East Dundas, but production small.

SECONDARY MINERALS (FOUND IN OXIDIZED ZONE OF LODES)

Anglesite.—Lead sulphate, $PbSO_4$. Usually colourless. Translucent to transparent.

Hardness: 2.75-3.0. Very brittle.

Specific Gravity: 6.3-6.39.

Found at Comet mine, Dundas and occasionally elsewhere in the Zeehan field.

Cerussite.—Lead carbonate, $PbCO_3$. Frequently in long delicate white needles, or as a coating on galena.

Hardness: 3-3.5.

Specific Gravity: 6.5.

Occurs at the Comet mine, Dundas, and the Queen, Austral and Sylvesters mines at Zeehan. Fine examples are on show in the Zeehan Museum.

Crocoite.—Lead Chromate, $PbCrO_4$. Bright red or scarlet. May occur as long slender needles or prismatic crystals which may be hollow, such as the magnificent specimens shown in a special cabinet in the Zeehan Museum.

Hardness: 2.5-3.00. Very brittle.

Specific Gravity: 5.9-6.1.

From the Adelaide and West Comet mines, Dundas; Kapi mine. NE Dundas.

Dundasite.—Basic lead and aluminium carbonate, $Pb(AlO)_2(CO_3)_2, 4H_2O$. Small spherical masses of radiating fine white crystals, sometimes associated with crocoite at the Adelaide mine, Dundas.

Mimetite.—Lead Chloroarsenate, $(\text{PbCl})\text{Pb}_3(\text{AsO}_4)_3$. In rounded aggregates of yellowish to brown crystals, or in crusts. The variety of campylite has typical barrel-shaped crystals.

Hardness: 3.5.

Specific Gravity: 7-7.25.

Both varieties recorded at the Britannia mine, Zeehan.

Pyromorphite.—Lead chlorophosphate $(\text{PbCl})\text{Pb}_3(\text{PO}_4)_3$. Dark green hexagonal crystals or globular shapes.

Hardness: 3.5-4.0.

Specific Gravity: 6.5-7.1.

In the Sylvesters mine, Zeehan and occasionally elsewhere in the Zeehan-Dundas region.

Tin Minerals

PRIMARY

Cassiterite.—Tin oxide, SnO_2 . Usually reddish brown to brownish black, but may be yellowish or white. Coarsely or finely granular.

Hardness: 6-7.

Specific Gravity: 6.99-7.02.

Common, especially in the Heemskirk and Renison Bell areas.

Stannite.—Copper tin pyrite., Cu_2FeSn_3 . May also contain silver. Grey black colour with metallic lustre.

Hardness: 4.

Specific Gravity: 4.3-4.5.

Occurs in the Oonah and Zeehan-Queen mines.

Zinc Minerals

PRIMARY

Sphalerite.—(Zinc blende) Zinc sulphide, ZnS (Zinc 67%). Pearly to pale yellow, dark brown and almost black. Usually in coarse crystal aggregates with a good cleavage. Resinous lustre. Brittle.

Hardness: 3.5-4.0.

Specific Gravity: 3.9-4.1.

Commonly associated with galena in the Comstock district (Zeehan) and at Dundas.

Copper Minerals

PRIMARY

Chalcopyrite.—Copper pyrite, CuFeS_2 (Copper 34.52%). Usually massive or finely crystalline. Golden colour; often iridescent or tarnished. May be associated with pyrite which is harder and paler in colour.

Hardness: 3.5-4.0.

Specific Gravity: 4.1-4.3.

Occurs on Colebrook Hill, NE Dundas and near Mt Heemskirk. The most important ore of copper, but to date has not been found in economic quantities in the Zeehan Quadrangle except in the Cuni district where it was formerly worked with nickel ore.

Tetrahedrite.—(Fahl Ore), Copper antimony sulphide. Sometimes in the form of tetrahedral crystals but is usually massive and often associated with galena. Frequently contains large amounts of silver (over 2000 ozs. per ton) and therefore has been important as an ore of silver in the NE Dundas area (Curtin-Davis and Fahlore mines), as well as near Zeehan (Oonah and Western mines).

Hardness: 3-4.

Specific Gravity: 4.4-5.1.

SECONDARY

Atacamite.—Hydrated copper chloride. Green copper ore sometimes found in a fibrous or radiating form in the Dundas area.

Azurite.—Hydrated copper carbonate, $2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$. Bright blue mineral, usually as a coating in veins carrying chalcopyrite from which it was derived. Occasionally found in the NE Dundas area.

Malachite.—Hydrated copper carbonate, $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$. Bright green crusts and coatings, sometimes with concentric pattern. Not common. May occur in the NE Dundas region, Central Balstrup lease, near Manganese Hill, Zeehan in association with antimonial silver-lead in a siderite gangue. Has not been found in commercial quantities.

Nickel Minerals

PRIMARY

Millerite.—Nickel sulphide, NiS (Nickel 64.7%) Brassy or bronze-yellow massive sulphide intergrown with chalcopyrite in the Nickel Reward and Devereaux orebodies in the Cuni district. Also occurs at North Cuni.

Pentlandite.—Nickel iron sulphide, $(\text{Fe,Ni})_9\text{S}_8$. Massive, with metallic lustre and pale bronze-yellow colour. Granular intergrowths with pyrite, chalcopyrite and pyrrhotite in North and South Cuni and the Vaudeau orebodies. Small amounts occur intergrown with heazlewoodite (Ni_3S_2) near Trial Harbour.

SECONDARY

Zaratite.—Complex hydrated nickel carbonate. Bright green blebs and patches derived from the alteration of nickel sulphides for example heazlewoodite. Recorded from the Cuni district and Trial Harbour. Of little economic value except as a guide to the presence of nickel-bearing sulphides.

Iron Minerals

Limonite (Gossan).—Yellowish-brown earthy iron oxide frequently forming a capping to silver-lead or tin orebodies; often associated with fine crystalline quartz, as in the Renison Bell and Razorback tin mines. Derived from the decomposition of iron sulphides. "Black" gossan contains a certain amount of manganese and was formed from manganeseiferous siderite.

Magnetite.—Magnetic iron ore, $\text{FeO} \cdot \text{Fe}_2\text{O}_3$ (Iron 72.4%). An important iron ore when found in bulk. Fine-grained segregations in calc-silicate rocks at the Tenth Legion mine.

Hardness: 5.5-6.5.

Specific Gravity: 5.17 (Deflects compass needle. Check with magnet).

In striated bands or scattered small block octahedral crystals in the serpentine north of Mt Razorback and near the Argent Tunnel.

Marcasite.—"White" iron pyrites, FeS_2 . Pale bronze-yellow with a metallic lustre.

Hardness: 6-6.5.

Specific Gravity: 4.9.

Probably derived from the alteration of pyrrhotite. Unstable; breaks down into limonite and soluble greenish ferrous sulphate. Occurs in the Renison Bell and Razorback tin mines.

Pyrite.—Iron sulphide, FeS_2 . Pale brassy-yellow with a metallic lustre. Usually massive or granular. Small cubic crystals often developed.

Hardness: 6-6.5.

Specific Gravity: 4.95-5.1.

Abundant in the Zeehan Quadrangle as a gangue mineral.

Pyrrhotite.—"Magnetic pyrites", Approximately Fe_7S_8 . Bronze-yellow, often with red, blue or green tarnish. Usually massive with a metallic lustre.

Hardness: 3.5-4.5.

Specific Gravity: 4.58-4.64.

Fairly abundant, with fine-grained tin, in the Renison Bell and Razorback mines; associated with nickel minerals in the Cuni area, and with arsenopyrite in the Frazer mine (NE Dundas).

Other Metallic Minerals

Arsenopyrite.—"Mispickel", FeAsS (46% Arsenic). Silvery-white fine crystals or massive sulphide, with metallic lustre.

Hardness: 5.5-6.0.

Specific Gravity: 5.9-6.2.

Occurs at the Frazer mine (NE Dundas), and on Colebrook Hill.

Bismuthinite.— Bi_2S_3 (Bismuth 81.2%). Fine needle-like or prismatic crystals with lead-grey colour and metallic lustre.

Hardness: 2. Can be cut.

Specific Gravity: 6.4-6.5.

Not common. Found in the Curtin-Davis mines (NE Dundas) and at the Federation mine, South Heemskirk.

Chromite.— FeCr_2O_4 . Fine black octahedral crystals with a metallic lustre. Occurs in the serpentines and pyroxenites near Dundas and the Huskisson River. Some chromite in alluvial gravels.

Gold.—Minor amounts in the alluvial gravels in the Ring and Pieman terrace gravels. Derived chiefly from zinc-lead-copper lodes of Mt Read District. Limited economic value to date.

Molybdenite.— MoS_2 (Molybdenum 60%). Foliated or flaky scales with a metallic lustre and lead-grey colour. Soft with a greasy feel. Resembles graphite but gives off sulphur fumes on charcoal block.

Hardness: 1-1.5. Easily cut.

Specific Gravity: 4.7-4.8.

Occasionally found in the Heemskirk Granite but so far in only small quantities of no economic importance.

Osmiridium.—(Iridosmine). Heavy shining tin-white partly worn scales or plates sometimes found in alluvial gravels in tributaries of the Pieman River, Huskisson River and the Wilson River. Derived from serpentine and pyroxenite.

Hardness: 6-7.

Specific Gravity: About 20. One of the heaviest metals.

Only minor amounts produced to date. (The Wilson River osmiridium field west of the Huskisson River, which lies north of the Zeehan Quadrangle, was extensively worked between 1910 and 1930. One nugget weighed 1 oz. 19 dwts. $7\frac{1}{4}$ grs.)

Pyrolusite.—Manganese dioxide, MnO_2 . Soft black masses occur in small quantities near Manganese Hill, Zeehan.

Hardness: 2-2.5. Often soils the fingers.

Specific Gravity: 4.73-4.86.

Wolfram.—(Fe,Mn) WO_3 . Well-formed bladed dark grey crystals sometimes occur in clusters in quartz-cassiterite veins in the South Heemskirk district. Has not yet been found in economic quantities.

Hardness: 5-5.5.

Specific Gravity: 7-7.5.

Non-Metallic Minerals

Actinolite.—Calcium-magnesium-iron amphibole. Green fibrous and radiating crystals associated with axinite and pyrrhotite on Colebrook Hill.

Axinite.—Calcium-aluminium borosilicate. Occurs in striking well-shaped lustrous violet crystals on Colebrook Hill.

Chrysotile (Asbestos).—Fibrous serpentine. Delicate silky fibres, often very pale greenish white in veins within green serpentine near Argent Hill and north of Mt Razorback. Some 360 tons were produced from veins which rarely exceed $1\frac{1}{2}$ inches in width.

Diopside.—Calcium-magnesium pyroxene, $CaMg(SiO_3)_2$. White to pale green. Occurs both massive and crystalline near the Tenth Legion mine. Formed by the contact metamorphism of calcareous rocks.

Dolomite.— $CaMg(CO_3)_2$. White to brownish gangue mineral associated with manganiferous siderite in the silver-lead orebodies in the Dundas area. Pale green and pinkish dolomite at the Razorback mine, near Montezuma Falls, &c., has been formed by the alteration of serpentine. Reacts only slowly in cold acid. Dolomite grades into ankerite with the replacement of part of the magnesium by manganese and iron. Ankerite weathers brown and occurs at the Comet mine, Dundas.

Fuchsite.—Chrome mica. Potash mica together with small amounts of chromium probably derived from the decomposition of chromite in ultrabasic intrusions (compare stichtite). Found in the "Fuchsitic Conglomerate" near Rosebery golf course.

Serpentine.—The major constituent of serpentinites formed by the alteration of ultrabasic igneous rocks, for example, pyroxenite, norite or gabbro; the rock itself is familiarly termed serpentine, and varies in colour from yellowish green to bright apple green. Shear or slip planes would limit its use for ornaments or ornamental stone.

Siderite.— FeCO_3 . Usually massive or coarsely crystalline with a pearly lustre. Cream or pale brown in colour. Common in the Zeehan and Dundas fields as a gangue mineral in silver-lead orebodies. Frequently contains manganese.

Stichtite.—"Chrome serpentine". Lilac coloured streaks, bands and patches with green serpentine. The chromium probably originated from the decomposition of chromite crystals. Fairly abundant on Stichtite Hill, Dundas.

Talc.—Hydrated magnesium silicate. Soft massive creamy or yellowish-brown rock, usually containing iron, which occurs as a decomposition product of serpentine at the Razorback mine, Dundas.

Tourmaline.—Complex aluminium and boron silicate, with magnesium, iron, calcium, &c. In 3-sided prismatic crystals or in a radiating habit. Usually strongly striated. The iron-bearing black variety *schorl* is abundant in the Heemskirk Granite and is also present on Pine Hill. Some green and brown tourmaline is associated with cassiterite in the South Heemskirk field.

MINES AND PROSPECTS

1. Tin

THE HEEMSKIRK TINFIELD

Introduction

Alluvial cassiterite was found at North Heemskirk by C. P. Sprent in 1876. A number of leases were pegged, and exploration was stimulated by the discovery of the first cassiterite-bearing orebodies within the granite in 1879. After 1881, batteries were erected at the Montague, Cumberland, West Cumberland, Orient, Empress Victoria, Cornwall, Peripatetic, Wakefield, Carn Brae, Sweeney's, Kelvin and Prince George mines. Several companies were sluicing alluvial ground, and over 150 miners were at work, in addition to other workers. The boom collapsed almost as quickly as it started. Less than 50 men were employed by the seven companies still operating in 1884, and by 1890 the field was practically deserted. A number of factors contributed to its failure. It is likely that rich patches of detrital cassiterite led prospectors to believe that large orebodies existed which were comparable with those at Mt Bischoff at Waratah, then being opened up. Exaggerated reports and speculation encouraged the pegging of a large area, part of which was under the sea. At least 15 companies installed batteries and plant brought in at great expense, frequently before proving workable ore. Some ore is pyritic and plant was not equipped to treat it. In one or two instances, black tourmaline, which is abundant, and hematite appear to have been mistaken for cassiterite. The ore-shoots, though rich in places, were found to be relatively small and little capital remained to finance systematic development.

In 1893, a company was formed to take over the old West Cumberland mine, but once more, funds were spent on plant and water supply, and the project was short-lived. Interest in the field was somewhat revived in 1901 by the discovery of coarse detrital cassiterite at Mayne's mine, east of Trial Harbour, which yielded at least 200 tons of concentrates (156 tons of tin) up to 1909. Between 1913 and 1920, at North Heemskirk, the Heemskirk Tin Syndicate produced about 237 tons of alluvial cassiterite from the Tasman River. From 1927 to 1929 and 1935 to 1938, 107 tons of

cassiterite were extracted from the Federation mine, but the leases were relinquished in 1938 when reserves were exhausted. Since 1920, a few men have also produced a small annual output totalling about 43 tons of concentrates, chiefly from detrital or alluvial deposits. The total recorded production from the Heemskirk field is at least 1300 tons of concentrates containing some 814 tons of metallic tin.

Location and Access

Most of the old mines and prospects are on the north, SW and south flanks of the Heemskirk Range. The South Heemskirk mines lie north and NE of Trial Harbour, about 15 miles by gravelled road SW of Zeehan, and the present coast road north to Granville Harbour passes close to a number of them. The alluvial tin workings of North Heemskirk are 16 miles NW of Zeehan. The first 8 miles from Zeehan is a good gravel road, but the remainder is a rutted and swampy track. Work is now in progress on a new route from the "8 mile" to Eureka Plains.

General Geology

Mineralization accompanied the intrusion in Middle Devonian times of the Heemskirk Granite into folded sediments assigned to the Onah Quartzite and Slate, which is Upper Proterozoic or Lower Cambrian. The thick sequence includes pale grey quartzite, grey micaceous siltstone, and greenish shale or slate while phyllite and low grade schist are developed locally. In the north and west, there are scattered patches of gravels with quartz-tourmaline pebbles and alluvial cassiterite resting on a late Tertiary erosional surface. They are more extensive in the upper reaches of the Tasman River, where they have been partly resorted by Quaternary streams. Near Donnellys Lookout, Tertiary gravels, sands and clays are overlain by the remnants of a basalt flow.

Heemskirk Granite

This is usually called granite but is in fact adamellite (See page 67). The most common variety is a coarse pink granite consisting of pink orthoclase with some albite, glassy quartz, biotite and abundant black tourmaline. Accessory minerals include apatite, zircon and magnetite. The pink granite merges into irregular belts of white or cream granite which is usually finer. There are many scattered dykes and veins of tourmaline microgranite, porphyritic microgranite and aplite. Thin veins of pegmatite occur, consisting of coarse orthoclase and quartz with some black tourmaline, but no cassiterite. Quartz-tourmaline veins and dykes are common and occasionally carry cassiterite. Veins of greisen are less abundant. A striking feature is the numerous nodules of quartz and black tourmaline scattered irregularly throughout the white granite and the tourmaline microgranite. Cassiterite is sometimes present in the nodules, for example near the Cliff and Federation mines.

Orebodies

Cassiterite is present in quartz-tourmaline fissure veins, chiefly round the north and south margins of the granite, and within the Proterozoic sediments to the SE, for instance at Mayne's mine. The veins are relatively short and trend generally between NW and NE ranging in thickness from mere coatings of quartz and tourmaline up to about 6 feet. They consist of central veins of green or black tourmaline and quartz with disseminated cassiterite crystals which locally may be concentrated to form layers. The central zone is bordered by a zone of tourmalinized or greisenized granite which may carry some cassiterite.

At Mayne's mine, rich tin was formerly extracted from irregular quartz-tourmaline veins which occasionally widen into vughs carrying coarse cassiterite. The walls are not well defined and the ore-bodies appear to grade into slate and quartzite impregnated with fine green tourmaline and quartz. At the Federation mine, a small irregular oval pipe of greisenized granite carried values ranging from 6% to 23% cassiterite.

Mineralogy

Although black tourmaline is abundant in the Heemskirk district, cassiterite appears to be associated rather with the green variety which may be taken therefore as a guide to prospecting. Small amounts of pyrite, chalcopyrite and arsenopyrite are sometimes present, particularly in the SE, and bismuthinite occurs at the old Federation mine. Wolfram and molybdenite are relatively rare. At the old Globe (or Mt Agnew) mine, galena, tetrahedrite, chalcopyrite, sphalerite, pyrite and cassiterite are associated with a gangue of quartz, green tourmaline, siderite and green and amethyst coloured fluorite. Stibnite has been recorded from Sweeney's mine. Hematite occurs with black tourmaline and quartz at Long's Iron Blow (North Heemskirk) and with black and green tourmaline in several veins near the Federation mine.

Cassiterite is usually fine and brown or brownish-black, but crystals may sometimes be up to $\frac{1}{2}$ inch in diameter. At Mayne's mine, Waller (1902c) reported nuggets of grey botryoidal cassiterite up to 20 lbs in weight.

North Heemskirk

ALLUVIAL DEPOSITS

Tasman River

The most important workings were those on the alluvial deposits in the Tasman River, east of Donnelly's Lookout. Cassiterite is disseminated through Tertiary and Quaternary gravels, sands and silts which reach a maximum thickness of about 50 feet, and rest on decomposed granite or Proterozoic shale and quartzite.

The property was originally known as the Granville mine, and the existence of tin-bearing gravels was demonstrated in prospecting shafts. About 1913, the Heemskirk Tin Syndicate took over the leases and started sluicing operations. Water was brought by a race from the Heemskirk River, almost 6 miles to the east, giving a head of not less than 75 feet. Plant was carried on a barge which was floated into position, after which the water was pumped out of the dam. Tailings from new ground were dumped on the old excavations behind and work progressed northwards. In 1914 the wash became deeper than the plant could handle and the company stopped work to investigate the ground by prospecting shafts and drilling. Between 1917 and 1920, sluicing was continued northwards until the alluvial ground was abruptly cut out by a ridge of quartzite underlying basalt and work ceased at the end of 1920. There has been only minor activity since that date.

The gravels were regarded by Waterhouse (1915) as river gravels deposited by tributaries on the floodplain of the ancient Tasman River which he believed may have then flowed northwards to the Pieman River, the drainage being later disturbed by flows of basalt. He concluded that the depth of wash therefore became thicker northwards under the basalt and beyond it. This concept has influenced later prospectors but is untenable for the following

reasons. (1) Scattered patches of Tertiary gravels containing rounded pebbles of quartz-tourmaline typical of those in the Tasman River extend from SE of Granville Harbour eastwards for at least 10 miles and have been mapped north of Zeehan. (2) A small outcrop of Tertiary limestone was noted $2\frac{1}{2}$ miles east of Granville Harbour. (3) An old shaft was examined one mile north of Donnellys Lookout (i.e., near the course of the old river postulated by Waterhouse). It is now water logged but the bottom was found to be 8 feet deep. The dump of gravel, including rounded quartz-tourmaline pebbles, indicates that the shaft could not have been much deeper than 8 feet, so that the gravels are less than 10 feet thick, resting on Proterozoic quartzite and slate. (4) On low hills east and west, the cover of gravels has been almost completely removed. The Tertiary gravels may be partly shallow water marine deposits.

In some quarters it is thought that the ridge of quartzite which stopped operations in 1920 may be a narrow reef and that the alluvium may be thicker under the basalt cover to the NE. The relations of the basalt and the Proterozoic were therefore closely examined, and it is clear that the Proterozoic basement rises eastwards, so that the basalt rests directly on it, or with only a thin spread of gravels between.

St Dizier Creek

Gravels with rounded quartz-tourmaline pebbles, quartz grits and sandy loam extend for about $\frac{1}{2}$ mile up St Dizier Creek from its confluence with the Tasman River. The first alluvial tin was found here in 1876 and Waterhouse reported in 1915 that much of the ground had been worked out. The depth of alluvium is generally less than 10 feet and values are patchy. In 1902, it was proposed that a tunnel should be driven from the Tasman River near its junction with St Dizier Creek, SE into the St Dizier wash. The proposition was supported by Waterhouse (1915). It was later cut, but there is no record of its date, nor of values within the alluvium. In recent years, small quantities of cassiterite have been produced by prospectors. Waterhouse described a pyritic quartz vein carrying fine cassiterite within Proterozoic quartzite west of the creek, and Waller (1902c) recorded a magnetite orebody with cassiterite in a branch creek to the east, but the lodes appear to be of little economic value.

Eureka Mine

The prospect lies $\frac{1}{2}$ mile west of the Heemskirk River and 400 yards north of the track to the North Heemskirk workings. The Oonah Quartzite and Slate is capped by Tertiary gravels which contain alluvial cassiterite. Waterhouse (1915, p. 54) stated that several parties were then working small patches of wash but there is no record of production. Between 1933 and 1952, concentrates representing about $6\frac{1}{2}$ tons of metallic tin were produced from the gravels and from lodes.

The workings were examined in detail by Burger (1950). The area had been tested by an old shaft and adit, a number of trenches and pits and also a cut with a drive leading off it. The cut was 83 feet long in a NNE direction, with a drive 25 feet long driven to the ESE along a mineralized fault zone. Pyrite and cassiterite occur in irregular pockets rather than in a well defined lode.

The hanging wall is poorly defined and the footwall is apparently a strike fault within decomposed slate and quartzite. Small veins of pyrite and quartz strike NE in a similar direction to the country rocks. A chip sample taken over 37 inches in the face of the drive assayed 1.78% tin.

Other Alluvial Workings

At various periods, alluvial gravels have been worked on a small scale in tributaries of the Heemskirk River and in Twelve Mile Creek, St Dizier Creek and other small tributaries of the Tasman River. Since 1920, a total of about 57 tons of cassiterite (34 tons of metallic tin) has been produced from alluvial workings at North Heemskirk.

CASSITERITE LODES

There has been little production from workings on cassiterite-bearing orebodies, which are briefly described below. Mineralization at the old Eureka mine has already been discussed.

Peripatetic Mine

The old mine is about 3 miles SW of the Tasman River alluvial deposits, on the NW slopes of the Heemskirk Range. It was one of the first mines to be opened up, and was explored by a series of 5 adits and 3 shallow shafts. The property was last described by Waterhouse (1915) at which time the workings had been abandoned for a number of years and little further work had been done since the report by Waller (1902c). Dressing plant was erected about 1884 before development, and was so inefficient that only the coarsest cassiterite could be recovered and much of the slimes were lost. The mine could not pay for its own development and was forced to close down. Lack of capital and low prices of tin in subsequent years prevented its re-opening.

Underground workings indicated the presence of at least one cassiterite-bearing vein striking NE with a NW dip within a greisenized granite. In No. 1 adit the lode was intersected 75 feet in and was driven on for 45 feet, at which point a winze was sunk on it for 33 feet. Waller was informed that the lode was 4 feet thick, with some rich patches of ore. A bulk sample taken by him over 7 feet of decomposed kaolinitic material near the mouth of No. 3 adit assayed 2.5% metallic tin. He concluded that mineralization was associated with dykes of aplite and microgranite.

Both Waller and Waterhouse regarded this prospect favourably, but there is no record of any exploration since 1915 when most of the workings were inaccessible.

Output of cassiterite is unknown but was probably small.

Long's Iron Blow

This prominent outcrop is two miles SE of the workings at St Dizier Creek, high up on the north slope of Mt. Heemskirk, and was described by Waterhouse (1915). The exposure is about 70 yards long and 50 feet wide, striking NW within the granite and consists of hematite, quartz and black tourmaline. In the early days of the field it was apparently mistaken for an enormous lode of cassiterite. A large sample across the outcrop collected by Waterhouse assayed 0.29% tin.

TABLE 3—Production—North Heemskirk

<i>Mine</i>	<i>Concentrates (tons)</i>	<i>Tin content (tons)</i>	<i>Remarks</i>
Heemskirk Tin Syndicate (Tasman R.)	237.10	155.62	1913-1920
Tasman River	17.36	11.44	1933-1939
Miscellaneous (including Eureka and St Dizier Creek)	40	22.77	Production prior to 1915 not known.

South Heemskirk

The old workings at South Heemskirk have been described in numerous reports since 1881. The most comprehensive was the bulletin written by Waterhouse in 1916. The chief prospects were re-examined by Keid (1943a), since when there has been only limited activity on the field by small parties or individual prospectors.

FEDERATION MINE (SEE FIGURE 8)

The first lease was taken up by W. Montgomerie in 1879 and later that year, the West Cumberland Tin Mining Company started mining on the property. The Cumberland and East Cumberland companies were formed about 1881 to exploit ground further east. Batteries were constructed by the first two groups and about 1884 the Cumberland Dam was built by the Cumberland Co. (in conjunction with the Montagu Co.) to supply power. Waller (1902c) stated that both the Cumberland and the West Cumberland mines produced considerable quantities of tin, but no figures are available, although Montgomery (1893b) estimated that 31 tons of cassiterite had been won from the latter. The field was practically deserted in 1890. About 1893, Fowler and Dunn worked the West Cumberland on a small scale and later in 1893, the New West Cumberland Co. took over the lease but were soon forced to abandon the mine owing to lack of funds. In 1900 the Federation Tin Mining Co. N.L. leased all three properties, but little development took place in subsequent years, except on the Tributors' Workings. Between 1920 and 1923, Federation Tin N.L. explored and sampled the orebodies in spite of limited capital. In 1926, Federation Tin Mines Ltd. was floated in England and work started in the following year. About £80,000 was spent on plant, a hydro-electric scheme and the construction of an aerial ropeway to carry ore from the Black Face to the mill, as well as the re-construction of the road from the Comstock. Production started in 1928 but was interrupted between 1929 and 1934 owing to the low price of tin and lack of capital. Two boreholes drilled by the Government in 1938 proved disappointing and the company went into liquidation soon after. From 1939 to 1942, H. B. Geason extracted about 7½ tons of concentrates, mainly from the Western workings. About 7 tons of concentrates were produced from Heywood and Coleman's lease between 1942 and 1953.

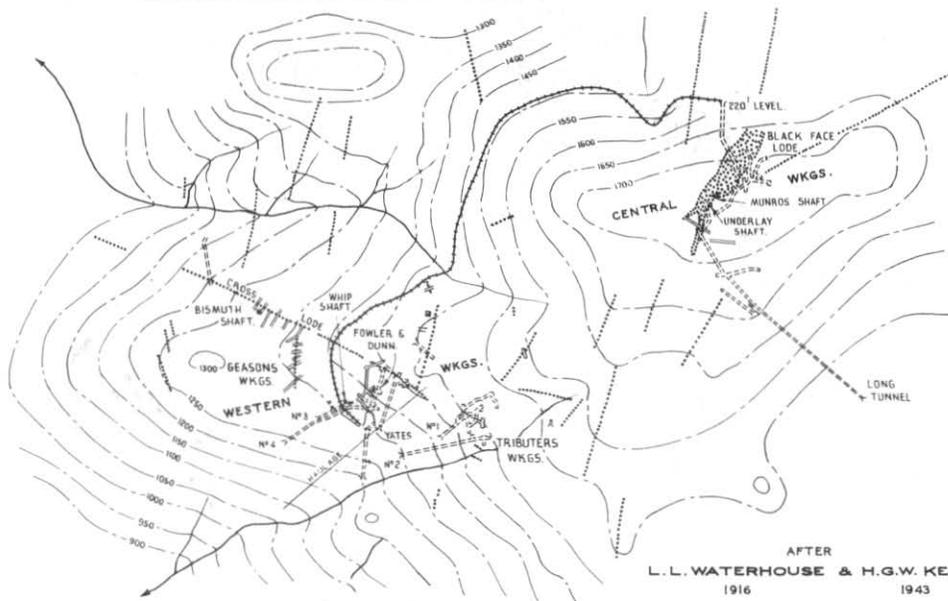
Most of the old workings have long been inaccessible so the following account is largely based on old records. The unpublished report by Keid (1943a) included descriptions of workings cut since those recorded by Waterhouse (1916), Waller (1902c) and earlier authors.

FEDERATION MINE – SOUTH HEEMSKIRK

0 5 10 15 20 CHNS.

LEGEND

-  LODE FORMATION
-  TRENCH
-  ADIT
-  FORM LINE



AFTER
L. L. WATERHOUSE & H. G. W. KEID
1916 1943

5 cm

FIGURE 8.

Western Workings

These were formerly worked by the West Cumberland Co.

No. 4 Adit (570 foot Level): (Levels were calculated according to their vertical distance below the collar of Munro's Shaft—the highest point on the Federation leases). The adit was driven by the old West Cumberland Co. for 418 feet NE on the course of an irregular quartz-tourmaline vein which ranged in thickness from a few inches up to 6 feet. About 237 feet in, a rise connected with No. 3 Adit (70 feet higher) and up into the Whip Shaft which has now been blocked for many years. Waterhouse (1916) commented that over much of the length of the drive, lode material had been left on the northern wall and its true width was frequently not exposed.

No. 3 Adit (500 foot Level).—This was cut by the West Cumberland Co. NE for 170 feet to intersect a vein exposed in surface trenches. A number of small irregular veins were found and tributors stopped out ore there over a length of about 16 feet and later broke through into the Whip Shaft overhead. The ore was soft and kaolinized, carrying cassiterite with pyrite and tourmaline. Pyritic material was picked out and dumped into a rise from No. 4 Adit. The lode was about 6 feet wide and was the same as that exposed in No. 4 Adit. Waterhouse (1916, p. 247) was informed that 300 tons had been crushed for a return of 1% tin. Before 1916, the Whip Shaft and been filled up and an opencut was excavated above No. 3 Adit. Waterhouse noted masses of crystalline quartz with very fine brown and black cassiterite with a little tourmaline. About 9 feet of ore was exposed in the face of the opencut, assaying 1% tin. From its position in Nos. 3 and 4 Adits, Keid (1943a) considered that the orebody pitches to the SW.

No. 2 Adit (530 foot Level).—This was driven by the old West Cumberland Co. 113 feet in a general NNE direction within hard fissured granite on a vein which at the portal was 3 feet wide. About 37 feet from the entrance a 3 feet 6 inches wide lode striking NW was cut, but it is not known if it joins the orebody driven on. One hundred feet in, a rise was put up by the company on a thin fissure coated with black tourmaline within hard granite, and 30 feet up rich ore was found yielding 60-70 tons of tin. Waterhouse (1916) stated that the workings had long since collapsed, but that the mass of ore had been 25 feet high, 20 feet wide and 30-40 feet long.

Fowler and Dunn's Workings

About 1893, Fowler and Dunn took over the West Cumberland property and an accidental fall of roof in the excavation in No. 2 Adit described above revealed more ore higher up. The old workings were unsafe, so the party sank from the surface and recovered 60 tons of cassiterite in an opencut.

No. 1 Adit (450 foot Level).—This adit was driven NNE for about 200 feet from the face of Fowler and Dunn's opencut by the New West Cumberland Co. formed later in 1893. Sixty six feet from the portal a lode about 16 feet wide was intersected and was also cut in a NW cross-cut but the grade of ore is not known. Waterhouse (1916) remarked on the intense fissuring in the granite for the first 100 feet in the adit. Bismuthinite was recorded in a waterlogged winze 50 feet deep about 144 feet from the entrance,

and also in a rise above the winze. A few feet from the end of the adit, a short drive was put in for 15 feet west on a lode striking NW (the "Cross Lode") and an old rise was reported to be in ore for 30 feet. The vein varies from 5 feet 3 inches to 8 feet 6 inches thick and probably dips steeply SW. It consists of iron stained kaolin, and also hematite and black tourmaline.

Yates's Adit.—About 60 feet east of No. 1 Adit and a few feet lower, this adit was driven for 283 feet NNE parallel with No. 1 Adit by the West Cumberland Co. The granite is highly fissured and faulted. A fault striking NNE was met 200 feet from the portal and the adit was driven part way along it. The Cross lode was cut at 235 feet and is 5 feet 3 inches wide, with a NW strike. It is vertical and consists chiefly of quartz with much black and some green tourmaline. At 252 feet, there is a short western drive with a winze sunk on the lode. The winze underlies to the west and the depth is unknown. A sample collected by Waterhouse over 3 feet assayed 3.76% bismuth (as bismuthinite) and 0.46% tin.

Cross Lode Surface Workings

A series of trenches, two shallow shafts and two adits has been excavated at different periods NW along the line of the Cross Lode. Lodes up to about 6 feet wide were revealed, but it is doubtful if the line forms one continuous lode. Vein material is chiefly quartz-tourmaline, reported to carry up to 0.75% tin. Almost above the position of the rise in No. 1 Level, Waterhouse described an outcrop of black tourmaline in a groundmass of hematite about 5 feet wide which contained a little cassiterite.

Geason's Workings

Between 1939 and 1942, J. B. Geason obtained small amounts of cassiterite, wolfram and bismuthinite from shallow shafts and trenches NW and NE of the old adits. Much of the ore came from a trench 75 feet long on a NW trend varying in depth down to 20 feet, and up to about 15 feet wide. Keid (1943a) reported a greisen orebody within the trench dipping about 20° SE.

Tributors' Workings

The workings are about 200 feet east of Yates's Adit and were mostly inaccessible before 1943. The original workings consisted of an opencut with a shaft from the floor, and an adit. After about 1916, two other adits were driven in to cut the ore-bearing formation in depth. The most important orebody was a pipe of soft greisen material within fairly fine white granite. Waterhouse (1916) noted that brownish-black crystals of cassiterite ranging in size from about half an inch to minute crystals were scattered singly and in aggregates throughout the lode-stuff which he regarded as a mixture of pinitite and kaolin. Crystals of pyrite up to an inch across were common. The pipe was followed down for 115 feet and a branch for 30 feet. The walls are very irregular and the workings tortuous, including a shaft sunk on the pipe and an adit driven about 60 feet below the collar. The orebody is roughly funnel shaped, with a lens-like cross-section, decreasing in size from about 25 feet by 15 feet at the surface to about 5 feet by 1 foot in depth. Values ranged from about 6% to 23% cassiterite, and a total of about 80 tons is reported to have been extracted from the Tributors' Workings (Keid, 1943a).

Central Workings

This group of workings lies on the highest section of the Federation property, at an altitude of over 1700 feet, NW of the Cumberland Dam and was originally operated by the old Cumberland Co., one of the first group to mine the Heemskirk district.

(a) Black Face Workings

The workings were named after a prominent outcrop of dark green tourmaline and quartz forming an irregular orebody striking NE within fractured granite. It was worked in an opencut in the early days of mining and Waller (1902c) reported that a bulk sample over 17 feet 8 inches averaged 1.64% tin, although much of the cassiterite was very fine grained. In 1927, Federation Tin Mines Ltd. exploited the area without profit. Keid (1943a) noted that assay results during an extensive sampling programme from 1927-1929 indicated that the grade of ore was too low to be profitable.

220 foot Level.—This was driven from the north slope of the hill south for 160 feet and then SSE for 220 feet. About 170 feet were cut by the old Cumberland Co., and Waterhouse (1916) reported its length as 214 feet, so that it may have been extended by the original Federation Co. The remainder appears to have been driven at some time between 1920 and 1938. Keid (1943a) recorded that the last 60 feet were in an irregular quartz-tourmaline formation which was also intersected in a SE crosscut 200 feet long. The crosscut was in the lode formation for 110 feet to the end, at which point a horizontal borehole was drilled in 1938 for 110 feet ahead of the crosscut. The hole was in lode formation for 90 feet before entering granite. A borehole declined at 60° from a point 55 feet from the face in the crosscut and drilled 120 feet in the same direction was also in the orebody for 110 feet. However, sampling in the crosscut showed that cassiterite was absent, although it is not known whether the drill cores were assayed.

115 foot Level.—This was driven for about 45 feet SSE by the old Cumberland Co. and was apparently extended for about 160 feet SSW by Federation Tin Mines Ltd. after 1927 (plan by Keid, 1943a). The last 60 feet was in quartz-tourmaline. A rise was put up to the opencut about 40 feet from the end of the drive, and a rise and winze were cut at the end. A SE crosscut leading off near the rise to the opencut was in quartz-tourmaline with bands of granite to the end of the crosscut at 120 feet, at which point 6 samples over a width of from 4 feet to 6 feet assayed between 0.21% and 0.77% tin.

85 foot Level.—This adit was cut in decomposed lode material in the early days of the field. Waterhouse (1916) reported assays of about 0.5% tin over 27 feet.

(b) Munro's Shaft

This is about 100 feet SW of the Black Face. The shaft has been inaccessible for many years and reports are confusing. Waller (1902c) stated that it was 25 feet deep on the lode and that a crosscut had intersected ore containing 1% tin for 16 feet to the

east wall. Waterhouse (1916) described a similar crosscut but quoted the depth as 51 feet. The lode consisted of hard quartz with green tourmaline and fine light brown cassiterite in cavities or disseminated throughout the orebody. Fine pyrite was present, and at the surface the outcrop is 43 feet wide.

(c) Underlay Shaft.

This is 80 feet south of Munro's Shaft and was water logged in 1902. Thureau (1881) stated that it was sunk on the hanging wall side of the orebody through granite until it intersected the main orebody and was then put down vertically in it for 25 feet. The total depth was 60 feet, and at the bottom a crosscut proved a width of 14 feet, probably of low grade.

(d) Long Tunnel

This was driven by the old Cumberland Co. from a point near the Cumberland Dam for 997 feet NW, and was probably designed to cut the Black Face lode system. A number of orebodies were intersected and worked by the company, but no production figures are available. Crosscuts were put in on one lode, 893 feet along the adit. The western cut extended for 40 feet in lode material and a winze was sunk 80 feet near the face, Waterhouse (1916) reporting assays of 0.5% tin here. Some stoping was done in an eastern crosscut which was said to carry up to 2% tin. It is not known whether this vein is connected with the Black Face lode system, but the possibility remains. Waller (1902c) calculated that it was cut 300 feet SW of the Black Face and 280 feet vertically below it.

Eastern Workings

Although worked intermittently from an early date, the workings are relatively unimportant and have long been idle. They have been explored in a prospecting shaft, later connected with a shallow adit in which some stoping was done. Fine pale brown and grey cassiterite occurs with quartz and pale green tourmaline within coarse pink granite. Waterhouse (1916) stated that 14 tons of concentrates had been produced by the old East Cumberland Co., but Keid (1943a) considered this an excessive estimate.

Heywood and Coleman's Workings

Before being taken over by Messrs Heywood and Coleman, the lease had been prospected by several trenches and two adits, about 600 yards south of the Black Face workings. A number of quartz-tourmaline veins were exposed and Keid (1943a) described recent trenching on an irregular greisen lode with some cassiterite, and also the occurrence of quartz-tourmaline nodules up to 2 inches in diameter containing up to 17% tin, in irregular clusters within decomposed granite. About 7 tons of cassiterite was produced between 1942 and 1953.

Within the old Federation leases there are a number of other trenches and pits which have revealed quartz-tourmaline lodes containing cassiterite and pyrite similar to those already described, but output has been on a small scale.

TABLE 4—Production—Federation Mine

<i>Company or Party</i>	<i>Concentrates (Tons)</i>	<i>Metallic Tin Content (Tons)</i>	<i>Remarks</i>
Cumberland and W. Cumberland	200	Est. 120	Water-house (1916, p. 324)
Federation Tin Mines Ltd.	107	66.23	} 1927-1929, 1935-1938 1939-1942 1942-1953 1951-1952
* J. B. Geason	7.50	3.58	
Heywood and Coleman's lease	7.35	3.90	
C. A. Anderson	0.28	0.15	
	322.13	193.86	

* Also sold concentrates containing 0.016 ton Bismuth.
Grade of Ore

<i>Treated</i>	<i>Concentrates Recovered (Tons)</i>	<i>Metallic Tin Content (Tons)</i>	<i>Tin in Concs. (%)</i>	<i>Tin in Ore (%)</i>	<i>Reference</i>
720	12.90	8.26	58.7-69.4	1.15	Black Face Waller (1902c)
330	5.50	3.63	63-69	1.1	500 ft. Level Waller (1902c)
450	11.79	8.03	68.11	1.78	Sec. Mines Rep. 1928
3892	5.00	3.00	60.	0.08	Rep. 1935
3461	10.00	6.00	60.	0.17	Rep. 1936
4798	25.00	15.40	61.6	0.30	Rep. 1937
935	4.87	2.80	57.5	0.30	Rep. 1938

NOTE.—The efficiency of treatment plant is not known but as much of the cassiterite is very fine, it is doubtful if recovery exceeded about 60%.

MAYNE'S MINE (see figure 9)

The old workings are on a spur in a bend of Pykes Creek $\frac{1}{4}$ mile south of Zeehan-Trial Harbour road, about 3 miles east of Trial Harbour. Coarse detrital cassiterite was accidentally found in late 1901 or early 1902 on J. Mayne's farm, a short distance south of the old Kelvin workings. In subsequent years, the cassiterite was won by sluicing on the ridge and in Pykes Creek, but as the equipment was primitive, only the coarse cassiterite was recovered, much of the fines being allowed to go to waste in the creek. When the detrital and alluvial tin was exhausted, the irregular cassiterite bearing veins beneath were worked but results appear to have been discouraging and the mine closed about 1906. In later years, some work was done by the Lyell Syndicate, but there is no record of any further production until 1935-1936 when H. Reid took out small quantities of cassiterite. The Golden Sovereign Co. held an option over the property in 1942 and the old battery was reconditioned, but work soon ceased as the cassiterite proved to be too fine for economic production. There has been little work on the leases since.

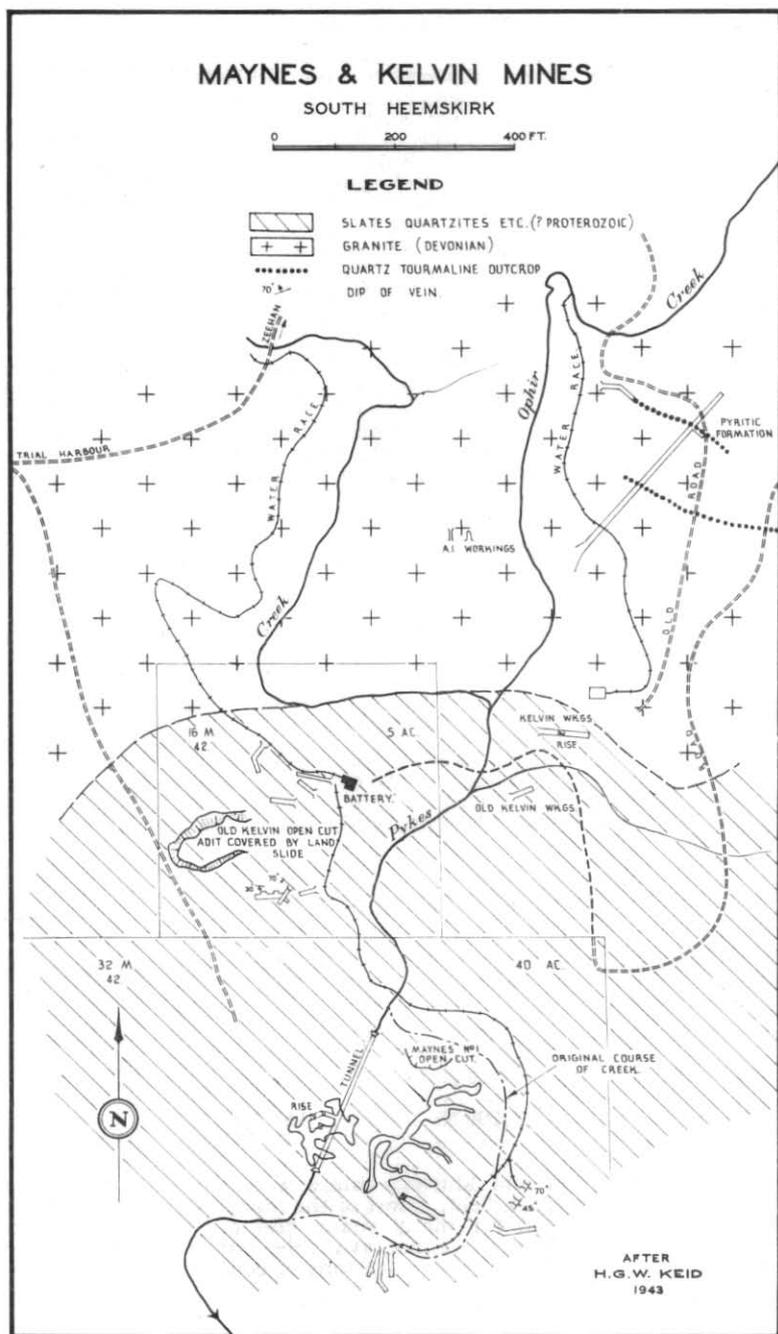


FIGURE 9.

5 cm

The deposit is the only one besides the Kelvin mine to have been worked within the sedimentary rocks at Heemskirk. The workings are about 400 feet south of the granite contact and mineralization has taken place in short and irregular fissure veins cutting indurated and tourmalinized Oonah Quartzite and Slate. The unusual nature of the detrital cassiterite was described by Waller (1902c), Clark (1904) and Waterhouse (1916). The depth of downwash on the ridge averaged only about 12-15 inches, but may have been about 3 feet on the southern slope. The cassiterite is grey and a considerable proportion was in nuggets weighing up to about 20 lbs. Some of the fragments were botryoidal, the centre being granular and surrounded by thin concentric layers or faintly radiating structures.

The country rocks are intensely fissured and the vein pattern is accordingly irregular and complex. Veins are usually short and range in thickness from mere threads of tourmaline up to about 4 feet, striking in different directions and with variable dips. They are chiefly of quartz and green tourmaline, with some black tourmaline, pyrite, galena and sphalerite. Most of the rich detrital tin was derived from vughs or bulges within veins in which coarse cassiterite was associated with kaolin and green tourmaline. The walls of the vughs are usually impregnated with fine green tourmaline and cassiterite.

Workings

The orebodies were worked in a number of opencuts, shallow shafts and adits, most of which were put in during the early days of mining. A tunnel about 200 feet long was also driven at this time NE across the bend in Pykes Creek and under the ridge, so diverting the creek with the object of working alluvial tin in the former bed. A number of veins were cut in the tunnel, but only one was developed which Keid (1943a) reported to be a flat-lying tourmaline vein driven on for about 20 feet. At the end of the level, a rise was cut to connect with a shaft from one of the opencut workings, but the ore was apparently low grade and no stoping was done.

TABLE 5—Production—Mayne's Mine

<i>Period</i>	<i>Concentrates (Tons)</i>	<i>Metallic Tin Content (Tons)</i>	<i>Remarks</i>
To 1916	200	Est. 140	Waterhouse (1916)
1935-1936	0.35	0.22	H. Reid
	<u>200.35</u>	<u>140.22</u>	

The Federation and Mayne's mines were the chief producers on the South Heemskirk field. Most of the numerous other prospects have been abandoned for many years, and are described briefly below. Accurate figures are not available, but they have yielded an estimated aggregate of about 445 tons of concentrates representing some 264 tons of metallic tin.

CORNWALL MINE

This is near the mouth of Packers Creek on both sides of a sharp bend a short distance from the sea. The old Cornwall company ceased to work in 1884 and there has been little activity since. The workings include opencuts, trenches, two short adits and a tunnel driven NE through the hill NW of the creek. The tunnel was originally used to transport ore to the battery near the coastline and in it a number of pyritic quartz-tourmaline veins were cut, ranging from 1 inch to 18 inches with northerly strikes. The water from Packers Creek was later diverted through it so that alluvial tin in the creek bed could be recovered.

Mineralization appears to be low-grade and production was insignificant. Thureau (1884) stated that several tons of ore had been shipped to Melbourne from the west side of the creek.

CLIFF (PACKERS CREEK) MINE

About $\frac{1}{2}$ mile SSE of the Cornwall mine the Cliff Mining Co. explored the area about 1881-1882 and some work was done in 1915-1916 and again in 1927, but the only production recorded is the 4 tons of detrital cassiterite mentioned by Thureau (1882). Mineralization occurs within medium to fairly coarse, strongly jointed, cream granite with numerous schorl nodules. The joints strike generally NW and NE and the veins tend to follow similar directions. They were investigated in an old shaft near the cliff face, about 18 feet deep, 2 adits and a narrow opencut. Waterhouse (1916) commented that much of the material crushed by the original company appeared to be ordinary black tourmaline which was apparently mistaken for cassiterite. Assays recorded by Scott (1928) ranged from 3.18% tin over 2 feet at the bottom of the shaft to 5.5% tin over 10 feet at the surface, 50 feet SE of the shaft. The latter sample probably consisted of detrital material collected at the surface.

EMPRESS VICTORIA MINE

About $\frac{3}{4}$ mile north of Trial Harbour. The mine was originally operated by the Empress Tin Mining Co. but the workings were waterlogged as early as 1884. Thureau (1884) stated that the shaft was sunk on ore within microgranite to a depth of 111 feet, and was opened out at the 105 foot level. An adit 117 feet long connected at the 53 foot level. Cassiterite cut out at a depth of 27 feet, the orebody apparently passing into a lode carrying arsenopyrite, pyrite and chalcopyrite with tourmaline. Thureau interpreted the change as a fault, but shaft timbering prevented further examination. While a fault is possible, it is more likely due to changes in the orebody itself.

The country rock is a medium grained cream coloured granite with nodules of quartz-tourmaline, which passes into coarse pink granite to the south.

From the dump near the shaft, Waterhouse (1916) noted greisen vein material consisting of quartz, muscovite, and sheaves of black tourmaline with some green tourmaline, while a little disseminated pyrite was also present.

A prospecting shaft about 20 feet deep was sunk about 100 feet NW of the main shaft, and a shallow adit was cut from which vein material with green tourmaline was obtained. About 100 yards SW of the main shaft, on the west bank of the creek, an adit had been put in about 300 feet NW into the hill through white granite.

At 250 feet, two narrow veins were driven on for a short distance SW, but little of value was found. There is no record of any production from the mine.

PRINCE GEORGE MINE

Near Packers Creek about 1 mile SW of the Federation mine, a short distance south of the present Trial Harbour-Granville road. The property was originally worked by the Great Western Co. and Tilley (1891) stated that tin was first found in the district here. A shaft was sunk 50 feet on an almost vertical quartz-tourmaline vein about 2 feet wide and an adit was driven on the vein for 144 feet revealing an average width of 2 feet to 3 feet 6 inches (Thureau, 1882). Other outcrops were investigated in shallow shafts and trenches. About 1916, R. Clarke excavated an opencut 50 feet long on the course of a vein 2 feet 6 inches wide striking NW on the SE side of Packers Creek and Waterhouse (1916) recorded that payable ore continued along the cut and in the face. Some prospecting had been done on the same vein NW of the creek. Production from this property is not known, but is unlikely to have been more than a few tons of concentrates.

MONTAGU MINE

The old workings lie about $\frac{1}{4}$ mile NW of the junction of the Granville Harbour road with the Zeehan-Trial Harbour road, on both sides of Montague Creek. The mine was one of the first to exploit the Heemskirk field, but it was soon abandoned and the main workings were flooded by 1882. Waller (1902c) based his description of the mine on local information as none of the workings were accessible. At that time, M. Bullen had produced small amounts of cassiterite from surface outcrops and the creeks. Little work was done in later years until about 1941 when M. Donahue put in short adits east and west of Montagu Creek.

The following account of the chief workings is compiled from reports by Waller (1902c), Waterhouse (1916) and Keid (1943a). The main lode strikes a few degrees east of north and is cut by Montagu Creek. It consists of a number of parallel veins of quartz-tourmaline and greisen which at the surface contained a rich shoot of cassiterite. A similar vein strikes north and a prospecting shaft was put down by the old Montagu Co. at the junction of the lodes. Cassiterite appears to have cut out at a relatively shallow depth, and the main shaft was sunk to a depth of 118 feet within white nodular granite, a short distance to the SW of the prospecting shaft. At 100 feet from the surface a crosscut was driven about 50 feet west to intersect the N-S lode, which proved to be 2 feet wide, but unproductive. The vein was driven on to its intersection with the main lode, where a rise was put up to connect with the prospecting shaft. A shoot of cassiterite-bearing ore was found, below the orebody prospected at the surface. The ore was stoped out to within 7 feet of the surface, and M. Bullen worked the remainder by underhand stoping. At the junction of the orebodies, the main lode was reported to be up to 12 feet wide, and slightly pyritic. It was driven on for only about 15 feet to the east before work stopped, although the ore was said to be encouraging. No driving was done westwards at this level.

Further to the east, other workings include trenches and shallow shafts on cassiterite-bearing quartz-tourmaline and greisen veins.

Between about 1941 and 1943, M. Donaghue produced small quantities of cassiterite from thin veins in an adit driven NE from the east bank of Montagu Creek.

At least 6 tons of cassiterite are known to have been produced from the Montagu lodes. In addition, Waterhouse (1916, p. 336) reported that 5 tons of alluvial cassiterite had been won by the old Montague company from a narrow strip of alluvium in Montagu Creek.

MONTAGU EXTENDED MINE

This is about $\frac{1}{2}$ mile west of the old Montagu mine. The old workings consist of a shaft about 30 feet deep which has been full of water for many years, and 3 adits driven NE, the longest of which is 170 feet long. On the dump near the shaft, Waterhouse (1916) noted fragments of quartz and black tourmaline containing a number of geodes encrusted with dark green tourmaline, and aggregates of small black cassiterite crystals were seen on fragments of chalcopyrite. A grab sample from the dump assayed 0.93% tin, and showed traces of copper, antimony and bismuth.

Keid (1943a) described work carried out by M. Humphries from about 1941. Two winzes were sunk, 12 feet and 35 feet deep respectively, in the longest adit and small amounts of cassiterite were recovered from irregular quartz-tourmaline veins. At the time of the inspection, both winzes were full of water but it was claimed that more than a ton of concentrates carrying 68% tin was taken out of the deeper winze. At this point the vein was about 2 feet 6 inches wide, but it rapidly thinned further along the adit.

WAKEFIELD MINE

This is situated on a steep slope, about $\frac{3}{4}$ mile south of the Federation mine. Like many of the other early-formed companies, capital was spent on equipment and little development was possible before funds were exhausted. Waterhouse (1916) suggested that the lode worked was discovered by tracing cassiterite up the slope from alluvial tin on the flat below. A quartz-tourmaline-cassiterite vein striking about N-S within greisenized and tourmalinized granite had been explored by an opencut leading to an adit driven on the vein. The adit was inaccessible, but Waterhouse was informed that the adit was between 45 feet and 50 feet long, and that the vein is about 3 feet wide in the face. Output of cassiterite was probably very small.

Waterhouse (1916) also reported that on the flat about 130 yards south of the mine, U. Gillham had recently sluiced alluvial and detrital material over an area 60 yards long and 35 yards wide, the depth averaging about 20 inches. Much of the cassiterite was coarse, in the form of angular nuggets or thin slabs of grey or reddish cassiterite derived from the weathering of thin veins.

From about 1956 to 1959, E. Coleman produced small quantities of cassiterite from the old Wakefield lease.

SWEENEY'S (OR BIRTHDAY) MINE

This is situated high up on the upper reaches of Pykes Creek, about $\frac{1}{2}$ mile north of the Zeehan-Trial Harbour road and 1 mile NW of Mayne's mine. Mineralization has taken place within coarse pink granite with aggregates of black tourmaline which has been intruded by dykes of aplite. The original workings were described by Waterhouse (1916) and Reid 1927a). A lode formation

was exposed in a shallow trench on a hill about 100 feet above the creek, and consisted of black sphalerite with pyrite and small amounts of fine stibnite and chalcopyrite in a gangue of quartz, siderite, fluorite and tourmaline. Assays indicated 0.75% tin. In 1916, an adit was being driven a few feet above Pykes Creek northwards with the object of intersecting in depth the stanniferous sphalerite orebody exposed on the hill, and was then 150 feet long. After 40 feet, the granite is kaolinized and contains crystals of pyrite, aggregates of amethyst coloured fluorite and some sphalerite. At 99 feet a short crosscut was driven west for 12 feet where a thin vein of fine cassiterite with pyrite was uncovered. Reid (1927a) noted that the adit had been extended to 166 feet and the altered granite carried very fine disseminated cassiterite. The adit was eventually driven to a total length of 245 feet from the portal (Keid, 1943a).

About 60 feet above the adit, a low grade orebody with abundant sphalerite and pyrite in a groundmass of quartz was partly exposed. There is a short adit and opencut on a similar body a little below this.

Samples taken by Reid and J. H. Levings from different parts of the property assayed up to 2.83% tin. Keid (1943a) recorded that in 1940 samples taken in 20 feet sections along the adit on behalf of W. E. Higgins varied from nil to 1.05% tin, and three samples from the crosscut in the adit assayed 1.05%, 0.97% and 0.51% tin.

The only recorded production is between 1903 and 1904 when about 13 tons of cassiterite was recovered. Much of the tin produced may have been alluvial, derived from the boulder filled bed of Pykes Creek, where alluvial cassiterite was worked in rich pockets by A. Tengdahl (Waller, 1902c) and by D. Sweeney (Waterhouse, 1916). Some of the cassiterite was granular, but a considerable number of nuggets and some boulders were also recovered.

KELVIN MINE (see figure 9)

This old mine was situated a short distance south of the granite boundary, and north of Mayne's mine. As in the latter, the cassiterite-bearing veins cut indurated Onah Quartzite and Slate. In the early days of the field, the area was part of the old Orient Co. leases, later worked by the Kelvin Co. About 1916, a party explored the veins in No. 2 opencut and No. 4 adit, when apparently the workings had been idle for many years. Keid (1943a) recorded that the old adits had collapsed and that recently an attempt had been made to uncover No. 3 adit which had been buried by a landslide in the old opencut, but work soon ceased without result.

Waterhouse (1916) noted that No. 1 adit was inaccessible. No. 2 adit had been driven 25 feet NW and in the face a thin pyritic vein with good tin values was cut. Encouraging values were also found in thin flat-lying veins in surface workings higher up the hill. Small cuts were sunk on a vertical vein striking NW, and on the same line at the top of the hill a lode containing grey cassiterite and green tourmaline had been worked to depths of 10 to 15 feet. The old Kelvin Co. excavated No. 1 opencut and were reported to have recovered 14 tons of cassiterite from oxidized lode material by sluicing. The orebody was said to strike east with a northerly dip of 25°, ranging from 2 to 6 feet in width and to have assayed 6% tin. No. 3 adit was driven from the opencut north for 24 feet with crosscuts 5 feet east and 21 feet west 16 feet in from the portal. Driving and stopping had been done on the west

crosscut, but the amount of ore taken out was small. The vein appeared to be flat-lying with vughs and consisted of kaolin with cassiterite and tourmaline impregnated with small crystals of pyrite. In No. 2 opencut, three irregular cassiterite-bearing veins within tourmalinized quartzite were exposed in the face. No. 4 adit was being driven in 1916 over a winze in the SW corner. It had been cut for 8 feet south, then 15 feet west and had exposed a lode varying in thickness from $1\frac{1}{2}$ to $5\frac{1}{2}$ feet. The richest ore only was being extracted, but there is no record of production.

ORIENT MINE

This is located NE of Mayne's mine and about $\frac{1}{4}$ mile south of the Zeehan-Trial Harbour road. The Orient Co. erected the first battery on the field to start treating ore in early 1884. The old workings are mainly in the granite except those later taken over by the Kelvin Co. in the SW. Thureau (1884) stated that much prospecting and dead-work had been carried out since 1882, but little of value was found. The property was taken up again in 1902 but no worthwhile development has since been recorded. The lodes were explored in a series of shafts, adits and trenches which exposed a number of quartz-tourmaline and greisen veins, sometimes pyritic, most of which were relatively thin, though some range up to about 3 feet thick. The veins strike generally NW or a few degrees north of west. East of Pykes Creek, an adit was driven 300 feet east and at 250 feet a cassiterite-bearing lode was cut, believed to be "Thorn's Lode" which outcrops at the surface (Thureau, 1884). Thureau's account is confusing as he also mentioned that the "Wheel Lode" was intersected 250 feet in from the portal, carrying a little cassiterite over a width of 12 feet. The adit had collapsed by 1916 but Waterhouse (1916, pp. 391-392) reported from the old dumps masses of phlogopite in plates up to $1\frac{1}{2}$ inches across, with a little tremolite and quartz. Quartz with lilac and green fluorite and small crystals of molybdenite also occurred, and aggregates of hornblende were associated with serpentinized olivine, magnetite and pyrrhotite.

Keid (1943a) concluded that in the Orient mine the grade of ore proved too low to be workable. It is doubtful if more than a few tons of cassiterite were produced.

GLOBE (OR MT AGNEW) MINE

About $1\frac{1}{2}$ miles NE of Sweeney's mine, on the southern slopes of Mt Agnew. The only workings consist of an adit driven on a bearing of 285° for over 200 feet into the hill which was blocked prior to 1916. Waterhouse was informed that the adit intersected an ore-body 5 feet wide striking NE, and the shoot had been worked over a length of 30 feet. The ore was handpicked and separated into galena and tetrahedrite rich in silver, and chalcopyrite ore. Specimens collected on the dump confirmed that the two groups of minerals were not intimately mixed. A little sphalerite and pyrite were also present, and gangue minerals included quartz, green tourmaline, green and amethyst-coloured fluorite and siderite. A grab sample from the dump assayed 0.37% tin and 29 oz per ton silver.

HEALEY'S AND MCIVOR'S MINE

This is situated a little over $\frac{1}{4}$ mile west of the Globe mine on the scrub-covered slopes of Mt Agnew. The workings consist of two adits, an opencut and a shaft which were inaccessible before 1916. Fine pale brown cassiterite was reported in quartz-tourmaline veins

and tourmalinized granite. Mineralization appears to have been low grade but no production figures are available. A sample of vein material consisting of quartz and green material collected by Waterhouse from a dump outside the western adit was found to contain only 0.14% tin.

ALLUVIAL DEPOSITS

Most of the creeks flowing off the Heemskirk Range contain alluvial cassiterite but stretches of alluvium are generally small. Pockets of cassiterite are to be expected within creek beds, as described in Montagu Creek. The bed of Pykes Creek south of Mayne's mine was formerly sluiced for tin, much of which was detrital, but the deposits were of no great depth. Waterhouse (1916) quoted official records showing that at least 8 tons of concentrates were recovered. Further downstream, potentially tin-bearing alluvium was described by Waller (1902c) near the junction of Pykes Creek with the Little Henty River. The alluvial flat here was considered by Scott (1927) as an encouraging prospect, although thick scrub and driftwood made an examination difficult. It covers about 2 acres in a strip about 200 yards long and up to 40 yards wide. Although it was prospected by the Publican's Purse Syndicate about 1905, it is not known if the area was worked. The cassiterite is derived from Mayne's and the Kelvin mine.

At the junction of Agnew and Healy Creeks, the Zeehan-Trial Harbour road crosses an extensive button grass flat which obscures the contact of the granite and the Proterozoic quartzites and slates. The detritus is a mixture of downwash from the slopes of Mt Agnew and of old alluvium, averaging about 3 feet in depth. Waterhouse (1916, p. 411) quoted a report that in 1900, the Mt Agnew Alluvial Tin Mining Co. held about 60 acres and had started hydraulic sluicing, but operations were apparently short-lived. Twelvetrees (1901, p. 59) referred to Bourke's alluvial deposits here, stating that the ground was patchy, but a rich section had been discovered after 11 months sluicing. Waller (1902c, pp. 41-42) mentioned recent prospecting by T. C. Climie who had obtained encouraging results. However, it is not known if work was resumed on the deposit.

TABLE 6—Production—South Heemskirk

<i>Mine</i>	<i>Concentrates (Tons)</i>	<i>Tin Content (Tons)</i>	<i>Remarks</i>
S Heemskirk* to 1916	200	Est. 120	
Federation Mine	322.13	193.86	
Mayne's Mine ..	200	Est. 140	
Miscellaneous	44.71	23.88	1924-1959
	<u>766.84</u>	<u>477.74</u>	

*Waterhouse (1916, p. 430) estimated production prior to 1916 at 600 tons of cassiterite, of which 200 tons came from the Federation mine (p. 324) and 200 tons from Mayne's mine (p. 381).

TABLE 7—Total Production—Heemskirk Field

	<i>Concentrates (Tons)</i>	<i>Tin Content (Tons)</i>
North Heemskirk	294.46	189.83
South Heemskirk	766.84	477.74
	1061.30	667.57

Summary

1. In the Heemskirk tin field, widespread mineralization has taken place, chiefly in a broad zone on the southern margin of the granite.

2. Cassiterite occurs in quartz-tourmaline or greisen fissure veins, and also within pipes or masses of soft greisenized granite. Many of the veins trend between NW and NE, but occasionally they may be extremely irregular, as in Mayne's mine. Some veins include vughs or cavities containing coarse cassiterite, but these and also the highly mineralized greisen pipes or lenses, are impossible to predict as past development has shown.

3. Except for the Kelvin section of the old Orient leases, and in Mayne's mine, the known orebodies lie entirely within the granite.

4. Although many lodes carrying cassiterite have been discovered and explored, rich concentrations are erratic and tend to form relatively short oreshoots. Taken overall, therefore, the orebodies must be classed as low grade, the cassiterite often being fine and disseminated. Pyrite may be present in depth in the unoxidized portion of the veins.

5. At North Heemskirk production has been mainly from alluvial deposits but these are only of limited value at South Heemskirk where most of the tin was mined from orebodies.

6. The past history of the field has shown that the policy of erecting costly plant before proving adequate reserves was invariably disastrous and that until such reserves are proved, the deposits can only be worked on a small scale. With this proviso, a number of old properties appear to be worthy of further investigation.

Conclusions and Recommendations

NORTH HEEMSKIRK

1. Most of the tin-bearing alluvium in the Tasman River appears to have been worked out. The depth to which the dredge operated by the Heemskirk Tin Syndicate worked is not known but was probably not greater than about 20 feet. The total depth of alluvium immediately south of the quartzite bar is also unknown but the last paddock worked is now covered by the dam. It is possible that there is tin-bearing alluvium under the dam but to work it, a considerable volume of water would have to be pumped out and the small creek diverted.

Small patches of alluvial gravels and sands remaining up St Dizier Creek and down the Tasman River might be worked on a small scale. The Tertiary sands, gravels and conglomerate in the district contain cassiterite (for example, assays ranging from 0.14% to 0.19% were recorded by Waterhouse, 1915, p. 16), but it is rarely in workable concentrations in the small creeks flowing north to the Pieman; only minor deposits could be expected and the amount of cassiterite should diminish northwards.

2. The Peripatetic mine has been abandoned for many years, but Waller (1902c) reported encouraging tin values. Little development was done but it is known that much of the cassiterite is very fine and is associated with pyrite.

SOUTH HEEMSKIRK

The alluvial deposits are of doubtful economic value. The flat near the confluence of Pykes Creek with the Little Henty River is the most extensive, but does not appear to have been sampled systematically. Thick scrub would make exploitation difficult.

Future prospecting in the South Heemskirk district should be concentrated on the area between the Federation and Mayne's mines. In the Federation western workings, crosscutting and sampling in the 570 foot level (No. 4 adit) should be considered. Little is known of the lode below this level, although Waterhouse (1916) reported good values over a width of 3 feet continuing underfoot, 88 feet in from the portal. It is debatable whether diamond-drilling would be justified owing to the difficulties in installing the plant, the weathered and fractured nature of the granite and orebodies, and the patchy concentration of cassiterite.

Little is known of the Cross Lode in depth. It was driven on for 15 feet at the end of No. 1 adit (450 foot level) and was cut in Yates's Adit but the only other workings are relatively shallow surface excavations, so that further testing is desirable.

Within the western workings, three rich greisen orebodies have been worked in the past. It is possible that similar bodies may occur in depth but this suggestion must be regarded as merely speculation as there is no direct evidence to support it.

The central workings have been exhaustively explored up to 1938 and appear to have been worked out.

At Mayne's mine, much of the cassiterite was derived from vughs within an irregular fissure vein system which has been tested over a vertical range of about 80 feet above creek level. Most of the veins are thin and low-grade. Exploratory drilling to test the vein system in depth would help determine whether or not further prospecting of this mine is warranted. A suitable location would be just above Pykes Creek near the northern end of the tunnel and the hole should be declined at about 45° to the south, for a drilled length of about 300 feet.

THE RENISON BELL TINFIELD

Introduction

The tinfield lies south of the township of Renison Bell which is 11 miles NE of Zeehan on the Emu Bay Railway and the main Queenstown to Rosebery road. Mineralization is present over an area of about 4 square miles between the railway and the Ring River, extending as far south as Pine Hill (See Figure 10).

Montgomery (1893b) recorded that alluvial cassiterite was found in 1890 by R. Nicholson in the Ring River near its confluence with Dalcoath Creek. Alluvial tin was later found in Dalcoath Creek and followed up Gormanston Creek, north of Pine Hill,, where many large nuggets of cassiterite were discovered, including the "Gormanston Nugget" which weighed 19 cwts. Twelvetrees (1906) estimated that up to that year about 200 tons of alluvial and detrital cassiterite had been produced.

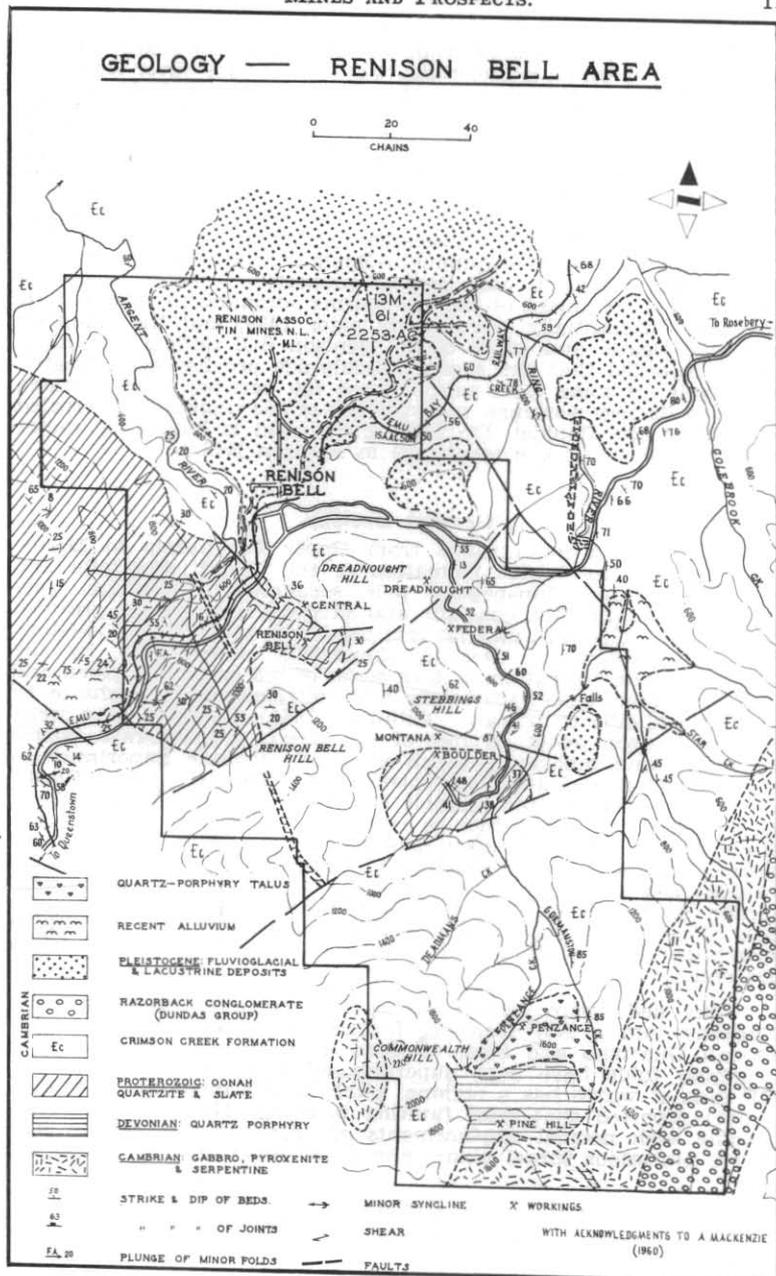
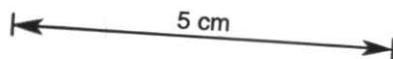


FIGURE 10.



About 1893, the gossan capping the "Commonwealth Lode", the location of which is uncertain, was explored for silver-lead, and fine-grained cassiterite was detected. Cassiterite-sulphide ore was found on the Renison Bell lease during the construction of the Emu Bay Railway in 1900, but little activity took place until about 1905 when a number of small companies started treating tin-bearing gossan and oxidized sulphide ore. By 1922, this easily worked ore was becoming exhausted and Reid (1922c) suggested that treatment of the complex massive sulphides must be considered. In 1934, the present company, Renison Associated Tin Mines N.L., took over the old Renison Bell and Dreadnought-Boulder mines, with option on the Federal, Montana and Central properties. After successful experimental treatment of the tin-bearing sulphides in 1936, output increased substantially, particularly after 1939, and the company now holds leases over much of the Renison Bell tinfield. Gilfillan (1961) recorded that the cassiterite-sulphide ore has been treated exclusively for some years past. About 400 tons per week is mined from the Battery workings, near the site of the original mill erected in 1907 by the Boulder Tin Mining Co., and is hauled by motor truck $2\frac{1}{2}$ miles to the present mill in Renison Bell.

General Geology

The country rocks range from Upper Proterozoic to Middle Cambrian. The lowest formation is the Oonah Quartzite and Slate comprising thin-bedded pale saccharoidal quartzite, grey muscovite-bearing fine quartzite and siltstone, and grey or greenish grey shale. The beds pass up into hard grey to dark grey siltstone and shale which are overlain, apparently conformably, by the Crimson Creek Formation, a thick series of red or purple, green and grey mudstone, shale, greywacke and conglomerate, thought to be Lower to Middle Cambrian. Gilfillan (1961) described as a well-defined horizon about 80 feet of red chert, conglomerate, coarse sandstone and mudstone, which is of considerable importance in mining and diamond-drilling correlation. This, the "Red Rock" of previous workers, for example Conder (1918) and Reid (1922c), is considered by the author to represent the base of the Crimson Creek Formation. The latter sequence has been regarded for many years as Dundas Group (Middle to Upper Cambrian), but Taylor (1954c) and Blissett and Gulline (1961a) showed that the Dundas Group, as defined, is younger. In late Cambrian times, numerous sills of gabbro or pyroxenite were intruded, and the dykes or sills of quartz-porphphy at Pine Hill and near Renison Bell are probably Devonian.

The beds were folded during the Devonian Tabberabberan Orogeny into a NW trending faulted anticlinal ridge, with the Oonah Quartzite and Slate exposed in the core. Minor gently plunging folds have been superimposed upon the structure, the SE nose of which has a regional pitch in this direction. Gilfillan (1961) reported that most faulting is along NW and NE trends, usually with normal displacements of about 10 feet to 100 feet. There are minor thrust planes and shear zones on the SW limb.

Orebodies

The 2 main categories of lode formation were summarized by Gilfillan (1961).

SECTION THROUGH BATTERY MINE

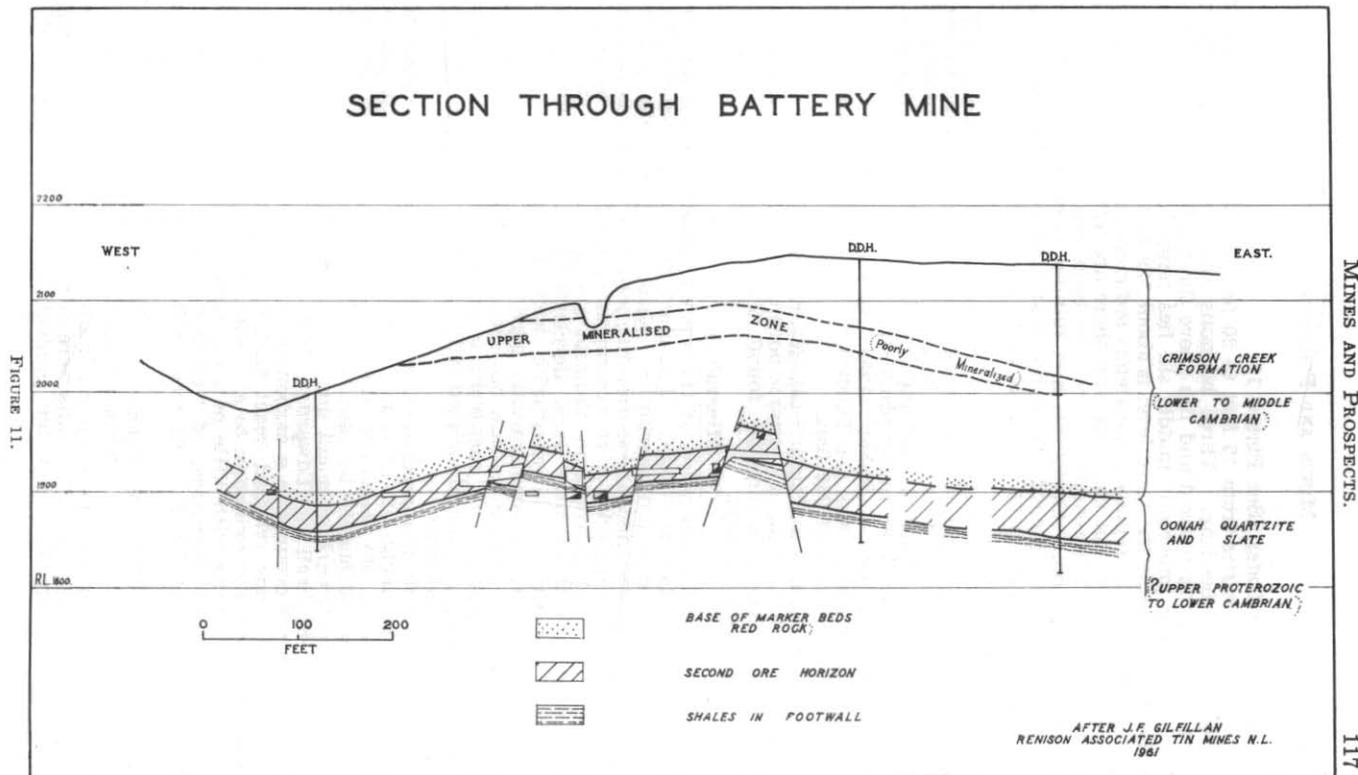


FIGURE 11.

5 cm

1. "Sill"-type Lodes (See Figure 11)

Thickness varies from 15 feet to 30 feet and the lodes are conformable with bedding. Three horizons are known. The upper zone is poorly mineralized and lies above the marker horizon ("Red Rock"). The important middle sill lies immediately beneath the marked beds, while the third level is about 120 feet below. Mineralization apparently replaced calcareous sediments over a wide area, but replacement is not complete and there are unmineralized zones. Mining of cassiterite-sulphide ore has been concentrated on the second sill horizon. Geological and mining interpretation of the sills has been greatly confused by the abundant small normal faults with movements of about 10 feet to 30 feet.

2. Fissure Lodes.—

(1) Replacement bodies on two major fault lines trending NW, apparently with a considerable vertical range. Strike lengths are of the order of 1000 feet, and widths vary from 10 feet to 30 feet but occasionally reach a maximum of almost 100 feet in places. Such masses have been major producers in the past, because of the depth of oxidation. Fisher (1953) recorded that the largest individual ore-shoot was the Federal lode which was worked over a continuous length of 750 feet.

(2) The quartz-tourmaline-cassiterite veins near Pine Hill are probably derived from the quartz-porphyr intrusion. Although coarse cassiterite was formerly found, the deposits are small and have not proved payable.

Mineralogy

The mineral composition of the ore was described at length by Stillwell and Edwards (1943). The chief minerals are cassiterite, arsenopyrite, pyrite and pyrrhotite. Quartz is the main gangue mineral, and some manganese-iron-magnesium carbonate is usually present. The sulphides were accompanied, or followed, by small amounts of chalcopyrite and stannite and in the later stages of mineralization there were local developments of sphalerite and galena. Wolfram and cassiterite were the earliest minerals, followed in order by arsenopyrite, pyrite, pyrrhotite, chalcopyrite and stannite. Wolfram is rare but occasionally forms the core of cassiterite crystals. The cassiterite is mainly fine, but richer and relatively coarser when associated with the quartz gangue than in the massive sulphides.

The presence of marcasite was attributed to the alteration of pyrrhotite, probably by solution in late stage carbonate fluids. Reid (1925a, p. 66) suggested that marcasite oxidizes to ferrous sulphate and ultimately to limonite. If associated with a quartz gangue, a meshwork of small quartz crystals coated with limonite remained. Stillwell and Edwards (1943) showed that where marcasite and pyrite occur with a carbonate gangue the sulphide oxidizes rapidly and acids released react with the carbonates, leading to decomposition and oxidation to a considerable depth. In contrast, massive pyrrhotite with little or no gangue oxidizes slowly. Reid (1922c) referred to masses of "black gossan", or manganiferous iron oxide which he thought was oxidized manganosiderite with low tin values.

Main Workings (See Figure 10)

1. Renison Bell Mine

The Renison Bell lode was cut during the construction of the Emu Bay Railway in 1900. Adits were driven from near the Argent River and on the Blow lode but production was intermittent until

1907 when ore containing about 22 tons of concentrates was treated. Up to 1914, concentrates totalling about 735 tons representing 490 tons of metallic tin were produced. The mine was not equipped to treat sulphide ore and in 1917 the leases were let to tribute parties who continued producing small quantities of cassiterite from oxidized ore until 1929. Since 1935, the property has formed part of the leases held by Renison Associated Tin Mines, N.L.

TABLE 8—Production—Renison Bell Mine

<i>Period</i>	<i>Ore Treated (Tons)</i>	<i>Concentrates (Tons)</i>	<i>Tin Content (Tons)</i>
1905-1914	c. 17,840*	734.65	Est. 490
1915-1917	11,160*	55.73	37.58
1918-1929	22,241	203.08	130.01
	<u>112,241</u>	<u>993.46</u>	<u>c. 658</u>

(*Ore treated 1901-1917 reported as 90,000 tons: Conder, 1918, p. 5)
Est. = Calculated from available figures.

2. Boulder Tin Mine later Dreadnought-Boulder

The oxidized outcrops of the lodes were discovered in 1893, and Ward (1909) recorded that Duncombe and Maddox had recovered 73 tons of detrital cassiterite before the leases were transferred to the Boulder Tin Mining Co. N.L. in about 1907. A mill and concentrating plant were built and until 1914, 262 tons of concentrates were obtained from oxidized ore. In June 1914, the company amalgamated with the Dreadnought mine on the sections from which C. Brumby and A. G. S. Morton had produced small quantities of cassiterite. The large Dreadnought deposits were linked with the Boulder mill by a tramway $\frac{3}{4}$ mile long, and up to about 1920 between 300 and 400 tons of concentrates were recovered. However, after the fall of tin prices at the end of 1920, only a few tributors were at work until the leases were taken over by the present company in 1934. Ore is now being mined from the Battery workings on the old Boulder lease (See Figure 11).

3. Montana Tin Prospecting Syndicate

Ward (1909, p. 101) stated that between 1907 and 1909, 88.4 tons of concentrates had been sold from the Montana lodes, and care in the concentration and recovery of fines upgraded the value of concentrates to 74.7% metallic tin. Production was chiefly from detrital material or oxidized gossan, and reached its highest level in 1911 when over 33 tons of concentrates were recovered. After World War I, the property was worked by tributors until about 1935.

TABLE 9—Production—Montana Tin Prospecting Syndicate

<i>Period</i>	<i>(Tons) Concentrates</i>	<i>Tin Content (Tons)</i>
1907-1909	88.40	65.42
1909-1925	305.04	Est. 210
1928-1935	5.88	3.81
	<u>399.32</u>	<u>c. 279</u>

4. Federal Workings

According to Ward (1909, p. 124) the Federal lode was discovered many years previously, and an adit had been abandoned after being driven 27 feet into the east slope of Stebbins Hill, 150 feet below the summit. About 1910, further adits and cross-cuts were put in to explore the deposit (Conder, 1918, p. 74), which is on the line of the Dreadnought lode. Vanning of samples resulted in an average grade of 0.75% cassiterite, and Conder calculated that there were large reserves of oxidized ore available for opencut work. During 1919 and 1920, Federal Tin Mines, N.L. treated 14,027 tons of ore from the opencut, extracting 109.68 tons of concentrates representing 69.04 tons of metallic tin, but work ceased at the end of 1920.

In 1936, Tasmanian Amalgamated Tin Mines started active operations on Dunn's lode, (SW of Stebbins Hill on the old Federal lease), and the Anglo-Tasman Development Co. resumed mining at the main Federal workings. All ore was treated in a mill constructed by the former company, and the latter apparently ceased work in 1938. Tasmanian Amalgamated Tin Mines worked the Federal orebody until 1943 when all oxidized ore was exhausted, and the mine closed because the mill was not suitable for treating sulphide ore. A total of 27,000 tons of oxidized ore was processed, yielding 212 tons of concentrates (140 tons of metallic tin). Of this total, the Anglo-Tasman Development Co. is recorded as having produced only 10.01 tons of concentrates containing 6.32 tons of tin from 1396 tons milled.

5. Renison Bell Central

The former lease 1215 M of 36 acres held by C. Brumby in 1907 lay between the Renison Bell lease to the west, and the Dreadnought Sections. The orebodies are part of the Renison Bell-Montana lode system and according to Ward (1909) although the workings were not extensive they were highly productive, yielding 25 tons of concentrates (70% tin) from oxidized material. A small plant had been erected in Renison Bell Creek to deal with the slimes and sand from the workings at the head of the creek. After prospecting by H. Evenden, the Renison Bell Central Co. was formed, and between 1915 and 1918, 91 tons of concentrates were recovered, partly by tributors on Hetherington's lode west of the creek. After 1920, the property was worked by the Electric Tin Mine but results were disappointing and there was little further mining.

Total production was about 130 tons of concentrates representing 86 tons of metallic tin.

6. Pine Hill area

There has been intermittent activity at Pine Hill since the discovery of alluvial tin in Gormanston Creek in 1893. Prospectors traced the tin up Gormanston, Dead Man's and Penzance Creeks to Pine Hill, where cassiterite-quartz-tourmaline veins are associated with a complex minor intrusion of quartz-porphry, probably of Devonian age. The country rocks are hornfelsed dark siltstone and chert assigned to the Crimson Creek Formation which were intruded in the late Cambrian by a thick sill of pyroxenite. The veins and old workings were described in great detail by Ward (1909) and Reid (1925a). Prospecting was hampered by talus slopes of weathered quartz-porphry which may be up to 20 feet thick, particularly on the steep north slope of Pine Hill below the intrusion. The chief workings were those of the Penzance mine on the north slope near Penzance Creek, where the lodes were explored in a series

of adits and trenches. The quartz-porphyry is probably a large dyke-like mass, trending NW, which throws off a series of minor dykes and sills. Cassiterite occurs in irregular ore shoots striking NW and NE, and usually green tourmaline is present. The main vein was exposed over a width of 15 feet near the crest of the hill and on the north slope, having a NW strike with a dip of about 50° to the SE. Ward (1909, p. 142) estimated the total output at 36 tons of cassiterite. About 20 tons were produced in 1913-1914, but since 1928 the total amount sold by a number of small parties has not exceeded 3 tons of detrital and alluvial tin.

The known veins are small, though sometimes rich, oreshoots; it is doubtful if they could be worked economically. Total production was about 59 tons of cassiterite, containing 37 tons of metallic tin.

7. *Renison Associated Tin Mines, N.L.*

The company holds consolidated lease 13M/61 of 2253 acres. After formation of the company in 1934, a comprehensive sampling and prospecting programme was instituted. The problem of treating the complex sulphide ore was partly overcome and regular production was started on the old Boulder lease. In 1950-1952, geophysical surveys were made by the Bureau of Mineral Resources, supported by exploratory drilling from 1952. The Mt Lyell Mining and Railway Co. acquired a large interest in the company in 1958. Data gained from recent geological mapping and drilling are now being studied.

TABLE 10—Production—Renison Associated Tin Mines, N.L.

Year	Treated (Tons)	Concentrates (Tons)	Tin Content (Tons)	Remarks
1935	577	4	2	Slimes
1936	Est. 3,000	27.6	16	
1937	5,331	24.9	16.2	
1938	Est. 5,300	24	15.6	
1939	1,500	4.94	3.34	
1940	12,694	86.27	57.8	
1941	18,138	124.70	80.62	
1942	10,152	81.82	54.90	
1943	11,630	95.33	61.19	
1944	10,562	110.08	72.43	
1945	10,656	117.05	76.21	
1946	11,429	120.78	84	
1947	13,946	97.30	67.13	
1948	11,526	84.21	56.98	
1949	10,209	90.55	60.57	
1950	10,291	68.66	46.33	
1951	8,844	67.72	46.04	
1952	10,079	82.23	55.41	
1953	15,834	107.95	69.77	
1954	9,790	99.70	63.65	
1955	7,698	66.16	40.72	
1956	10,207	127.48	84.64	
1957	10,538	107.70	75.30	
1958	11,622	121	81	
1959	9,846	139	87	From develop- ment
1960	11,778	133.36	84.17	
	253,177	2214.44	1459	

TABLE 11—Total Production—Renison Bell Tinfield

<i>Mine</i>	<i>Treated (Tons)</i>	<i>Concentrates Recovered (Tons)</i>	<i>Metallic Tin Content (Tons)</i>	<i>Tin in Con- centrates %</i>	<i>Tin in Ore (Recovered) %</i>	<i>Remarks</i>
Renison Bell	c. 112,241	993	658	66.26	0.59	1905-1929
Dreadnought- Boulder	?	665	440	66.16	?	Mainly to 1920
Montana	?	400	279	69.75	?	1907-1935
Federal	42,000	325	210	64.62	0.50	1919-1920; 1928; 1937-1943 (In- cludes Dunn's workings)
Renison Bell Central	?	c. 130	c. 86	Est. 66	?	About 1907-1919
Renison Asso- ciated Tin Mines, N.L.	253,000	2214	1459	65.9	0.58	1935-1960 Inclusive
Pine Hill Area ..	?	58.59	37.45	63.92	?	Intermittent work 1893-1945
Miscellaneous	?	336	203	60.42	?	Mainly 1893-1910 and 1926-1954. Includes 200 tons alluvial cassiter- ite recorded by Twelvetrees
		<u>5121.59</u>	<u>3372.45</u>			

Geophysical Surveys

Surveys over the Renison Bell Tinfield have been described by Davidson *et al.* (1957). The Imperial Geophysical Experimental Survey in 1929-1930 over part of the field indicated that the magnetic and self-potential methods were the most suitable and they were therefore used later by the Bureau of Mineral Resources, Geology and Geophysics, whose initial survey was made in 1950 over an area south of the present mill, mainly over known ore-bodies. It was shown that there was generally good agreement between magnetic and self-potential results, and that the known lodes produced strong anomalies. Anomalies were also recorded which might be caused by new sulphide bodies containing pyrrhotite. In 1951-1952, the survey was extended to the south and east. A number of well-defined anomalies were indicated, and recommendations were made for drilling and trenching. Subsequent drilling and detailed geological mapping has provided much valuable information which is now being investigated by the company's geologists.

Ore Reserves

Gilfillan (1961) recorded the following figures quoted by the company in August, 1960.

	Reserves	%
	(Tons)	Tin
Battery mine	183,000	1.23
Exploration area	1,000,000	0.60

Future

Gilfillan (1961) stated that the problem today is the same as it was 60 years ago: the extraction of very fine-grained cassiterite from massive sulphides. In parallel with metallurgical research, geological exploration of a large area is continuing.

Present metallurgical extraction of the cassiterite involves the flotation and rejection of the sulphides, and the concentration of the flotation sink-product on tables. It is anticipated that the installation of vanners in both mill and dressing plants will lead to greatly increased recoveries of the fine sizes.

EXE RIVER DISTRICT

The Exe River area lies about two miles due east of the main Renison Bell tinfield, and there is apparently little or no mineralization in the country between. Cassiterite was first discovered in 1911 north of the Emu Bay Railway line, and other deposits were subsequently found up the Exe River and its tributaries. Distribution of cassiterite proved to be patchy, and the lodes are generally small and irregular.

Country Rocks

The host rocks are indurated grey and black slate and siltstone and greenish or purplish greywacke and quartzite. They are part of the Crimson Creek Formation, believed to be Lower to Middle Cambrian, which was intruded by late Cambrian sills or dykes of serpentized pyroxenite and gabbro or norite. The beds are tightly folded into a complex syncline whose axis trends a few degrees west of north and there has been local shearing on a northerly, or NNW strike. Cleavage is poorly developed in a similar direction. Mineralization has taken place along complex and irregular fracture zones.

Exe Gorge and Falls

The orebodies near the mouth of the Exe River were first prospected about 1900 when the Emu Bay Railway was constructed but the presence of cassiterite was not suspected until 1911. Prospectors explored up the river, and during the next few years several lodes were tested by adits and trenches south of the railway and north of the present Renison Bell-Rosebery road. The veins generally strike NNW and the cassiterite is associated with quartz, arsenopyrite, pyrite and a little chalcopyrite. The sulphides generally oxidize to limonitic gossan. Cassiterite is scattered irregularly throughout the quartz gangue and assays do not exceed 1% tin (Conder, 1918, pp. 89-92). Small scale development took place between 1911 and 1918, and from 1928 to 1945, but the total recorded production is little more than 16 tons of concentrates (10 tons of metallic tin).

Exe River (X Proprietary Syndicate)

Alluvial cassiterite was found in the Exe River by T. Williams in 1911, and traced westwards up the slope to the main lode system. The X Proprietary Syndicate later explored the mineralized zone by surface trenching and an adit (No. 1) driven 225 feet NW into the ridge. The workings are about 200 yards west of the Exe River, a quarter of a mile south of the Renison Bell road. Conder (1918, p. 83) recorded that 350 feet to the north, two adits were put in, the longest of which (No. 2) was 400 feet long. Although a quartz vein was cut at 360 feet, mineralization was poor. Further NW, a quartz formation was tested by 3 adits and a number of trenches, but only pyrite and tourmaline were found. After about 1918, there was apparently no activity until 1934 when a party obtained small quantities of cassiterite from No. 2 Adit and the open-cut.

Since that date, there has been some further prospecting but output has been inconsiderable. The total production from the mine is about 7 tons of concentrates, representing about 4 tons of metallic tin. The main workings are at present part of lease 9M/57 of 50 acres in the name of P. Towndrow. They were examined in 1960 by A. B. Gulline upon whose notes the following description is based.

Mineralogy

Mineralization consists of complex fissure veins, predominantly quartzose, which carry cassiterite together with green tourmaline and accessory arsenopyrite and pyrite. Near the surface, the sulphides are oxidized and leached out. The cassiterite is usually fine, but occasional crystals up to about 1.5 mm across were noted. Ward (1911) reported that the veins, which may be up to 2 feet thick, were rich in patches, and masses of country rock penetrated by thin quartz stringers assayed up to 0.7% tin.

Veins and Workings

The main workings (No. 1 adit of Conder, 1918) were cut by the old X Proprietary Syndicate. Some stoping near the rise has been done by the present lessees. In the main drive a vein is encountered near the winze, 115 feet from the portal. The vein appears to be faulted off east of this point, and westwards it has been driven on for about 80 feet. The vein is extremely irregular, throwing off stringers and masses of quartz-tourmaline which enclose blocks of country rock. It has been stoped out as

far as the rise, and appears to become thinner upwards. Ten feet west of the rise, the vein splits into 2 well defined parallel veins each 4 inches wide and 2 feet 6 inches apart, which strike to 280° with a dip of 62° to the north. The veins peter out and were abandoned after being driven on for another 20 feet. Only traces of mineralization were revealed in 40 feet of crosscut leading north from the end of the main adit. No mineralization is visible in a drive 70 feet long on a bearing of 248° which starts near the top of the winze. Conder (1918, p. 82) wrongly recorded this drive as being from the bottom of the winze, which is now inaccessible, but reported to be 36 feet deep.

Fifteen feet from the adit portal, a drive was cut for about 90 feet on a bearing of 320° along the plane encrusted with limonite which passes into a vertical quartz-tourmaline vein. The vein has been stoped out at the end of the drive and two inclined rises connect with surface trenches. Little vein material is left here.

Conclusions

The pattern of mineralization is complex and while the regional trend of veins is generally NNW, in No. 1 adit veins carrying good tin values strike NW. The numerous irregular veinlets and inclusions of country rock indicate formation within highly disturbed and fractured ground which may be a fault zone. There is little ore left in the present workings, except that now being stoped out towards the surface near the main rise. It is not known if the main vein continued to the bottom of the winze nor if the vein was driven on at this level, 36 feet below the main adit. Investigation here might provide useful information.

Olympic Mine

This property lies due east of the Exe River mine, on the steep west slope of Colebrook Hill. The host rocks are indurated cherty green and purplish argillite, with dark grey or brown siltstone and greywacke. West of the mineralized zone, the sediments were intruded by a thick sill or dyke of serpentinized pyroxenite and norite, which strikes almost N-S.

HISTORY OF DEVELOPMENT

About the beginning of the century, an old adit (No. 3 of Reid, 1927b) was driven 180 feet in a search for copper but the presence of cassiterite was not realized until about 1911. The Olympic Prospecting Association then investigated the orebodies for a number of years but no worthwhile deposits were found and the leases were relinquished. In 1924, the Williamsford Tin Mine N.L. was formed. Plant was installed but apart from development in the existing adits, little further exploration was done and the mine closed in 1926 because of an insufficient ore reserve and the high cost of treating the small irregular veins. Reid (1927b) showed that the total reserve developed was only 600 tons of which 500 tons had been mined. Between 1934 and 1936, prospectors obtained small quantities of concentrates, but there has been little activity since.

WORKINGS

The ore-bodies were explored by 3 adits and an opencut which were described in great detail in an unpublished report by Reid (1927b).

No. 1 *adit crosscut* is 170 feet long on an easterly bearing. No. 2 lode is exposed at the portal and was opened up in a short drive, in trenches and in opencuts north and south over 150 feet. Southwards the vein strikes NNW with an easterly dip of 55°-65°, varying in width from 3 to 15 inches. Ward (1911, p. 22) recorded that some rich cassiterite ore was found at surface and that it was bagged at once for the smelters. Reid noted that to the north, the vein is about 5 inches wide and poor.

No. 3 lode was intersected 128 feet from the portal and was driven on for 18 feet but it is less than 1 inch wide; 13 feet along this drive there is a rise on the lode up from No. 2 *adit* level. Short drives were cut north and south 16 feet from the end of the *adit*. No ore of value is exposed in No. 1 *adit*.

No. 2 *adit crosscut* is 60 feet vertically below No. 1 and was driven east for 240 feet. 190 feet from entrance, No. 2 lode was intersected and was driven on north for 69 feet but little ore was revealed. A south drive here was cut for 100 feet SSE and then SE for 29 feet. At 42 feet, a winze was sunk 15 feet which exposed rich ore 3 to 6 inches wide. At 97 feet a rise to the surface was cut on ore 4 to 10 inches wide of average grade, and some ore was stoped between the winze and the rise.

About 270 feet along the *adit*, a rise on No. 3 lode connects with No. 1 *adit*, but the vein petered out 30 feet up. No. 3 lode is only 30 feet long and cannot be traced on the north side of the *adit*. No ore was exposed in a number of north and south drives in this *adit*.

No. 3 *adit crosscut* is 65 feet vertically below No. 2. No. 1 lode was formerly exposed at the portal, but the *adit* was not accessible in 1927. Ward (1911) reported that it was driven for 180 feet east some years previously by prospectors exploring for copper, and a short south drive was cut 120 feet from the portal on an oxidized vein now known to carry cassiterite. Conder (1918) stated that the *adit* was 534 feet long, but results appeared to have been discouraging.

PRODUCTION

Total production amounted to about 11 tons of concentrates, with a metallic tin content of 7 tons. The highest output was in 1926 when 323 tons of ore were treated for the recovery of 4 tons of concentrates, representing 2.8 tons of tin (Reid, 1927b).

CONCLUSIONS

On the west side of Colebrook Hill cassiterite is present in a series of NNW trending fissure veins dipping eastwards. Although rich in places, the veins are usually thin and impersistent, and as Reid emphasized, wide scale exploration should have preceded erection of costly plant in order to develop sufficient ore reserves. Topography is favourable for production in *adits*, but an intensive trenching programme would first be necessary in the search for economic mineralization, which appears doubtful, judging by the past record.

Athenic Mine

The leases formerly held by the Athenic Prospecting Association are east of the Olympic mine and include the crest of Colebrook Hill. Ward (1911) reported that an oxidized cassiterite-bearing vertical lode which strikes NW, was uncovered in a trench on the

east side of the hill, and was traced for some distance down the eastern slope. An orebody on the west side of the ridge, near the boundary with the Olympic lease, was being prospected but its value was not known. Samples when crushed and vanned showed the presence of fine cassiterite, rarely visible to the naked eye, associated with oxidized pyrite. The only visible cassiterite was found in thin quartz veins within the pyrite lode. Conder (1918) recorded that 2 adits had been driven from a gully on the east side of the hill, but nothing of value was found and the leases were surrendered.

There is no record of any production from the Athenic workings, nor of any further activity.

TABLE 12—Production—Exe River Area

<i>Mine</i>	<i>Concentrates (Tons)</i>	<i>Tin Content (Tons)</i>
Exe Gorge and Falls	16	10
Exe River (X Pty. Syndicate) ...	7	4
Olympic	11	7
	—	—
	34	21
	—	--

DUNDAS

Tin mineralization near Mt Razorback was described at length in Blissett and Gulline (1961b) and is summarized here. Drilling is now in progress on anomalies revealed by the geophysical survey carried out by the Bureau of Mineral Resources, Geology and Geophysics from January to March, 1960.

Fine grained cassiterite is closely associated with pyrrhotite, pyrite, arsenopyrite and chalcopyrite with small amounts of galena in a gangue of quartz and manganese siderite, and mineralization resembles that near Renison Bell, about 3 miles to the north. The upper parts of the orebodies have been oxidized to a considerable depth into a friable limonitic gossan which is now being worked at the Razorback and Grand Prize mines.

The country rocks include Middle Cambrian greywacke and chert conglomerate, greywacke, and mudstone or shale assigned to the Dundas Group. The sediments were intruded in late Cambrian times by pyroxenite carrying asbestos and magnetite which has been almost completely serpentinized. In the late Lower Devonian or early Middle Devonian, the formations were intensely folded along NW to SE axes during the Tabberabberan Orogeny, followed by NNW and NNE faulting and shearing. The faulting partly controlled mineralization which is believed to have accompanied the intrusion in Middle Devonian times of the porphyritic microgranite at Pine Hill, two miles NE of the Grand Prize mine.

Razorback Mine

NNW faulting has brought serpentine on the east against the Dundas Group sediments, and the fault zone provided a zone of weakness along which mineralization took place. The serpentine has been converted to ferruginous talc over a zone up to about 150 feet wide, and has also been dolomitized in places. Irregular veins of sulphides with quartz and cassiterite cut the talcose or dolomitic zones, and cassiterite is also disseminated through the talcose

serpentine and decomposed Cambrian formations west of the fault zone. Oxidation extends to a depth of at least 120 feet, and is best developed for about 800 feet northwards between the main opencut and Hodge's Adit.

Since tin was found in 1909, the orebody has been explored or worked in a series of 9 adits, an opencut and numerous trenches or pits. Mineralization is relatively poor south of the main opencut, but production figures in recent years indicate that to the north, ore with a grade of 1% to 2% tin is now being treated. Assuming an average tin content of 0.3%, a width of 60 feet and a depth of 120 feet, Taylor (1951a) estimated that there may be 320,000 tons of oxidized ore containing about 960 tons of tin over a length of 600 feet between the main open cut and Hodge's Adit to the north. Topography here favours opencut workings of the oxidized zone.

Grand Prize Mine

The lode occupies a tear fault trending NNW within Dundas Group formations and is up to about 25 feet wide. Mineralization is similar to that in the Razorback mine and as the vertical orebody strikes across a steep ridge, it has been oxidized to a considerable depth.

The workings include a vertical shaft which was sunk to 240 feet about 1890 in the search for silver-lead. Cassiterite was later discovered, and 4 adits were driven on the lode to cut the shaft. The portal of the lowest adit (No. 4) lies a few feet above the north bank of Nevada Creek. The present leaseholders are opencutting down below No. 1 level, (220 feet above creek level) using the shaft as an orepass into No. 4 adit, from whence the oxidized ore is taken out to the mill.

North of the workings, gossan has been traced in trenches and pits for at least 800 feet, over the crest of the ridge, and similar material may be seen over a distance of at least 700 feet SSE of Nevada Creek.

In 1959, 526 tons of ore were treated for the recovery of concentrates containing 4.05 tons of metallic tin, i.e., 0.77%. Efficiency of the mill is probably not greater than 60% so that the tin content of ore would be about 1½%.

TABLE 13—Production to end of 1960—Dundas District

<i>Mine</i>	<i>Concentrates (Tons)</i>	<i>Metallic Tin Content (Tons)</i>	<i>% Tin</i>
Razorback Mine	84.17	48.88	58
Grand Prize Mine	31.20	18.33	58.75
	115.37	67.21	

ZEEHAN

Stormsdown Mine

In 1937, E. A. Tomkins and W. Ledger found cassiterite on the NW slopes of Queen Hill. The prospect was explored in shallow trenches and pits and in 1938 Zeehan Tin Development N.L. produced 10½ tons of concentrates containing 3 tons of tin. Between 1957 and 1959, D. Dunkley and D. McLaren extracted concentrates representing 2.27 tons of tin from pyritic ore.

Lease 31M/54 of 10 acres is now held by R. Fieldhouse and D. Dunkley, and preparations are well advanced for the treatment of soft pyritic pug containing fine-grained cassiterite. The prospect has been described recently (Blissett, 1961) and a representative sample of 92 lbs of soft ore was shown by the Department of Mines Laboratory, Launceston to assay 4.13% tin, although recoveries in vaning tests did not exceed 50% owing to the fine nature of the concentrates.

On Queen Hill, quartzite, siltstone and dark slate of Younger Proterozoic or Lower Cambrian age with associated spilite flows have been tightly folded, then highly faulted or sheared both before and after mineralization. The soft pug extends over a length of 29 feet in No. 1 Adit and is believed to mark a fault zone which has shattered an irregular pyritic orebody carrying cassiterite and possibly a little stannite. Auger holes and a rise in the adit have outlined at least 300 tons of pug in a zone about 20 feet wide which may continue in depth.

MISCELLANEOUS TIN PROSPECTS

At various periods, small amounts of cassiterite have been won in different areas, chiefly from alluvial deposits, but they have little economic value. About 2 tons of concentrates were produced from the Melba Flat (east of the Cuni district), while between 1933 and 1935 about $\frac{3}{4}$ ton was extracted from alluvial ground near the mouth of Crimson Creek, together with traces of gold and osmiridium.

Nye (1931a) reported that Messrs Evenden and Abel had discovered alluvial tin in Great Northern Creek, south of the junction with the Ring River (North Dundas). The cassiterite is derived from veins on the west slopes of the creek. No production was recorded and reserves are likely to be low.

Stannite

Stannite ores in the Zeehan district are described in the section on the Oonah mine but no figures are available for the amount of tin contained in stannite ore. The ore was at first exploited for its silver and copper content, a small allowance being made for the tin in some cases by the buyers.

After metallurgical tests about 1908, smelters were erected which produced copper-silver matte and a copper-tin alloy, with small concentrations rich in silver, bismuth and tin.

TABLE 14—Total Tin Production—Zeehan Quadrangle

<i>District</i>	<i>Concentrates (Tons)</i>	<i>Tin Content (Tons)</i>
Heemskirk	1061.3	667.6
Renison Bell	5121.6	3372.4
Dundas	115.4	67.2
Exe River	34	21
Queen Hill	15	5.3
Miscellaneous*	455	236
	6802.3	4369.5

* From 1917. To 1916 mainly from South Heemskirk and included in 600 tons estimated by Waterhouse (1916, p. 430). Possibly some produced from Stanley River Tinfield.

2. Silver Lead

ZEEHAN AREA

Montana Silver-Lead Mine

The property lies a short distance west of the Corinna road, about 3 miles NW of Zeehan; the workings are located near the SW corner of Lease 11789M.

Between 1894 and 1896, the May Queen Prospecting Association N.L. explored the lodes below the outcrops of limonitic gossan in a costean, a shallow pit and an underlay shaft 15 feet deep south of the present workings. The ground was held by the Western Extended North Silver Mining Co. N.L. in late 1896, and by H. S. M. Evans in 1898, being transferred later in the same year to the Western Extended Silver Mining Co. which produced small amounts of galena. The Western Consolidated Silver Mining Co. N.L. took over in 1900, but after a few tons of ore had been extracted, the lease was relinquished in 1902. From 1907 to 1908, the lease was held by R. Clabburn but there is no record of any production. In 1913, a considerable amount of trenching was done in the North Zeehan area generally by prospecting parties under H. Conder, the State Mining Engineer. Several parties carried out further shallow exploration between 1923 and 1927, while from 1935 to 1937, a prospecting party led by G. W. S. Clarke, and supported by Government assistance, found orebodies in the vicinity. Leases were taken up by Montana Western Extended Silver-Lead Co. N.L. in 1937, and were transferred to Montana Silver-Lead Co. N.L. in 1939. The old May Queen shaft was deepened but inflow of water prevented sinking below 297 feet. The mine was opened up on the Adit, Intermediate, 100 foot and 150 foot levels but closed down in 1941 owing to the low price of lead. Between 1947 and 1950, the upper levels were drained and worked on tribute by R. E. Clarke and T. Brampton. The company resumed active operations in September, 1950 until the mine was abandoned in early 1958, after exhausting visible ore reserves.

GENERAL GEOLOGY

The country rocks are a monotonous series of alternating pale grey saccharoidal quartzite, siltstone and green, grey and black shale or slate which form part of the Oonah Quartzite and Slate (Upper Proterozoic or Lower Cambrian). The beds were tightly folded and faulted during the Devonian Tabberabberan Orogeny. The folds strike NW with reversals of plunge produced by cross folding. Fault and shear zones provided zones of weakness trending mainly NNE or NNW along which mineralization took place later in the Devonian. After long peneplanation, Permian tillite was deposited across the eroded Proterozoic rocks and during intense faulting, probably in Tertiary times, Proterozoic quartzite and slate were thrust over the Permian glacial formation.

STRUCTURAL GEOLOGY

Evidence for the Permian age of the tillite has been discussed (p. 72) and it was shown that apparent interbedding with the Proterozoic is due to thrusting of the latter from the east on a fault trending NNW. The thrusting, which is probably Tertiary, may be quite extensive in the Zeehan area. Previous authors regarded such faults ("slides") as potential mineralized zones, for example Twelvetrees and Ward (1910) and Taylor and Burger (1951b).

The "Tillite Lode" in the adit cross-cut in the Montana Silver-Lead mine was shown by Campana and King (1958) to be a post-mineralization thrust plane striking NNE with a SE hade. The fact that there is Tertiary faulting makes a re-interpretation of the local structures necessary. In the mine area, there are 2 directions along which thrusting has taken place. On the road 200 yards east of the mine, the fault strikes NNW with an easterly hade of 45°. The upthrow on the east is not known but is not less than 200 feet. In the adit cross-cut, the thrust trends NNE with an upthrow on the south of at least 150 feet. The workings are now flooded and any description must be largely based on previous reports.

OREBODIES

At the surface, at least 6 parallel lodes were recorded by Blake (1936). The only one worked underground was "Clark's Lode" (The "main lode" of Taylor and Burger, 1951b) which was developed in the 4 main drives.

The lodes are irregular fissure veins up to about 8 feet wide along shear zones striking NNE with SE dips ranging from about 40° to 60°. Galena occurs within irregular veins up to about 2 feet wide on the hanging wall, in irregular lenses connected by mere stringers, or is disseminated throughout shattered shale between shear planes and thin mineralized fissures.

MINERALOGY

Galena is accompanied by sphalerite (including marmatite) and small amounts of pyrite and chalcopyrite in a gangue of quartz or siderite with thin veinlets of calcite. Taylor and Burger (1951b) suggested that pyrite was the earliest formed mineral, followed closely by quartz, siderite, sphalerite and galena, with a later generation of quartz as veins in small fracture planes. The sulphides are scattered sporadically throughout the gangue.

MAIN WORKINGS (see figure 12)

Adit Level.—The portal is 460 feet SW of the main shaft and the adit cross-cut was driven SE through tillite. At 167 feet from the entrance, the tillite is faulted against shattered shale containing a 6 inch band of siderite with a little galena and sphalerite. The thrust zone is about 2 feet wide, striking NNE with a SE hade of 54°, and, being regarded as the "Tillite Lode", it was driven on northwards for a little over 20 feet. East of the fault, the adit is cut through about 70 feet of faulted and shattered shale and quartzite, and about 240 feet from the portal a shear zone was intersected. Taylor and Burger (1951b) stated that the footwall of the zone is a prominent fault plane trending NNE with a steep southerly dip and it was regarded as part of a major zone of shearing in which the main orebodies in the mine were found.

The zone was driven on south for about 60 feet. About 20 feet south of the adit cross-cut, No. 1 Prospecting Shaft connects with the surface. South of the shaft, only one to two inches of galena was found on the hanging wall and no stoping was done. The north drive eventually connected with the small Eastern Adit workings, about 280 feet north of the adit cross-cut (Taylor and

Burger, 1953). The orebody in the north drive is irregular, ranging generally up to about 3 feet wide as far as No. 2 Prospecting Shaft, 160 feet north of the adit cross-cut. The mineralized zone was reported to be between 7 feet and 15 feet wide for a short distance north of this shaft.

Values in the adit workings are patchy. A series of 7 channel samples taken by Taylor and Burger at wide intervals over widths ranging from 2 feet 6 inches to 5 feet assayed between 0.5% and 18% lead, 0.6 ounces to 16.2 ounces of silver per ton, and from 0.4% to 2.2% zinc.

Intermediate Level.—This level is 28 feet above the south drive on the 100 foot level, with which it is connected by a rise. The level is about 100 feet long, but no mineralization was found.

100 foot Level.—No. 1 West Crosscut extends from the main shaft for about 160 feet south of west, and No. 1 East Crosscut is about 155 feet long, but both were in barren contorted quartzite and shale. The shear zone was driven on northwards for 114 feet from a point 10 feet west of the shaft, but only traces of sulphides were found. The ore zone was driven on southwards along a sinuous course for a total of 556 feet and was explored in a number of east and west cross-cuts, a bypass drive and several rises. The main mineralized zone starts about 60 feet south of the shaft and probably extends for at least 120 feet southwards. Mineralization is not continuous and is apparently highly faulted. At one place, galena was reported by Taylor and Burger (1951b) in an irregular vein 2 inches to 4 inches thick on the hanging wall. Further south, two lenses of galena ore were found up to 25 feet long and 4 feet wide separated by barren lode material.

150 foot Level.—The fault zone was intersected about 20 feet east of the shaft and was driven on NNE for about 120 feet, then NE for a further 170 feet, but little ore was found in the drive, or in east and west cross-cuts. By 1953, the irregular south drive had been cut for about 260 feet. Several lenses of ore up to 50 feet long and 7 feet 6 inches wide were recorded and 8 samples assayed between 1% and 24% lead, 1.3% and 5% zinc, and from 1.6 ounces to 34.3 ounces per ton of silver. There was little mineralization in the last 90 feet of the drive. In 1955, the drive was extended a further 80 feet SW, presumably in barren ground.

200 foot Level.—A plat was partially excavated before 1941, and in 1955 the shear zone was driven on for 76 feet north, but no indication of economic mineralization was found.

270 foot Level.—Taylor and Burger (1953) recorded that an east cross-cut had been driven from the main shaft. A horizontal bore-hole drilled in the same direction intersected a low grade mineralized zone. The cross-cut was extended to 120 feet and a lode formation carrying a little galena was driven on SSE for 11 feet. It was noted in the Annual Report of the Director of Mines for 1957 that the 270 foot level had been cleaned out and extended but no ore was found.

Taylor and Burger (1953) concluded that in the mine, economic mineralization extended over a length of about 290 feet and had been blocked out down to the 150 foot level.

MONTANA SILVER LEAD MINE

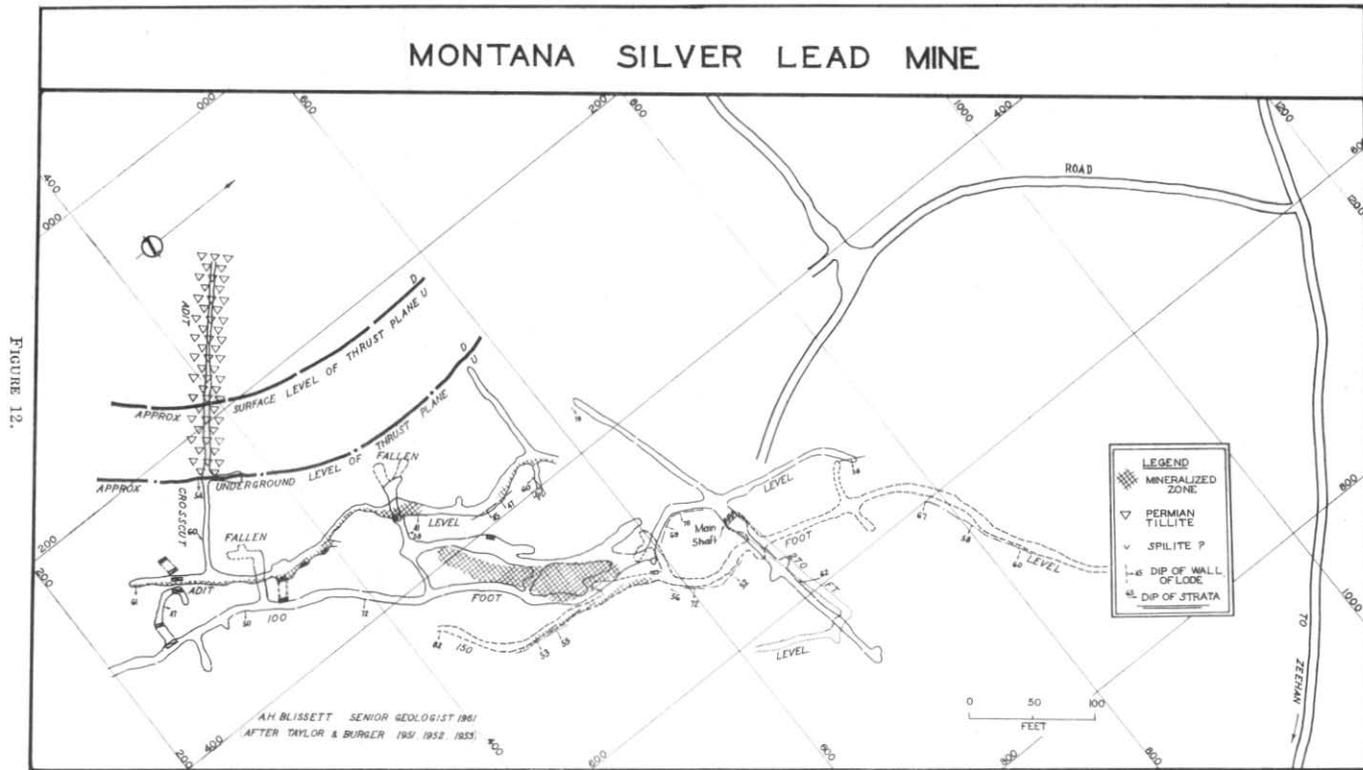


FIGURE 12.

5 cm

TABLE 15—Production—Montana Mine

Year	Ore (Tons)	Concen- trates (Tons)	Lead (Tons)	Silver (Ozs)	Remarks
1899	?	4.6	} 27.96	2,563	*
1901	?	32			
1902	?	10			
1937	?	101.9			
1938	81	?	16.30	1,921.6	
1940	852	123.6	79.87	9,488	
1941	919	96.7	65.90	6,916	
1947	?	4.42	2.94	442.3	Old dumps
1948	104	85.34	54.85	8,473.57	On tribute
1949	?	228.78	142.55	22,863.4	On tribute
1950	?	172.78	97.35	15,117.6	On tribute
1951	2,161	292.93	171.76	23,314.6	
1952	2,643	357.69	207.03	28,408.4	
1953	9,141	948.65	468.96	55,296.2	
1954	6,059	448.68	272.56	29,005	
1955	6,220	365.28	213	24,901	
1956	5,280	407.56	198.22	18,717	
1957	4,770	338.48	202	20,937	
1958	500	39	24	2,170	
		c. 4100	2304	279,348	

* In 1901 assayed 60% lead and 55 ounces of silver per ton.

CONCLUSIONS

1. Mineralization took place within highly sheared and fissured quartzite and slate of Upper Proterozoic or Lower Cambrian age. The lodes are extremely irregular in size and mineral content. Hanging walls are usually well-defined but the footwalls are often indistinct. Veins frequently split and galena may be disseminated throughout the shattered country rock within the shear zone.

2. Post mineralization thrust faults dislocated the mineralized shear zones, probably in Tertiary times. The mine workings lie within a block which was upthrown at least 150 feet relative to country overlain by Permian tillite to the NNW, while east of the Corinna road, Proterozoic rocks to the east have been upthrown at least 200 feet relative to the mine area.

3. There are 2 types of fault or shear zone. The earliest faulting provided zones of weakness trending NNE which were mineralized during the Devonian. At a much later period, thrusting took place along NNW or NW trends, and there was also renewed movement along a strike similar to the mineralized shear zones. It should be possible to distinguish the later faulting from the mineralized fractures by zones of soft pug, loose brecciated quartzite or slate and shattered vein material. The mine is now flooded and it is not known to what extent lodes have been dislocated.

4. One of the Tertiary thrust zones lies approximately along the Corinna road. The mineralized zone worked in the mine may have originally extended in this direction but would have been dislocated and upthrown on the eastern side. The upthrow might have been sufficient for any vein system to have been eroded away.

5. Little is known of the ground below the 100 foot level drive south of the No. 2 West Cross-cut. About 40 feet south of the cross-cut, Taylor and Burger (1951b) described a small mineralized zone about 25 feet long and up to 4 feet 6 inches wide, a channel sample of which assayed 10.4% lead, 14.5 ounces of silver per ton, and 1.7% zinc. A winze was sunk here to 15 feet (Taylor and Burger 1953), but it is not known if mineralization continued. The end of the south drive on the 150 foot level showed some metal, but was still 50 feet short of the position of the winze on the 100 foot level.

6. Lodes may have been preserved underneath the cover of Permian tillite in the downthrown block NW of the mine, though no definite evidence can be offered.

RECOMMENDATIONS

1. A lode striking NNE has been worked in the Big Ben mine about $\frac{1}{4}$ mile west of the Montana Silver-Lead mine. Much of the country between is obscured by Permian tillite and alluvium and exploratory drilling should be considered to test the underlying Proterozoic host rocks NW of the thrust in the adit cross-cut. A suitable site would be near the small creek about 200 yards west of the Montana mill, or west of the adit portal. A hole should be declined at 45° to the NNE and should be drilled for at least 250 feet.

2. If the mine were re-opened, the winze south of the No. 2 West Cross-cut on the 100 foot level should be deepened and connected to an extension of the south drive on the 150 foot level.

Zeehan-Western Mine

The old main shaft lies $1\frac{3}{4}$ miles NW of Zeehan post office, a few yards east of the Corinna road. The Beauty shaft is about $\frac{1}{4}$ mile further north.

In 1888, A. Simpson prospected for silver-lead on three 40 acre leases: 754, 755 and 756-87M, which were transferred to the Western Silver Mining Co. N.L. later that year. Orebodies found on Section 755-87M were actively developed and exploited in two adits and later in workings from a shaft which by 1900 had been sunk to 630 feet. The mine was forced to close in late 1901, partly because of the slump in metal prices. In 1903, the property was taken over by a British company, Zeehan-Western Ltd., and mining was resumed on 5 levels. The company also took over Section 892-87M (north of 755-87M and west of 756-87M) which had been explored by the Silver Beauty Prospecting Association N.L. since 1889. As the upper levels became worked out, the shaft was deepened to 800 feet by the end of 1904, and although veins were intersected on this level, mineralization was erratic and limited. Further development on No. 4 and 5 levels proved disappointing, but a large number of tributors obtained considerable amounts of ore from the old upper stopes. In 1908, the shaft was continued with Government financial aid to a final depth of 1000 feet; the mine is therefore the deepest in the Zeehan region. Three thin veins were intersected on the No. 12 (1000 foot) level, but were unworkable,

and the lower levels of the mine were abandoned. After 1909, limited stoping was done in the upper levels, and exploration was focussed on Section 892-87M where the Beauty Shaft was sunk to a depth of 50 feet before inflow of water halted operations on this level. An inclined prospecting shaft and several pits were put down on lodes to the south near the Zeehan-Montana boundary but only small quantities of ore were produced by tributors. The leases were surrendered in 1918 and there has been little activity since.

GENERAL GEOLOGY

The host rocks are contorted black to greenish-grey shale and slate with alternations of dark micaceous siltstone and pale grey quartzite, and a number of interbedded flows of spilite or keratophyre ("melaphyre"). The beds are probably the upper part of the Oonah Quartzite and Slate (Upper Proterozoic or Lower Cambrian) and they were tightly folded along NW trending axes during the Tabberabberan Orogeny. Fault and fracture planes striking NNW and NNE provided zones of weakness along which mineralization took place.

OREBODIES

The orebodies are steeply dipping irregular fissure veins, usually striking from a few degrees west of north to NE, and ranging in thickness from mere films to at least 8 feet. Waller (1902d) described 11 veins in the mine but pointed out that the veins frequently split and so were difficult to correlate in different parts of the workings. The most important was No. 1 (the "Main Lode") in which a continuous band of galena was worked over a length of 700 feet from the surface to No. 2 (110 foot) level. A number of veins were thin and limited in extent.

MINERALOGY

Argentiferous galena occurs with small amounts of sphalerite, pyrite and chalcopryrite as narrow bands or irregular masses and patches within a gangue of siderite, with a little calcite and quartz in places. Recorded assays indicate that the silver content ranged from about 86 ounces to over 100 ounces per ton. In 1907, tributors extracted galena in No. 11 (800 foot) level which assayed 77.3% lead and 148.5 ounces of silver per ton. Small amounts of tetrahedrite and chalcopryrite were found on No. 8 level (Waller, 1904) and also in a winze 80 feet deep sunk on No. 11 level (Twelvetrees and Ward, 1910, p. 109).

WORKINGS

The mine has long been inaccessible and the following description is condensed from old reports, including the Annual Reports of the Secretary for Mines. The mine was worked on 12 levels: No. 1 (45 foot); No. 2 (110 foot); No. 3 (170 foot); No. 4 (230 foot); No. 5 (290 foot); No. 6 (360 foot); No. 7 (430 foot); No. 8 (500 foot); No. 9 (600 foot); No. 10 (700 foot); No. 11 (800 foot); No. 12 (1000 foot). In the upper 5 levels, the workings are extensive and complex, and yielded much of the property's output of ore. Clark (1904) estimated that there were about 13 miles of drives and cross-cuts in the mine at that time.

No. 1 Lode.—The main orebody is No. 1 lode ("Main Lode") with a variable strike ranging from NE to NNE, which is faulted off to the north by No. 1 "slide". The lode was highly productive in the upper levels, but deteriorates below No. 3 level. On No. 5

level it is irregular with much barren gangue and was poor throughout No. 6 level, though small shoots of ore were worked in the south drive. The veins appeared to split a little below No. 6 level, being represented by two parallel veins which were stoped out on No. 7 level. Two branches were also intersected on No. 8 level, but the western one was unworkable. The eastern one is poorly mineralized in the south drive, but northwards a shoot of payable galena was driven on for at least 120 feet north of the crosscut. Waller (1902d) stated that here the lode is 6 feet wide, and includes about 6 inches of galena with 3 to 5 feet of good second class ore. The drive was continued later, but the ore cut out except for small amounts of tetrahedrite and chalcopyrite. On No. 9 level, No. 1 Lode was intersected and driven on for 100 feet but consists only of 1 foot 6 inches of low grade ore (Waller, 1904). It was later cut on No. 11 level and driven on for a total of 1000 feet but little workable ore was revealed, except for small rich patches stoped out by tributors. A vein was intersected on No. 12 level in 1908 but it contains only traces of chalcopyrite in a siderite gangue.

No. 2 Lode.—The orebody strikes NNW with a steep easterly dip; Waller (1902d) reported that it branches off No. 1 lode a little to the east of the shaft.

Considerable quantities of ore are said to have been produced over a length of at least 400 feet north of the junction, but it is apparently barren below No. 5 level.

No. 3 Lode.—A vertical vein strikes NNW and joins No. 4 Lode in depth. Much ore was extracted from the north end above No. 2 level, but the lode becomes poorer southwards. Payable ore was worked down to No. 4 level.

No. 4 Lode.—A significant tonnage was produced from this orebody which strikes NW and dips NE at about 50°. A short but rich shoot was worked down to No. 6 level where it cut out. On No. 3 and No. 4 levels, the lode splits into two branches, near its junction with No. 1 Lode.

No. 10 Lode.—Waller (1902d) suggested that the vein is cut off north and south by faults ("slides"). Payable ore was found in drives on No. 3, No. 4 and No. 5 levels where the orebody is about 2 feet wide, but it is poor on No. 2 level.

Although the other six lodes listed by Waller (1902d) are relatively small and of limited extent, a useful quantity of ore was produced from them.

SIMPSON'S WORKINGS

The highly faulted country to the NE was explored in drives and crosscuts from a shaft sited about 1000 feet NE of the Western main shaft. Waller (1902d) reported that there is a network of small veins of galena, but there is no separate record of production. According to Waller (1904) a lode exposed in the main workings on No. 4 level was driven on north towards Simpson's workings. The lode is unpayable but the drive allowed Simpson's workings to be worked economically, and ore was stoped over a length of 120 feet. The drive is 24 feet below Simpson's workings, which are therefore probably about 200 feet deep.

TABLE 16—Production—Zeehan-Western Mine

Year	Ore (Tons)	Lead (Tons)	Silver (Ozs)	Remarks
To				
31.3.1901	37,000		3,599,344	By Assay
1901	1,019	19,717		
1902	12			
1903	59			
1904	962			
1905	2,727			
1906	2,415			
1907	1,806			
1908	1,054			
1909	1,205		* N.A.	* N.A.
1910	691		c. 6,600	c. 1,200,000
1911	554			
1912	383			
1913	329			
1914	25			
1915	29			
1916	72.5			
1917	38.8			
1928	3	2.7	313	
	<u>50,384</u>	<u>c. 26,300</u>	<u>c. 4,800,000</u>	

* N.A. Not available. Figures based on estimate of 50% lead and 90 ounces of silver per ton. Part of ore was in form of gossan flux.

CONCLUSIONS

In the Western mine, irregular branching fissure veins contain galena with a high silver content within a siderite gangue. The area is intensely faulted and orebodies have been dislocated by faults or thrusts which may be of Tertiary age. The upper levels from which most of the ore was produced have long been worked out and mineralization in depth proved to be poor or erratically distributed. There appears little prospect of the mine re-opening.

Junction Mine

The old shaft is about 300 yards SW of the Zeehan-Western main shaft, and $\frac{1}{4}$ mile NNE of the Oonah workings, in the NE sector of lease 11780 M of 76 acres.

Leases 818-87M and 819-87M, both of 80 acres, were taken up by A. N. Allison in 1888 and were transferred to the Junction Silver Mining Co. N.L. in 1889. Section 818-87M became void in late 1894. According to Montgomery (1890), a NW striking lode containing 12-18 inches of galena had been driven on for about 12 feet in the NE corner of Lease 819-87M. By 1893 a shaft had been sunk to a depth of 56 feet on the line of the Zeehan-Western main lode and a level was cut at 50 feet. Levels were later driven at the 92 foot (No. 2) level and on the 122 foot (No. 3) level; Montgomery (1896) stated that the shaft was to be sunk as far as No. 4 (182 foot) level.

In late 1901, the neighbouring Zeehan-Western mine closed down and flooding of the mine also inundated the Junction workings. Section 819-87M was transferred to the Oonah Silver Mining Co. N.L. in that year. The re-opening of the Western mine in 1903 drained the Junction workings and Waller (1904) noted that tributors were working silver-bearing kaolin in the old stopes. J. Hanrahan had been prospecting the main Junction lode south of the shaft and had discovered pyritic ore carrying argentite and pyrargerite within 40-50 feet of the old Junction south workings. In the next few years, tributors produced silver-bearing gossan and kaolin, and also sideritic flux, but work ceased when the closing of the lower levels of the Western mine in 1909 again flooded the Junction mine.

OREBODIES

The Junction Lode is the southern continuation of the No. 1 (Main) Lode of the Zeehan-Western mine, but the shoot of galena extended only a short distance into the Junction workings, where the sulphides occur as impersistent bands or patches throughout a sideritic gangue. Between 1904 and 1909, the siderite was mined on Nos. 3 and 4 levels as a low-grade fluxing ore, averaging up to about 18 ounces of silver per ton.

Kaolinitic gossan, said to contain between 80 ounces and 120 ounces of silver per ton, was worked on a small scale, but no details have been put on record.

The pyrite-argentite-pyrargerite lode in Hanrahan's adit was variable in content but was said to assay up to 513.5 ounces per ton (Waller, 1904).

WORKINGS

(a) SHAFT WORKINGS

No. 1 (50 foot) Level.—According to Montgomery (1893b), a crosscut was put in 37 feet west to a lode striking NNE which was driven on for 60 feet south and 30 feet north. Little galena was visible in the drive, but there was from 2 inches to 1 foot of galena ore in the stopes above.

No. 2 (92 foot) Level.—There is no record of this level.

No. 3 (122 foot) Level.—The lode is said to have been poor, but the extent of the workings is not known. Waller (1904) stated that low grade sideritic ore suitable for flux had been proved 4 feet to 5 feet wide over a length of 100 feet.

No. 4 (182 foot) Level.—Sideritic flux was also worked on this level but details are not available.

(b) HANRAHAN'S ADIT ("GOSSAN TUNNEL")

The workings were described by Waller (1904). The south extension of the Junction Lode was intersected in an adit crosscut 332 feet long. At this point, mineralization was poor but 80 feet along the north drive on the lode, a rich shoot of pyritic ore containing argentite and pyrargerite ("ruby silver") was found. The shoot appears to have been a lens-like body, 40 feet long, which was followed in a winze 40 feet deep, but it petered out a short distance above adit level. In a surface winze above the position of the shoot, the lode was probably represented by 1 foot 6 inches of gossan assaying 60 ounces of silver per ton. Northwards along the drive, the shoot passes into poor and patchy galena ore within siderite. Waller stated that the Junction workings were below the shoot of rich ore in the adit and within 40 or 50 feet of it but no details were given.

Sideritic ore containing 50 ounces of silver per ton was worked in 1904-1906, after which the workings were apparently abandoned.

TABLE 17—Production—Junction Mine

Year	Ore (Tons)	Silver (Ozs)	Lead (Tons)	Remarks
To 1893	25	Est. 2500	Est. 15	Montgomery (1893b)
1903-1904	59.3	6228	...	Waller (1904, p. 58)
	<u>84.3</u>	<u>8728</u>	<u>15</u>	

(Production 1904-1909 included in figures for Oonah Mine).

CONCLUSIONS

The main lode is the southern extension of No. 1 lode in the Zeehan-Western mine, but is relatively poor. Short lenses or bands of sulphides occur within a sideritic gangue which apparently becomes uneconomic southwards and in depth. The small body of silver-bearing pyritic ore in Hanrahan's Adit was worked out. The mine has been flooded since 1909 and further exploration is unwarranted. If for any reason the Zeehan-Western mine was pumped out, the Junction workings would also be drained and could be examined.

Zeehan-Montana Mine

The No. 1 shaft lies a few yards west of the Corinna road, $\frac{1}{4}$ mile NNW of the junction with the Trial Harbour road, near the northern boundary of the former Section 2154-87M. The No. 2 shaft (the old Silver Queen No. 1 shaft) is about 200 yards NE of the junction in what was the SW corner of Lease 1636 M.

The lodes later worked in the No. 1 Montana shaft were prospected by V. L. Butler and J. M. Bowen in 1889, the lease being transferred to the Montana Silver Mining Co. N.L. later that year. In 1890, the property was held by Mt Zeehan (Tasmania) Silver-Lead Mines Ltd. and was taken over by the Zeehan-Montana Silver-Lead Mine Ltd. in 1892. The mine was opened up and was for many years one of the most important in Zeehan. The company acquired the sections held by the Silver Crown company (including the old Despatch Mine), and in 1903 the No. 1 Queen workings were taken over as the Montana No. 2 mine.

The Montana No. 2 Mine was first prospected by G. Bell, W. Bell and W. G. Barker in 1887. The lease was transferred in 1888 to the Silver Queen Prospecting Association N.L. who sank a shaft 200 feet deep and worked an orebody west of the shaft at the 100 foot and 200 foot levels. The section was held by Mt Zeehan (Tasmania) Silver-Lead Mines Ltd. in 1902, and when the Zeehan-Queen company was floated the property was taken over by the Zeehan-Montana company. In 1909, the company's holdings were consolidated into lease 3990-M of 422 acres.

By 1906, the No. 1 shaft had been sunk to 830 feet; No. 2 shaft was deepened to 500 feet by 1909 and some low grade ore was produced from the old Silver Crown workings (No. 3 Shaft). The high grade ore in the upper levels was worked out and despite

active exploration, reserves of workable ore became exhausted. The poorer lower levels were abandoned in early 1914 though parties of tributors carried on above water level for a number of years. Only small quantities of ore have been produced since 1924.

Output from the Zeehan-Montana workings was the highest from the Zeehan mines.

GENERAL GEOLOGY

The host rocks are intensely folded and shattered alternating dark slate, siltstone and pale grey quartzite, with interbedded flows of spilitic lava, believed to be the upper part of the Oonah Quartzite and Slate. To the SE they are overlain by deeply weathered purplish and grey shale, siltstone and greywacke assigned to the Crimson Creek Formation (Lower to Middle Cambrian). The No. 2 workings are almost entirely within the latter sequence.

The beds are highly faulted and, as in the Zeehan-Western and Oonah mines, the NW trending faults ("slides") were taken previously to be ore channels. There is much evidence that they are post-mineralization and that the orebodies have been dislocated. For example, Waller (1904, pp. 37-38) described a series of "cross-lobes" striking NW and having NE at angles between 40° and 55°. They are slickensided and Waller suggested that the north block had moved west. Again, he noted (p. 41) that No. 4 lode, which generally strikes NNE, changed direction to NNW within 6 feet of the "slide" on several levels in the mine, showing that the relative movement was north block west. The writer would suggest that by comparison with the thrusting near the Montana Silver-Lead Mine, faults in the Montana workings may be Tertiary thrusts on which transcurrent movement has also taken place; thus movement may have been north block up and west.

OREBODIES

The orebodies are fissure veins infilling fault or fracture planes striking mainly between NNW and NNE. They are irregular in thickness, ranging up to about 4 feet, and frequently split.

MINERALOGY

Irregular lenses and bands of galena, accompanied by sphalerite and pyrite, are distributed throughout a gangue of siderite and some quartz. In the No. 1 workings, the galena is said to have assayed up to 68% lead and 115 ounces of silver per ton. The silver content is lower in the No. 2 workings where, in the lower levels, No. 2 lode consists of pyrite with galena and quartz.

WORKINGS

No. 1 (Main) Shaft.—The shaft was sunk to 830 feet and the mine was opened up on No. 1 (112 foot); No. 2 (193 foot); No. 3 (295 foot); No. 4 (401 foot); No. 5 (503 foot); No. 6 (604 foot); No. 7 (700 foot) and No. 8 (800 foot) levels.

No. 1 Lode strikes NNE with a steep easterly dip and on No. 1 level was driven on for 550 feet of which 350 feet was reported to be good ore. On No. 2 level, the shoot was only 200 feet long passing north and south along the drive into barren gangue. Workable ore was found over a length of only 20 feet on No. 3 level.

No. 2 lode strikes a few degrees east of north and is vertical or has a steep westerly dip. South of the shaft it was driven on for 300 feet on the adit level, and for 200 feet in an intermediate level 60 feet below. On No. 1 level, a north drive was on the lode for

200 feet as far as the "main north slide" (Waller, 1904). Only siderite with patches of galena was found in a north drive on No. 3 level, and it does not appear to have been recognized with certainty in the lower levels.

No. 3 lode is small and was mainly worked SW of the shaft. Payable ore was found only above No. 2 level.

No. 4 lode is east of the main shaft and was driven on for 200 feet on No. 1 level. To the north it was cut off by a NW striking fault ("slide") having at 28° to the NE. Productive ore was worked over a length of 300 feet on No. 2 level and nearly 360 feet on No. 3 level. The lode was driven on for at least 800 feet on No. 4 level, for 570 feet on No. 5 level and was also worked on No. 6 level.

No. 6 lode appears to have been faulted and was extensively developed down to No. 6 level, but was poor below 420 feet. Only traces of galena were found in a long drive on No. 8 level, and the ore channel is probably a fault zone (Twelvetrees and Ward, 1910, p. 105).

No. 8 lode strikes NNE and was reported by Waller (1904) to have been dislocated by a NNE trending fault between No. 2 and No. 4 levels, with an upthrow of 200 feet on the east block. There is further faulting on No. 5 level where the country rocks are highly disturbed. Workings on the orebody are extensive down to No. 8 level but the value of ore appears to have been variable.

In 1907, lodes were found north of the "main slide" and in subsequent years were worked on Nos. 2, 3, 4 and 5 levels. Little ore was found in north drives on the lower levels. The orebodies were correlated with veins south of the main thrust, which were regarded as a "cross-lode", but it is doubtful if such correlation is valid owing to the extensive faulting in the mine.

No. 2 Shaft is 500 feet deep and work was carried out on No. 1 (100 foot); No. 2 (200 foot); No. 3 (300 foot); No. 4 (400 foot) and No. 5 (500 foot) levels. Two lodes were exploited; on the two upper levels No. 1 was originally worked by the Silver Queen Prospecting Association and No. 2 by Donnelly's tribute party.

No. 1 Level.—An ore shoot in No. 1 lode was 160 feet long. A large pyritic body, striking NE, was driven on for a considerable distance a little to the west of No. 1 lode but proved unpayable. The west crosscut was extended a further 140 feet and intersected No. 2 (Donnelly's) lode which ranged up to about 2 feet 6 inches of galena and pyrite.

No. 2 Level.—The shoot of ore in No. 1 lode shortened to 70 feet, and was said to be only 13 feet long at the bottom of a winze 75 feet deep. No. 2 lode was driven on for at least 140 feet but was variable in quality.

East of the shaft, an old crosscut was extended for a total of more than 1400 feet eastwards towards the Despatch section but no workable ore was found. Bullock's Lode was intersected 1232 feet east of the shaft but is apparently poor and unprofitable.

No. 3 Level.—No. 1 lode is faulted off in the south drive, and is thin and poor in the north drive except for a shoot of ore about 50 feet long. No. 2 lode passes into pyrite with traces of galena in the south drive. The stopes above the north drive are about 350 feet long but the quality of ore is not known.

No. 4 Level.—In the north drive, No. 1 lode is only a few inches thick and it eventually pinches out, while in the south drive it is cut off by a fault. No. 2 lode is represented only by a thin vein of quartz and pyrite in the north drive, and patches of ore were stoped out above the south drive, at the end of which the lode is faulted off.

No. 5 level.—No. 1 lode was uncovered in a crosscut 100 feet west of the shaft. In the north drive, patches of ore were found which pass northwards into barren slate, and in the south drive the ore channel is cut off by a fault zone. The orebody was shown to be barren in a rise until within 20 feet of No. 4 level. In No. 2 lode small patches of galena assaying up to 103 ounces of silver per ton were sampled in the south drive but the orebody is generally poorly mineralized. Little ore is present in a rise cut for 56 feet towards No. 4 level.

TABLE 18—Production—Zeehan-Montana Mine

Year	Concentrates (Tons)	Silver Content (Ozs)	Lead Content (Tons)		
1892-Mar., 1898	26,405	2,643,694	14,270		
Apr.-Dec., 1898 ..	2,503				
1899	3,334				
1900	3,392				
1901	3,802				
1902	4,030				
1903	3,634				
1904	3,932				
1905	4,223				
1906	4,901				
1907	4,363				
1908	3,573	} Est. 4,388,000	} Est. 35,110		
1909	7,423				
1910	2,910				
1911	2,233				
1912	1,433				
1913	1,425				
1914	654				
1915	107				
1916	291				
1917	224				
1918	126				
1919				6,986.56	52.13
1920				2,843	7.78
1921		1,603	18.05		
1922		9,197	73.12		
1923	} c. 350	1,295.52	13.51		
1924		1,206	10.57		
1925		615.2	5.46		
1928		51	0.30		
1929		2,361	16		
1936		4	270.5	2.4	
		85,272	7,058,122	49,580	

Notes.

Estimates based on 60% lead and 75 ounces of silver per ton (cf Twelvetrees and Ward, 1910, p. 103. Silver content in No. 2 workings lower than in No. 1).

After 1904, part of production was from No. 2 shaft, and a small crosscut from No. 3 (Silver Crown) workings.

CONCLUSIONS

In the Zeehan-Montana workings, profitable ore was worked out many years ago, after extensive exploration and development to a depth of 800 feet. The flooding of the mine, the intense post-mineralization faulting and the impoverishment of ore in depth provide pertinent arguments against any further investigation.

Oonah Mine

The old shaft and workings are situated on the lower SE side of Oonah Hill about $\frac{1}{4}$ mile NW of the Trial Harbour road, on Section 11780M of 76 acres.

In 1888, an 80 acre lease 819-87M was pegged by A. N. Allison, while to the south F. R. Evans held lease 1110-87M of 75 acres and a 74 acre section 1111-87M, further west. Allison's lease was transferred in 1889 to the Junction Silver Mining Co. N.L. which worked orebodies in the northern part. The lease was eventually taken over by the Oonah Silver Mining Co. N.L. in 1901.

Evans's leases were acquired by the Oonah Silver Mining Co. N.L. in 1890, and two orebodies were explored in adits and shallow shafts. In 1893 the property was let to tributors who discovered several small but rich veins of galena, but Montgomery (1893b) recommended that the company should sink a shaft to work the orebodies in depth when the tributors' time expired. By 1896 the main shaft had been sunk to a depth of 260 feet and the mine was being worked on 4 levels. An important development was the discovery of a stannite lode in 1897: a valuable asset to the property in later years when reserves of galena became exhausted. Milling and concentrating plant was installed in 1898 and important quantities of argentiferous galena were recovered in the next two years. The shaft was deepened to 450 feet, and the mine was opened up on No. 6 (424 foot) level but it closed early in 1901 as the upper levels were almost worked out and the orebodies were apparently poorer in depth. Tribute parties carried on work above water level, mainly in the stannite workings, until 1905 when known reserves of stannite in the upper levels were exhausted, though active exploration continued. A British company was later granted an option on the mine, which was dewatered, and from 1907 to 1909 the stannite lode was developed on Nos. 4, 5, and 6 levels. After metallurgical tests on the complex stannite ore, smelters were built in South Zeehan to treat it and in 1909, Oonah Mines Ltd. was formed to exploit the stannite lode. By early 1910, about 60 tons were being sent to the smelters daily and it was planned to sink the shaft another 150 feet, but towards the end of the year the mine and smelters ceased operations after the closing of the main Zeehan smelters, and many miners left the Zeehan field.

In 1911, the leases were taken up by A. E. Bruce and for a number of years parties of tributors extracted substantial amounts of pyrite and silver-lead ore but there has been little production since 1924. Lease 11780 of 76 acres covering the main workings was pegged by A. D. Sligo in 1937, and the property changed hands several times in subsequent years, becoming void in 1954.

GENERAL GEOLOGY

The country rocks are part of the Oonah Quartzite and Slate, which includes interbedded flows of spilitic ("melaphyre"). The rocks were folded along axes trending a few degrees north of west during the Tabberabberan Orogeny.

OREBODIES

The orebodies are fissure veins striking chiefly a few degrees west of north, with easterly dips. Several small lodes trend NNE so that the pattern of mineralization is similar to that in the Zeehan district generally. "Bradshaw's Lode" is a series of pyrite lenses trending NE, in which pyrite partly replaces the country rock.

The most important veins are the main galena lode and the stannite lode about 250 feet to 300 feet further west. The veins are parallel, and dip NE, but the stannite lode apparently dips at a less steep angle. Twelvetrees and Ward (1910) suggested that they may join about 150 feet below No. 6 level (at a depth of about 575 feet). According to these authors, and Waller (1904), the veins terminate in the north against a "slide" striking N 75° W with a NE dip. The stannite lode was reported to emerge north of the slide, though further west, but the galena lode had not yet been found on the north side. It was believed that the "slide" deviated, but did not fault the lodes, and that it had itself become a definite ore channel with patches of ore over two feet wide.

It is possible that the "slide" or "cross-lode" is a thrust zone similar to those in the Montana Silver-Lead Mine and other mines in the vicinity. Faulting could have taken place during mineralization but it is likely that there were later movements, probably in the Tertiary, which dislocated the orebodies. Twelvetrees and Ward (1910, p. 128) stated that on approaching the zone, the main lodes bend round to about 30° west of north from an almost N-S trend. The change in direction suggests drag caused by lateral movement along the thrust zone and displacement therefore may have been north block up and west.

MINERALOGY

The mineral assemblage is unusual and complex and may be divided into several distinct groups.

(a) GALENA LODES

Irregular veins and masses of pyrite with galena and sphalerite occur in a gangue of siderite and some quartz. The galena contains up to at least 127 ounces of silver per ton.

(b) STANNITE LODE

The orebody consists of bands of stannite, pyrite and chalcopryite, with a little galena, tetrahedrite, cassiterite, jamesonite, arsenopyrite, bismuthinite and wolfram in a gangue of quartz with some siderite and fluorite. The stannite ore is described below.

(c) CASSITERITE LODE

Twelvetrees and Ward (1910, p. 131) noted the discovery of a westerly-striking vein a few inches thick of grey cassiterite and pyrite on the hill east of the gully near the mine. In 1913 an adit was driven on the lode for 117 feet, revealing up to 2 feet of siliceous gossan and pyrite. A bulk sample of 15 tons assayed only 0.25% tin.

(d) PYRITE LODE: ("BRADSHAW'S LODE")

The orebodies are overlapping lenses of pyrite up to 30 feet wide striking NE, and were formerly exploited for the production of sulphuric acid. According to Twelvetrees and Ward (1910, p. 132) a little chalcopryite is present and also cassiterite. Specimens of pyrite are said to have assayed between 0.3% and 0.4% tin.

STANNITE ORE

The stannite ore has a complex composition as shown in Table 17 taken from an unpublished report by Nye (1933a). Polished

TABLE 19—Analyses of Stannite Ore (Oonah Mine)

	1	2	3	4	5	6	7	8	9	10
Silver (Ounces per ton)	63	22	97.3	84	50	63	59.6	75.5	60.5	68
Copper %	10.7	5.5	26.77	11.5	10.3	13.8	12	13.5	12.25	11.5
Tin—										
(as sulphide) %	9.2	4.5	{ 23.27	{ ?	16	{ ?	9.73	{ ?	8.7	9.0
(as oxide) %			{ 0.64	{ ?		{ ?				
Arsenic %	4.4	Tr.	Tr.							
Bismuth %	Tr.	0.4-0.45	2.27							
Antimony %	Tr.	...	0.505							
Zinc %	ND	ND	0.475							
Iron %	ND	26-27	12.11							
Sulphur %	29.75	29	32.1							
Silica %	23	22-27	1.4							
Alumina %	2.2	4-5	...							

1. Bulk assay of 70 tons sold in 1903.
 2. Bulk analysis of ore as mined (Twelvetrees and Ward, 1910, p. 53).
 3. Analysis of picked stannite (J. H. Levings. Annual Report of Secretary for Mines for 1907, p. 32).
 - 4-10. Assay of parcels of ore, ranging from 11 tons to 82 tons, sold 1901-1903.
- Tr. = Trace.
ND = Not detected.

sections of the ore were studied by Stillwell (1930) who recognized two generations of minerals: the earlier including pyrite, arsenopyrite and cassiterite with quartz, the later consisting of stannite and chalcopyrite, with smaller included amounts of tetrahedrite, bismuthinite and galena. Varying degrees of replacement of the earlier minerals by the later partly account for the wide variation of mineral content in different specimens of ore. Wolfram was not detected in the polished sections but would undoubtedly belong to the earlier generation.

Stannite

Stannite is the most abundant mineral in the ore and contains inclusions of pyrite, arsenopyrite, cassiterite and quartz. Numerous small inclusions of chalcopyrite, tetrahedrite, bismuthinite and galena were also found.

Cassiterite

Crystals occur as bunches along the margins of quartz and stannite, and are also embedded in stannite, particularly in areas rich in chalcopyrite where they may be surrounded by a thin sheath of chalcopyrite.

WORKINGS

Main (Galena) Lode

The shaft was sunk to a depth of 450 feet, and the mine was opened up on No. 1 (Adit or 50 foot), No. 2 (137 foot), No. 3 (163 foot), No. 4 (250 foot), No. 5 (322 foot) and No. 6 (424 foot) levels. In the upper levels particularly, the drives and crosscuts are extensive and the orebody was largely stoped out before 1900. A rich shoot of ore was mined between No. 1 and No. 4 levels, and was payable over a length of 600 feet on No. 4 level. On No. 5 level the orebody was poor in the north, but to the south a block of ore was stoped for 230 feet. No ore was found in a drive 250 feet long on No. 6 level, though Waller (1904) was doubtful whether the drive was on the lode channel.

Waller stated that another orebody had been cut on No. 1 and No. 3 levels west of the main lode. It was said to carry payable ore being worked by a party of tributors until rising water forced them to stop work when the mine closed in 1901.

Stannite Lodes

Between 1897 and 1905, the workings were in the hands of tribute parties. Waller (1904) recorded that on No. 1 (Adit) level, the drive on the Main (galena) Lode was driven along the "slide" NW for about 60 feet and was then continued as a west crosscut south of the "slide". At 300 feet, the crosscut intersected the eastern stannite lode which was driven on north for 120 feet as far as the "slide". The drive followed the "slide" NW for 80 feet and some stannite was reported. The east lode was cut north of the "slide" and the west stannite vein a little further west, both being driven on northwards. Waller commented that the lodes were parallel, irregular and frequently branched, and were worked from 3 other adit levels to the north at vertical distances of about 40 feet from each other, representing workings over a length of 400 feet.

A stannite lode was found south of the "slide" on No. 3 level but was poor, and when the mine was re-opened by Oonah Mines Ltd. in 1909, development was concentrated on Nos. 4, 5 and 6 levels.

On No. 4 level, the lode improved (Twelvetrees and Ward, 1910). In the south drive a shoot of ore was found up to 6 feet wide, with 2 feet 6 inches of solid stannite ore in stopes above the level. Towards the end of the drive, the lode ends abruptly, being replaced by a siderite-stannite orebody, known as the "West Carbonate" Lode in which good ore had been stoped from No. 5 level up to within 40 feet of this point. The relation of this lode to the main stannite orebody is not known. Some 400 feet of driving was done on No. 4 level.

On No. 5 level there are 320 feet of drives. The stannite lode is about 2 feet 6 inches wide and had been stoped out for 50-60 feet above the north drive over a length of 80 feet. On the west side of the drive, a formation of siderite with chalcopyrite and pyrite 7 feet wide joins the stannite lode from the west. For 25 feet near the junction, the stannite is reduced to a mere thread and then widens to 4 feet, passing up into a large body of ore in the stopes above. In the south drive 20 feet past the crosscut, the ore at the end of a shoot 160 feet long slowly peters out to only 1 inch of stannite, with no indication of faulting. Twelvetrees and Ward (1910, p. 130) considered that the ore-shoot pitches south, so extending further south on No. 6 level.

The lode was driven on for a total of 250 feet on No. 6 level. Ore was found along the north drive but was generally poorer than on No. 5 level. About 2 feet of solid stannite was cut in a short west crosscut at the end of the drive.

According to Twelvetrees and Ward the south drive is along a lode of pyrite, chalcopyrite and a few inches of stannite, passing at the end of the drive into "soft and running graphitic lode-filling". The writer suggests that here the orebody may be faulted.

Bradshaw's Lode (Bradshaw's "Copper Lode" or Bruce's Tribute)

The workings lie about $\frac{1}{4}$ mile south of west from the main Oonah workings. The pyritic lenses, which strike NE and dip to the SE, were described by Twelvetrees and Ward (1910). They were worked in an opencut, a shallow shaft, and 4 adits on 3 levels. The lowest adit is Brice's which was driven for 700 feet west, intersecting the pyritic formation at 650 feet. Bradshaw's adit is another crosscut, about 60 feet higher, in which pyrite was stoped over a width of 25 feet. Walshe's and Leatherbarrow's adits are driven on the orebodies about 60 feet higher still.

The lodes were formerly regarded as copper lodes, and Waller (1904) reported that bulk assays were as high as 6% copper, with small quantities of gold and silver, though he was doubtful about the accuracy of sampling. Twelvetrees and Ward (1910, p. 132) recorded that chalcopyrite is present but concentrates did not assay more than 1% copper. The ore carries 0.3% to 0.4% tin, presumably as fine-grained cassiterite.

Pastkuchen's Lode

This is a pyritic orebody with thin bands of galena and sphalerite striking NE on the upper eastern slope of Oonah Hill, about 300 yards west of Bradshaw's Lode. A few tons of galena were produced many years ago in a shallow shaft and a trench. The pyrite contains about 0.3% tin (Twelvetrees and Ward, 1910).

TABLE 20—Production—Oonah Mine

Year	Galena Ore (Tons)	Stannite Ore (Tons)	Gossan & Flux (Tons)	Pyrite (Tons)
1888-1897	6,134	....	....	....
1898	1,611	....	....	....
1899	1,807	35	....	....
1900	325	....	....	....
1901	227	76	....	....
1902	255	600	51	....
1903	135	457	....	....
1904	223	326	1,094	....
1905	....	26	585	1,028
1906	390	....	207	....
1907	1,960	....	447	1,052
1908	730	500	223	3,100
1909	49	2,296	409	3,847
1910	54	10,348	3	3,987
1911	....	....	....	3,738
1912	....	....	....	3,892
1913	25	....	....	2,778
1914	3,265	....	....	....
1915	1,550	....	....	....
1916	251	....	....	....
1917	36	....	....	....
1918	50	....	....	....
1919-1925	Est. 300	....	....	....
	19,377	14,664	3,019	23,422

Estimated Contents of Ore

	Ore (Tons)	Silver (Ozs)	Lead (Tons)	Copper (Tons)	Tin (Tons)
<i>Galena:</i>					
1888-1918	19,077	1,526,160	11,446	....	....
1919-1925	300	24,485	190	....	....
<i>Stannite:</i>					
1899-1905	1,520	76,000	....	152	Not known
1908-1910	13,144	262,880	....	789	Not known
<i>Gossan:</i>	1,714	137,120	88	....	....
<i>Sideritic Flux</i>	1,305	23,490	....	....	....
		2,050,135	11,724	941	Not known

Notes:—

1. Content of galena ore 1888-1918 taken as 60% lead; 80 ounces of silver per ton (cf. recorded figures in 1898; 1899.).

2. Stannite 1899-1905. Figures calculated on 10% copper and 50 ounces of silver per ton (cf. Reid, 1929). Tin content sold unknown.

Stannite 1908-1910. Taken as 6% copper and 20 ounces of silver per ton. 1784 tons of copper-silver matte were produced. Amount of copper-tin alloy produced unknown.

3. Silver content of gossan matte taken as 80 ounces per ton; of flux 18 ounces per ton.

4. Part of production of flux, gossan and galena was from Junction workings.

CONCLUSIONS

1. In the Oonah mine, the pattern of mineralization is complex, and the association of minerals is an unusual one.

2. The "slide" of earlier authors may be a post-mineralization thrust or shear zone which has dislocated the orebodies in the main workings. Movement appears to have been north block up and west. It is likely that there are other similar faults in the workings which are now inaccessible.

3. The galena lode appears to have been unworkable on No. 6 level. The stannite lode was exploited on this level, but there is no record of development below it. The mine closed in 1910, shortly after plans were made to sink the shaft a further 150 feet, presumably to work the stannite lode.

4. The pyritic lenses of Bradshaw's Lode are relatively small and are of little economic interest. Cassiterite is disseminated throughout the pyrite but is low grade.

RECOMMENDATIONS

Any future exploration should be concentrated on the stannite lodes, the most important of which may join the galena lode at a depth of about 575 feet below the collar of the shaft (Twelvetrees and Ward, 1910). If the east dip of the galena lode is maintained, its position at this depth will be about 200 feet east of the shaft. A borehole declined 60° would have to be sited about 550-600 feet east of the shaft and should intersect the lode after about 650-700 feet. Favourable siting of a borehole might reduce the drilled distance by as much as 50 feet but drilling would still be a considerable undertaking. There is always the possibility that other veins might be intersected in such a hole.

Zeehan-Queen Mine

The old workings lie on the NW flank of Queen Hill and in the valley of Queen Creek south of the Oonah mine. The No. 1 shaft workings later became known as the Montana No. 2 workings and have been described in the section on the Zeehan-Montana mine. No. 4 shaft is a few yards south of the Trial Harbour road, about half a mile SW of the junction with the Corinna road and in the SE part of the former lease 1638M. No. 2 shaft is sited north of the Trial Harbour road, about 300 yards further west, while No. 3 shaft is 150 yards east of No. 2. The 3 shafts are near the watertable and have been full of water for many years.

The Queen Hill area was prospected extensively in 1887 by G. Bell, W. Bell and W. G. Barker whose leases were transferred in 1888 to the Silver Queen Prospecting Association N.L. The orebodies were exploited from No. 1 and No. 2 shafts, the latter being sunk on a lode carrying rich galena ore at the surface, which became poor in depth. This shaft was put down to a depth of 170 feet and levels were opened up at 80 feet and 157 feet but by 1893 little underground work was in progress. The property was regarded favourably by Montgomery (1893b) who pointed out that at least 12 lodes had been found in the Silver Queen leases but capital was essential for development. Two years later a number of tribute parties were active. No. 2 shaft was deepened to 220 feet, No. 3 underlay shaft was taken down to a depth of 117 feet on No. 3 lode, and No. 4 shaft was being sunk on an orebody which had been tributed at surface by Aird and Lamb. On Clarke's tribute on the

NW slope of Queen Hill an adit was driven to cut Clarke's lode in which stannite had recently been identified. The company later bought out the tributors and resumed production, almost entirely from the workings centred on No. 4 shaft. Work ceased once more at the end of 1899, but tribute parties produced a useful tonnage of ore until early 1901 when the main workings were abandoned. Tributors continued operations on the stannite and galena ore from Clarke's lode.

In 1902 the property was sold to Mt Zeehan (Tasmania) Silver-Lead Mines Ltd. and in the following year, the Zeehan-Queen Co. Ltd. was floated to take over the old Silver Queen workings and plant. The new company held a total of 258 acres and mining was concentrated on No. 4 lode north and Clarke's lode in the No. 4 shaft workings. In spite of much underground exploration, payable ground became worked out in late 1905 and the mine closed. Parties of tributors carried on for a number of years and although the government financed an exhaustive prospecting programme in 1914, no further discoveries of importance were made. Taylor's lode was exploited by tributors between 1914 and 1917 and the last recorded production of silver and lead from the Zeehan-Queen lodes was in 1929. The production of cassiterite from the north end of Queen Hill is described in the section on the Stormsdown mine.

GENERAL GEOLOGY

The orebodies occur within a tightly folded sequence of slate, siltstone and pale-weathering quartzite containing flows of splittic lava, which is considered to form the upper part of the Oonah Quartzite and Slate (Upper Proterozoic or Lower Cambrian). Devonian mineralization took place along zones of faulting and fissuring trending generally between NW and NNE, and lodes were later dislocated by numerous Tertiary (or Jurassic) faults with trends ranging from a few degrees north of west to NW.

OREBODIES

The lodes are fissure veins up to about 4 feet 6 inches wide and argentiferous galena is associated with some sphalerite in a gangue of siderite which in depth may pass into pyrite. Clarke's lode is a pyritic orebody striking NE and dipping at about 60° to the SE, containing irregular bands and aggregates of galena and stannite together with minor amounts of sphalerite, chalcocite and quartz. Fine-grained cassiterite could be present as in the Stormsdown mine. The lode was chiefly worked for its galena content but at least 44 tons of stannite was produced between 1901 and 1905.

TABLE 21—Analyses of Stannite Ore

	1	2	3
Tin %	8.5	14	12.5
Lead %	6	.....	6
Copper %	8.9	16	12.4
Silica %	7	.....	.....
Silver Ozs per ton	57	78	72.4

1. Picked sample of ore assayed in Oonah Mine laboratory (Twelvetrees and Ward, 1910, p. 133).

2. Assay of 20 tons of ore (Twelvetrees and Ward, 1910, p. 134).

3. Progress of the Mineral Industry of Tasmania. (Quarter ending 31.12.1904, p.17).

MAIN WORKINGS

No. 4 Shaft.—The shaft was sunk to a depth of 230 feet and levels were opened up at 110 feet (No. 1 level) and at 210 feet (No. 2 level). At a depth of 28 feet, a connection was made with what was known as the 44 foot level from Mace's shaft (Waller 1904, p. 61).

44 foot level.—Clarke's lode was driven on for 600 feet and much stoping was done above the level prior to 1904. Tributors are said to have worked a rich shoot of ore in a drive 200 feet long further north at about the same level.

No. 1 (110 foot) level.—Waller (1904) recorded that the drive on Clarke's lode had been extended 210 feet and two shoots of ore 35 feet and 27 feet long were cut, separated by barren lode material, but the ore proved to be low grade and pyritic. The level was later driven for a total length of 900 feet from the crosscut at the shaft and a rise was excavated up to the surface. Workable galena and stannite ore was stoped out before the closing of the mine at the end of 1905.

On No. 4 lode, a drive was cut for a total of 340 feet northwards. At 270 feet from the shaft, ore was intersected in the floor of the drive and a winze was sunk to a depth of 30 feet. Mineralization is erratic but was generally workable and included up to 1 foot 6 inches of galena and 3 feet of milling ore.

No. 2 (210 foot) level.—According to Twelvetreets and Ward (1910, p. 133) Clarke's lode was exposed on this level but no details are available and it may not have been worked. In 1904 a crosscut west from the shaft intersected No. 5 lode which is poor. In the following year, No. 3 lode was also cut and although it was driven on north and south over a total length of 212 feet, no workable ore was found.

Intermediate level.—Waller (1904, p. 62) stated that No. 4 lode south strikes NNE with a SE dip varying from 20° to 45° and that it had been stoped out from this level, 50 feet below No. 2 level, up to the surface. Below the level, a winze sunk 50 feet deep on the lode passed into pyrite at the bottom. Waller commented that several workable masses of good second class ore had been left so that only the richest galena ore appears to have been extracted.

No. 2 Shaft.—The shaft is 300 yards west of No. 4 shaft and Waller (1904) noted briefly that No. 2 lode was driven on for 440 feet at the 80 foot level, for 360 feet on the 157 foot level and for 240 feet on the 224 foot level. The orebody strikes to 60° and is vertical, and although a large amount of ore was produced, no details were placed on record. No. 3 lode was driven on at the 224 foot level.

No. 3 Shaft.—An inclined shaft about 150 yards east of No. 2 shaft. Two levels were cut on No. 3 lode, but the amount and quality of ore produced are unknown.

Adit Crosscut.—Clarke's lode was first explored in an adit driven from near the Trial Harbour road, NE of No. 4 shaft. Montgomery (1895) remarked that the orebody varies between 4 feet and 6 feet in thickness, with well-defined walls. Galena, chalcopryrite and a little tetrahedrite were associated in a gangue of pyrite, and W. F. Petterd had recently identified stannite.

TABLE 22—Production—Zeehan Queen Mine

	<i>Ore</i> (Tons)	<i>Silver</i> <i>Content</i> (Ozs)	<i>Lead</i> <i>Content</i> (Tons)	<i>Remarks</i>
To 13/12/1902	25,028			
1903	94			Ore and gossan
1904	151			
1905	3,618			Included 1717 tons of tailings
1906	1,314			
1907	324			
1908	234			
1909	1,210			Mainly gossan
1910	17			
1911	293	Est. 1,951,000	16,262	Included 257 tons of flux
1912	2,026			Included 1866 tons of flux and pyrite
1913	390			Included 264 tons of pyrite
1914	281			
1915	178			
1916	247			
1917	318			
1918	502			
1919		2,561	36.40	
1920		7,948	81.75	
1921		2,065	12.69	
1922		5,128	62.27	
1923	Est. 500	1,216	16.76	
1924		1,569	17.63	
1925		1,737	33.50	
1928		138	3.00	
1929		384	6.00	
	<u>36,725</u>	<u>1,973,746</u>	<u>16,532</u>	

Note:—44 tons of stannite included in ore 1901-1905. Tin content sold not recorded.

CONCLUSIONS

In the Zeehan-Queen workings, mineralization is in the form of short but relatively rich veins, bands and irregular masses in a siderite, pyrite or quartz gangue within ore channels trending between NW and NNE. Both sideritic and pyritic lodes are present and the orebodies tend to become pyritic in depth while at the same time the galena content diminishes. In the underground workings, profitable galena ore was worked out by 1905 and since then, shallow deposits on the property have been thoroughly prospected. The best chance of further development appears to lie in the detailed examination of Clarke's lode and the other possible stannite and cassiterite bearing orebodies on Queen Hill. Waller (1904, map) showed Clarke's lode as a continuous orebody about half a mile long striking NNE, west of the summit of Queen

Hill and east of the Trial Harbour road. Although it was reported to have been worked over a considerable length in No. 4 shaft workings, towards the north end of Queen Hill there is much faulting which would displace the orebody, so that Waller's map should be regarded with caution.

RECOMMENDATIONS

Diamond drill holes should be considered from sites east of the Trial Harbour road, near and north of the bend about 150 yards east of No. 4 shaft. Clarke's lode dips at about 60° to the SE but holes to the east of the outcrop would be handicapped by difficult access to Queen Hill and lack of water. To the west of the orebody, the favourable slope of the hill, easy access and water supply would tend to offset the disadvantage of the SE dip, but it would be necessary for holes to be declined at angles less than about 45° . The line of Clarke's lode would be intersected in drilled distances ranging from about 300 feet to over 700 feet, depending on the location selected.

The old adits NE of No. 4 shaft might be cleaned out and systematically sampled for stannite and cassiterite.

Mount Zeehan Mine

This mine should not be confused with the old workings of the Mount Zeehan (Tasmania) Silver Lead Mines Ltd., a British company with extensive holdings further south (see p. 162).

The first claim pegged in the Zeehan district was section 559M of 80 acres which was granted in early 1883 to F. H. (Frank) Long who discovered galena in Argent Creek towards the end of 1882. The original lease included that part of Zeehan township now lying south of Tarleton Street, east of Shaw Street and NW of Wilson Street. At the same time, lease 560M of 40 acres to the SW was taken up by W. Johnstone, but it was forfeited later in 1883 and was next charted in 1884 as section 909M in the name of B. P. Farrelly. Both leases were later transferred to the Arthur and Long Plains Prospecting Association and in 1888, the Mount Zeehan Silver-Lead Mining Co. N.L. was formed to work a number of orebodies below gossan outcrops. On section 559M, a main shaft was sunk to 136 feet and the Main lode was opened up on the 124 foot level, and also at the 60 foot level in an airshaft. Several orebodies were cut in the workings, but proved to be variable in quality and Montgomery (1893a) commented that the growth of Zeehan had interfered with the development of several promising lodes in other parts of the leases. Most of section 559M was subdivided into residential or business blocks and mining was restricted by Grant Deeds to below depths ranging from 30 feet to 50 feet from the surface.

Underground work came to a standstill about 1893, though several tribute parties raised small quantities of galena from shallow workings. In 1896, the leases passed to the New Mount Zeehan Silver-Lead Mining Co. N.L. and the Main crosscut was extended east and west. Although a number of veins were intersected little driving was done. No. 2 and No. 3 shafts were sunk and shallow levels were opened up in them but were soon abandoned. South and SE of the main shaft, three adit crosscuts were put in, the most important of which lay near the southern boundary of section 559M. The company stopped work in 1900 and the property was let on tribute. About 1904, the Williams tribute party sank a shaft about 80 feet deep on Williams's lode, on lease 909M, some 400 yards SW of the main shaft. The orebody is pyritic and was not rich but the party obtained useful amounts of galena.

Little ore has been produced since 1910. The leases were surrendered and combined in Consolidated Lease 3840M in 1908, becoming void in 1911. The old section 559M was taken up as section 5754M (79 acres) by G. W. Ellis in 1912, passing to the Central Zeehan Prospecting Syndicate N.L. between 1912 and 1913. The ground was last chartered as lease 11912M (A. S. Robertson). Part of the former lease 909M was covered by the 5 acre lease 9688M between 1926 and 1928 (J. Reynolds, J. A. Cornish and G. Heywood) while from 1937 to 1939, W. J. Hodge and E. McDade held section 11817M of 10 acres.

GENERAL GEOLOGY

The majority of the orebodies trend NNE or NNW within weathered, folded and fissured Cambrian greywacke, siltstone and shale believed to be part of the Crimson Creek Formation. East of the main workings, the Cambrian rocks have been faulted against Silurian Crotty Quartzite, while to the NE, the beds have been brought against decomposed Ordovician Gordon Limestone by the NNW striking Despatch Fault. The orebodies contain irregular and impersistent bands, masses or lenses of galena with some sphalerite in a gangue of siderite. Barytes was recorded by Montgomery (1890) in the Main (No. 2) lode in a shallow shaft 90 feet south of the air shaft. The lodes in the old workings appear to have been up to about 5 feet wide. According to Tilley (1891), bulk assays from 22 tons of ore sent to Sydney gave a return of 52% lead and 73 ounces of silver per ton. Montgomery (1893b) was informed that 415 tons of concentrates yielded 66.2% lead and 65.37 ounces of silver per ton, while a further parcel of 40 tons contained 59% lead and 76 ounces of silver per ton. Most of the ore produced from the mine was stoped out from the Main lode on the 60 foot and 124 foot levels in the Main shaft workings.

WORKINGS

Little can now be seen of the abandoned underground workings, which have been waterlogged for many years.

Main Shaft

The shaft lies near the east bank of Argent Creek, about 200 yards NE of the south end of Shaw Street. It was sunk to a depth of 136 feet and at the 124 foot level, the Main crosscut was driven a few degrees south of east for 205 feet, then for 255 feet SE. No. 1 lode East was intersected at 205 feet and was driven on for 202 feet NNE and for 211 feet SSW. At 337 feet No. 2 lode East was cut but it was driven on for only 59 feet SSW.

The Main (No. 2 West) Lode was cut in the Main crosscut 227 feet west of the shaft, and about 15 feet north of the intersection an air shaft was sunk to the 124 foot level. Montgomery (1890) noted that the lode ranged between 18 inches and 3 feet wide, consisting of patchy galena and sphalerite in siderite. The orebody was developed in drives north and south at the 60 foot and 124 foot levels. The 60 foot level was driven for a total of about 520 feet NNE and 180 feet SSW. On the 124 foot level the lode was driven on for about 525 feet NNE of the Main crosscut, with a rise to the 60 foot level at 75 feet. At 325 feet, a long crosscut was driven for a total of 594 feet NE but workable ore was apparently not found. The south drive is about 464 feet long, at the end of which a SW crosscut was driven 90 feet.

West of the Main lode, the *Main Crosscut* was extended a further 422 feet west, and short drives were put in on No. 3 lode West at 202 feet, No. 4 lode West at 270 feet and No. 5 lode West at 422 feet. Twelvetrees (1901) commented that No. 3 and No. 4 lodes carried high-grade ore 10 inches to 1 foot wide but they were intensely faulted.

No. 2 Shaft

About 683 feet NE of the Main shaft. It was sunk to a depth of 70 feet at which level a SSE drive was put in for 145 feet, and a crosscut was driven 304 feet eastwards. The shaft is above the end of the north crosscut at the 124 foot level in the main shaft.

No. 3 (Gaiety) Shaft

About 495 feet east of No. 2 shaft. It is 50 feet deep and a SW crosscut was driven for about 115 feet, but there is no record of any mineralization.

No. 1 adit

The portal is about 240 yards SSW of the Main shaft, and 65 yards from the southern boundary of the former lease 559M. The adit was cut for about 190 feet SE and east. At 80 feet, an orebody 2 feet wide was intersected and driven on NNE for about 163 feet. Several winzes were sunk about 25 feet between which workable ore was stoped out. At 141 feet from the portal, a short drive was cut SSW but mineralization was presumably poor.

No. 2 adit

A crosscut adit was driven 192 feet eastwards from a point 315 feet SE of the Main shaft. Twelvetrees (1901) noted that a wide formation of black pyritic pug had been cut but little galena was present. At about 123 feet, white sandstone was found, suggesting that the adit had crossed the fault into Silurian Crotty Quartzite.

PRODUCTION

Total production of concentrates was 2567 tons, with a metal content estimated at 1540 tons of lead and 166,850 ounces of silver (based on an average of 60% lead and 65 ounces of silver per ton).

CONCLUSIONS

Although a number of orebodies have been explored on the old Mount Zeehan leases, the Main lode is the only one which proved workable. It is surprising that the Main shaft workings were not taken below the 124 foot level, a logical step while the orebody was being stoped out above that level. Nothing is known about the quality of the Main lode and no winzes from the 124 foot level are shown on the mine plans. There are two possible explanations: either the Main lode was so variable in value that further sinking was not encouraged, or the company lacked funds to install the pumps necessary to prevent flooding of deeper workings. The second reason appears to be more likely.

Twelvetrees (1901) pointed out that at least 9 lodes cross Main Street in the northern part of the former section 559M but the company faced legal problems as most of the ground was taken up for building blocks.

The area is highly faulted and much of the disturbance probably took place in Tertiary times. For example, Twelvetees (1901) remarked that No. 3 and No. 4 lodes in the Main shaft workings had been dislocated, and on the mine plans a fault is shown which has displaced the Main lode in the northern part of the 60 foot level. The faulting may be an extension of that in the Zeehan-Western and Oonah mines to the NW.

RECOMMENDATIONS

The main lode should be tested in depth below the 124 foot level in the Main shaft workings. The cost of draining the workings and rehabilitating levels which have probably collapsed is not warranted, but valuable information might be gained by core-drilling. The position on the mine plans of the 60 foot and 124 foot levels show that the orebody is nearly vertical, swinging to a steep easterly dip near the air shaft. A borehole 400 feet long, declined at 45°, should intersect the line of the lode at a depth of 250-300 feet if drilled to 280° from a point immediately north of, and about 60 feet east of the old main shaft.

Despatch Mine

The old main shaft is about 600 yards NNW of Zeehan post office on the limestone flat a short distance west of Main Creek. Lease 562M of 80 acres was pegged in 1882 by J. W. Healy who accompanied Frank Long, the pioneer prospector of the Zeehan silver-lead field, and the Despatch section was therefore one of the two original claims at Zeehan. There was little activity until 1885 when the Despatch Silver-Lead Association investigated lodes in the south part of the lease, which was relinquished in 1887. Later that year, the block was taken up by E. Mace as lease No. 243-87M, passing in 1888 to Bowes Kelly. In 1891 the Despatch Silver Mining Company (Zeehan) N.L. was formed to work the orebodies. Montgomery (1893a) noted briefly that a shaft was sunk which was swamped with water and the company stopped work, leaving only a party of tributors prospecting the property. Tributors obtained small quantities of galena ore from the south part of the lease (Montgomery, 1893b) but there was little development. The section was acquired by the Tasmanian Crown Silver Mining Co. Ltd. later in 1893 and was transferred to the Zeehan-Montana company in 1898. Bullock's lode in the SW corner of the lease was later intersected 1232 feet east of the No. 2 Montana shaft in the eastern crosscut on No. 2 (200 foot) level but is unworkable.

No production has been recorded from the Despatch workings and the few small orebodies are unlikely to be of economic value.

New Great Eastern Mine

The chief holding was lease 1666M of 80 acres (north of the Despatch lease), which was first taken up by G. Bell, W. Bell and W. G. Barker in 1887. The section changed hands a number of times, being part of the Silver Queen holdings in 1888. In 1891, it was held by the Silver Queen Block I Silver Mining Co. N.L. and in the following year, it was transferred to the New Great Eastern Silver Mining Co. N.L. Montgomery (1893b) stated merely that a main shaft was sunk but the pump was unable to cope with the flow of water, and the mine was shut down. The section passed to the Silver Queen Prospecting Association in 1895, the Mt Zeehan Queen Co. Ltd. in 1903, and later that year was finally taken over by the Zeehan-Montana company.

The old shaft was sunk in the valley of Main Creek which flows over weathered Gordon Limestone (Ordovician) overlain to the east by the sandstone and grit of the Crotty Quartzite (Silurian) forming the King Extended Hill. Mineralization is low grade and of little economic value. No ore has been produced on the lease.

Tasmanian Crown Mine

The former leases covered the eastern slopes of Montana Hill, east of the Zeehan-Montana mine, and the limestone flat across which Dunkley's tram runs. The holding included five 40 acres leases which were first prospected in 1887-1888 by J. Dunn (Section 197-87M), J. Will (198- and 199-87M), J. R. Cahill (201-87M) and W. E. Brooks (736-87M). The leases passed to A. Simson in 1888, and in 1891 the Silver Crown Prospecting Association was formed to work the orebodies. Montgomery (1890) remarked that the two most easterly veins in the Montana workings were thought to have joined in Section 736-87M and had been cut in a small shaft on Montana Hill near the south boundary of the blocks. About 6 tons of galena from the shaft yielded 114 ounces of silver per ton. An adit was driven 150 feet SW towards the lode from a gully nearby, about 90 feet vertically below the shaft. Tilley (1891, p. 59) noted that several other orebodies had been discovered by trenching on the limestone flat. In 1892, the property was taken over by the Tasmanian Crown Silver Mining Co. Ltd., which also acquired in 1893 lease 243-87M of 80 acres originally worked by the Despatch company. Work in 1893 was confined to surface exploration and the sinking of a main shaft to about 200 feet on Section 199-87M, located in the valley of Main Creek, east of Dunkley's tram and about half a mile NE of the old Zeehan-Western mine. Montgomery (1895) described the workings at the 100 foot and 170 foot levels and the extensive but unsuccessful surface prospecting. The adit on lease 736-87M, driven by the old Silver Crown association, was extended for a total length of 1033 feet, and intersected 3 orebodies. An adit was cut from the west side of the hill and connected to the eastern adit by a drive along the most westerly lode found in the latter.

In 1898, leases 197-87M and 198-87M became void, and the remaining sections were taken over by the Zeehan-Montana company. The old shaft on Montana Hill was pumped out in 1907 and deepened to 85 feet, becoming known as the Montana No. 3 shaft. Tributors extracted small quantities of low grade ore on the 40 foot and 85 foot levels but work apparently ceased in 1908. Between 1934 and 1938, prospectors produced small amounts of concentrates from the former Crown leases, but exploration has proved disappointing.

GENERAL GEOLOGY

Highly folded and disturbed slate, siltstone and quartzite (Onah Quartzite and Slate) forming Montana Hill are faulted to the east against Ordovician Gordon Limestone. As in the rest of the Zeehan district, the decomposed limestone has given rise to a swampy buttongrass flat across which Main Creek flows. The fault trends NNW in a similar direction to many orebodies in the Zeehan field so that it may be of Devonian age, though further movement may have taken place in the Tertiary. Montgomery (1895) recorded bursts of water and slurry with fragments of galena in the NW crosscut at the 170 foot level in the main shaft.

OREBODIES

The lodes are fissure infillings of galena and sphalerite within a sideritic gangue, striking between NW and NE. Although patches of good ore occur, they appear to be limited in extent and the deposits are mainly of low grade milling ore.

Workings

Main Shaft

The shaft was sunk to a depth of about 200 feet, and levels were opened up at 100 feet and 170 feet, but few details are on record. Montgomery (1895) described a sideritic lode at the surface about 200 feet NNE of the shaft. On the 170 foot level a crosscut was driven for 210 feet NW in hard limestone and a horizontal borehole was drilled a further 266 feet in limestone and slate but no veins were found. Much water and slurry was encountered in an eastern crosscut on the same level. A borehole at the end of the crosscut passed through soft slate and the lode channel was reported to have been intersected within hard dolomite, but it is apparently barren. A shaft was sunk on the outcrop of the orebody, designed to connect with the 100 foot level in the main shaft. However, in depth lode material was replaced by soft slurry with some fragments of ore and the project appears to have been abandoned.

Montana Hill Workings

Records are sketchy, but the old shaft is presumably that later worked on a small scale to a depth of 85 feet as the Montana No. 3. The adit driven SW by the old Silver Crown Prospecting Association below the lode exposed in the shaft was extended WNW to a total length of 1033 feet by the Tasmanian Crown company. Three orebodies were found, the first of which had been worked by the original owners. The second lode strikes NNE and was reported by Montgomery (1895) to consist of barren siliceous gossan which had been driven on for 50 feet on each side of the adit. The adit was connected to the old adit from the west side of the hill by a drive along the third lode on which some stoping was done (Montgomery, 1896). This orebody may be the faulted continuation of a lode stoped out by a tribute party over a length of 130 feet to a depth of 100 feet in the NW corner of Section 736-87M.

TABLE 23—Production—Tasmanian Crown Mine

	Concentrates (Tons)	Silver Content (Ozs)	Lead Content (Tons)	Remarks
To 1893	12	1,200	8.5	
1898	106	10,600	74.2	
1934	21	2,103	13.8	
1935	13.20	1,305.5	9.41	
1936	2	150.8	1.33	
1938	4.06	225.4	2.2	
1956 c.	9	152.9	3.9	From dumps
	<u>167.26</u>	<u>15,737.6</u>	<u>113.34</u>	

CONCLUSIONS

The orebodies in the former Tasmanian Crown leases are mainly low grade and have been prospected thoroughly. While small quantities of argentiferous galena might be found near surface within the area, drainage problems and the disturbed nature of the host rocks do not encourage further exploration in depth.

Florence Mine

The old Florence main shaft lies on the lower NW slope of the Florence ridge, half a mile SW of Zeehan post office. Flaherty's shaft is near the top of the ridge, about 110 yards east of the main shaft and Currie's shaft is 55 yards NE of the main shaft.

The property formerly consisted of Section 943M of 40 acres and 546M of 80 acres. Lease 943M was first pegged by J. Smith in 1884 and was known as "Smith's section" before the formation of the Silver Smith Mining Co. about 1900. The lodes were worked chiefly by parties of tributors until the Florence Silver Mining Co. N.L. was floated in 1902. Lease 546M was taken up by the company in 1903.

The main shaft was sunk to a depth of 216 feet and levels were opened up at 128 feet and 200 feet. In 1908, it was planned to sink the shaft to 400 feet but a heavy inflow of water in a crosscut on the lower level flooded the mine. New pumps were installed in 1909 but mining was interrupted and the property was taken on tribute by the Tasmanian Smelting Company. About 60,000 gallons of water per hour had to be pumped out of the workings and production ceased at the end of 1910. A few tons of ore and gossan were extracted near surface in 1913 and 1925.

GENERAL GEOLOGY

The main shaft and western workings are within highly weathered greywacke, greenish siltstone and green, purple and grey slates forming part of the Cambrian Crimson Creek Formation. East of the main shaft the Cambrian rocks are faulted against disturbed pale grey sandstone, pebbly grits and shale assigned to the Crotty Quartzite (Silurian) which outcrop at the northern end of the Florence ridge.

Devonian faulting and zones of fissuring partly controlled the pattern of mineralization, but there is good evidence of post-mineralization faulting which dislocated the orebodies. Waller (1904, pp. 34-35) described a "lode-formation" which had been cut in the east crosscut from Flaherty's shaft. He described it as a loose open formation striking NNE, and when it was intersected, there was "a burst of water, carrying with it quantities of slurry, broken slate, carbonate of iron and slugs of galena". Again, Waller reported that while driving on the course of Currie's lode, a man was drowned by a sudden inflow of water from a "large vugh, described as being 30 feet wide, 40 feet high and of unknown length. The rush of water carried with it an enormous quantity of slurry, angular blocks and fragments of slate, carbonate of iron and galena". The open fissures were attributed by Waller to the leaching away of sideritic gangue in an orebody ("Flaherty's lode") but the writer would suggest that they may be fault fissures of Tertiary or Jurassic age and that the fragments of country rock, siderite and galena represent a post-mineralization fault-breccia.

OREBODIES

The orebodies are fissure veins of galena within a gangue of siderite which strike between NW and NNE, and vary from a few inches to about 8 feet in thickness. Galena occurs in irregular shoots and patches, and Waller (1904, p. 68) recorded that up to about 8 feet of solid ore was discovered near the junction of Currie's lode and "Flaherty's lode".

MAIN WORKINGS

Currie's Shaft

Waller (1904) stated that N. Currie and party had worked Currie's lode before the formation of the Florence company. The workings are about 400 feet long and 150 feet deep and the whole of the orebody was stoped out above the bottom level. The lode appears to swing round to the SW in the south where it was reported by Waller to join "Flaherty's lode", but the latter may be a post-mineralization fault plane.

Horton's Workings

According to Waller (1904), the workings are a short distance west of Currie's, and were thought to be partly in "Flaherty's lode" and partly in Astle's lode which was later worked from the Florence main shaft. The workings are very irregular but yielded a large quantity of ore.

Main Shaft Workings

The shaft was sunk to a depth of 215 feet and levels were opened up at 128 feet (No. 1 level) and 200 feet (No. 2 level).

No. 1 (128 foot) level. The crosscut from the shaft was continued as a drive on Astle's lode and then again as a crosscut to intersect Currie's lode which proved to be poor. Currie's lode was driven on for 140 feet north of the crosscut. The first 50 feet was on a thin siderite vein in the footwall, and Currie's main lode was discovered in a short crosscut from the drive. The main lode was driven on for 90 feet at which point a rise was put through to the old Currie's workings. Waller (1904) reported 1 foot 6 inches of milling ore in the level, and another lode up to 4 feet wide found 50 feet up in the rise was stated to consist of good ore.

South of the crosscut from the shaft, another workable orebody was intersected and driven for 464 feet south.

No. 2 (200 foot) level. Astle's lode was intersected 50 feet from the shaft. The orebody strikes NW with a NE dip, ranging up to about 2 feet in thickness. Waller (1904) stated that it had been stoped out above No. 2 level over a length of 200 feet and to a height of 35 feet, and at that date had yielded the greater part of the Florence mine's output of ore.

A crosscut was later driven westwards about 280 feet to intersect McKay's lode which had been worked from the surface in a shaft 85 feet deep by a tribute party. The lode was driven on north and south and workable ore was stoped out. The line of Flaherty's lode was cut in a crosscut about 300 feet east of the shaft, and a rise was put through to Flaherty's workings 90 feet above.

In 1908 the mine was flooded from a drive on No. 2 level and the lower levels were abandoned.

Flaherty's Shaft.

Little information is available on Flaherty's workings. It is clear from the description by Waller (1904, p. 68) that the ground in the east crosscut from the shaft is highly disturbed and that "Flaherty's lode" at this point may be a fault-zone in shattered country rock and vein material.

PRODUCTION

The Florence mine has yielded about 15,800 tons of concentrates with an estimated content of 10,200 tons of lead and 1,400,000 ounces of silver.

CONCLUSIONS

Galena occurs as irregular bands and masses within sideritic lodes striking between NW and NNE. Exploitation of the orebodies was hampered by the heavy inflow of water due partly to the disturbed nature of the country rocks, but profitable ore appears to have been worked out to a depth of 200 feet in the main shaft workings. Available evidence indicates that the lodes have been dislocated by extensive Tertiary faulting. There is little hope of the mine re-opening.

Mount Zeehan (Tasmania) Silver-Lead Mines

This mine should not be confused with the Mount Zeehan Mine (see p. 154).

Between 1890 and 1923 Mount Zeehan (Tasmania) Silver-Lead Mines Ltd. held a total of 584 acres round the Argent Flat and Manganes Hill, embracing leases formerly worked by the *Argent*, *Silver Queen*, *Silver Queen Extended*, *Balstrup*, *Spray* and *Brittania* companies. The Argent and the Spray mines contributed a large part of the company's production until about 1912 when much of the property was let to tribute parties.

ARGENT MINES

Sections 192-87M of 40 acres, held as lease 561M by W. S. Monks between 1882 and 1886, and 193-87M (20 acres) were taken up by W. E. Brooks in 1887 and transferred to the Argent Silver Mining Co. N.L. in 1888, but there was little serious development until after 1890 when the leases passed to Mount Zeehan (Tasmania) Silver-Lead Mines Ltd. In the next few years, a number of orebodies were exploited in adits and shallow shaft workings on lease 192-87M by the company and also by parties of tributors, but after about 1904, when much of the richest ore near surface had been worked out, attention was switched to the lucrative Spray orebodies. The Argent sections were included in Consolidated Lease 3728M of 584 acres which was eventually surrendered by the Mount Zeehan (Tasmania) company after liquidation in 1923.

In 1914, a tribute of 132 acres covering the old sections 1643M, 192-87M, 193-87M and part of 1209M was let to the government and the *State Argent Flat* mine was opened up from the No. 5 Argent shaft. The shaft was deepened from 150 feet to 300 feet, at which level Flaherty's lode and Fulton's lode were driven on, and long crosscuts were put out east and west. The orebodies range from 2 feet to 4 feet in width but there was insufficient ore to be payable and after workable galena elsewhere in the workings had been extracted the mine closed in May, 1917.

NO. 2 ARGENT MINE

The workings are on the former lease 189-87M of 80 acres transferred by E. Clark in 1887 to the Silver Queen Extended Prospecting Association N.L., and taken over by the Mount Zeehan

(Tasmania) company in 1890. A number of lodes were worked by tributors and later by the company from No. 2 shaft which was abandoned towards the end of 1908. About 1917, the No. 2 Argent Prospecting Syndicate N.L. was granted a tribute of 120 acres over the old section 189-87M and also lease 1665M of 40 acres which had originally been held by the Silver Queen Prospecting Association. Production was at first from small but rich shoots in the upper levels, but in 1922 more powerful pumps were installed and the shaft was drained. Difficulties were encountered and the mine was let on tribute to employees of the syndicate later the same year. In 1923, the pump broke down and production was confined to tributes above water level. Since that date, various parties and individuals have extracted small quantities of galena concentrates, and the last leases to be held over the ground were section 12M-46 (30 acres) charted in the name of K. L. Everett between 1946 and 1961, and lease 11708M of 50 acres which has been held by W. F. Thomas since 1936.

NO. 6 ARGENT MINE

No. 6 shaft was sunk about 1904 to 127 feet by the Mount Zeehan company in the SE corner of lease 192-87M. Several lodes were driven on and stoped at the 122 foot level until an accident to the pumping gear flooded the mine and the company abandoned the workings. In 1918, a tribute area was granted to the No. 6 Argent Prospecting Syndicate N.L. whose activities were chiefly confined to No. 3 (Astle's) lode. The syndicate's funds were exhausted by the cost of installing powerful pumps to control the inflow of water. The 160 foot level was opened up by a winze from the 122 foot level and although promising ore-shoots were cut, the mine was forced to close in 1921 because of lack of capital and low metal prices.

Vaudeau and Levings (1921) recommended further sinking and development, but emphasized that any company re-opening the mine should be backed by adequate capital. In 1922 the No. 6 Argent Mining Co. N.L. was formed and east of the Main shaft an auxiliary shaft was sunk to the 122 foot level and a winze connection was completed through to the 160 foot level. Owing to financial difficulties the company stopped work in October 1923, and offered tributes to its employees. Tributors carried on for a few months until payable ore was worked out and the mine was closed. Between 1937 and 1939, the area was included in leases 11982M (38 acres) and 11983M (39 acres) held by M. R. Menzie.

GENERAL GEOLOGY

The Argent mine lies on Argent Flat north of Manganese Hill and most of the workings are within faulted and sheared Cambrian greywacke, mudstone and shale. The Cambrian rocks are faulted against Devonian Florence Quartzite east of the No. 6 shaft, and against Proterozoic quartzite and slate forming Queen Hill north of the No. 2 shaft and west of the No. 4 shaft. The ground between the No. 1 and No. 5 shaft is now part of Zeehan golf course.

The orebodies are fissure veins of siderite and quartz with bands and irregular masses or lenses of galena, sphalerite and pyrite. The lodes trend between NW and NE, and the most important set strikes approximately NNW. Published assays of the galena ore gave returns ranging from 65% to 78% lead and 86 to 190 ounces of silver per ton.

MAIN WORKINGS

No. 5 Argent Shaft (State Argent Flat)

The shaft was originally sunk to work No. 1 lode (No. 16 lode of Waller, 1904) which had been cut 50 feet below the surface in

an adit driven westwards from a point near No. 3 shaft. In the adit the lode is oxidized and contained little mineralization in a drive 80 feet long, but galena assaying 78% lead and 190 ounces of silver per ton was uncovered in a winze. No. 5 shaft was later sunk to a total depth of 317 feet and levels were opened up at 150 feet and 300 feet.

150 foot level. In 1909, No. 1 lode was driven on SSE for 316 feet but only about 70 feet of low grade ore was found. A west crosscut intersected No. 2 (Flaherty's) lode at 284 feet and a shoot of payable ore 140 feet long was discovered. The south drive was eventually extended for about 280 feet on 6 feet of siderite with traces of chalcopyrite. The north drive on No. 2 lode was driven at least 1027 feet and a connection was made with the No. 1 shaft workings. At 212 feet along the drive, a NW crosscut was put in for 93 feet to cut Fulton's lode which was driven on north and south for a total of 233 feet. A crosscut at 560 feet was driven for 102 feet NW without meeting Fulton's lode. At 669 feet, a NE crosscut 126 feet long intersected the NNW striking No. 3 lode which was followed for only 85 feet.

The western crosscut was extended a further 497 feet west of Flaherty's lode, apparently without finding orebodies. East of No. 5 shaft, the eastern crosscut is 817 feet long, and No. 3 lode was cut at 584 feet, below the old No. 3 shaft. At 743 feet, No. 4 lode was intersected, being driven on for 61 feet NNW and about 160 feet SSE.

Mineralization appears to be poor on the 150 foot level, except for the north part of No. 3 lode.

300 foot level. Flaherty's lode was intersected at 362 feet in the NW crosscut from No. 5 shaft. The orebody was driven on northwards for 447 feet, and though it consists of 2 feet to 5 feet of pyrite, quartz and siderite, galena is impersistent and of low grade. The crosscut was extended 130 feet NW as far as Fulton's lode which is apparently not payable.

The eastern crosscut is 747 feet long. No. 1 lode was cut at 136 feet and is reputed to have contained ore assaying between 250 ounces and 300 ounces of silver per ton. The lode was driven on southwards for 51 feet where it is faulted off. No. 3 lode was intersected at 492 feet, and though 4 feet wide, it is very poor. At 740 feet, No. 4 lode was cut and driven on for 23 feet north and 72 feet south. Thin bands and nodules of galena were found in the drive and in a rise 53 feet high. The lode is about 4 feet wide, but apparently low grade.

TABLE 24—Production—No. 5 Argent

	<i>Ore (Tons)</i>		<i>Lead Content (Tons)</i>	<i>Silver Content (Ozs)</i>
1915	458.15	} Est.	1100	170,000
1916	812.08			
1917	618.64			
	<u>1888.87</u>		<u>1100</u>	<u>170,000</u>

Note: Figures for Mount Zeehan (Tasmania) Ltd. from 1908-1909 may include some production from No. 5 Argent.

No. 2 Argent Shaft

The extensive workings were described at length by Waller (1904, pp. 74-77). Three groups of orebodies had been worked in adits NE, SE and SW of the shaft which was sunk to explore and work the orebodies in depth. Levels were opened up at 65 feet (No. 1) and at 170 feet (No. 2). The workings are complex and irregular, partly owing to the faulting of the lodes which are frequently poorly defined and variable in quality. In the NE part of the workings, the two most important lodes were No. 10 and No. 15, which were stoped out prior to 1904. To the SW No. 30, No. 13, No. 29 and No. 11 lodes were the most productive though dislocated by faulting. A winze sunk in 1922 for 25 feet on No. 11 lode at the 170 foot level revealed a vein of galena with good values but the flooding of the lower levels of the mine in 1923 prevented further development here. The SE group includes No. 12 and No. 14 lodes which were productive only in the upper levels.

Adit workings, trenches and shallow shafts north of the No. 2 Argent workings on leases 11708-M (W. F. Thomas) have been described by Keid (1943b) and Taylor and Burger (1951a). A number of thin veins of galena occur within faulted and fissured slate and quartzite, but they are of limited economic value and are dislocated by post-mineralization faults trending a few degrees north of west.

TABLE 25—Production—No. 2 Argent

	Ore (Tons)	Lead Content (Tons)	Silver Content (Ozs)	Remarks	
1899	12	} Est. 1,200	140,000		
1902	78				
1903	81				
1904	24				
1905	65				Ore & flux
1906	202				
1907	260				
1908	535				
1909	51				
1910	42				
1912	238				
1913	229				
1914	200				
1920	} Est. 900			96.44	17,763	Tributors
1921		32.02	4,110		
1922		250.75	26,892		
1923		138.49	14,530		
1924		16.96	1,712	Stock of 2nd class ore	
1925		15.55	2,340	Tributors	
	<u>2,917</u>	<u>1,750.21</u>	<u>207,347</u>		

Note.—To 1898, production may be included in figures for Mount Zeehan (Tasmania).

No. 6 Argent Shaft

The main shaft was sunk to 127 feet, and at 122 feet a cross-cut (No. 3 level) was driven east for 292 feet. At 18 feet, a north crosscut intersected No. 1 lode which was driven on for at least 360 feet NNW, and also Lambert's lode on which a drive about 100 feet long was put in. Lambert's lode was also intersected 150 feet from the shaft in the east crosscut, but there is no record of values. At 190 feet, Inglis's (No. 2) lode was cut but it proved unproductive in short drives NNE and SSW. Astle's (No. 3) lode was found at about 250 feet, being driven on for 300 feet NNE and about 90 feet south. According to Waller (1904, p. 72) the orebody proved to be poor and the crosscut was therefore extended further east. At 292 feet east of the main shaft, a shattered lode (No. 4) was intersected which contained good galena ore in drives north and south. At this point the Cambrian greywacke and shale are faulted against Devonian Florence Quartzite, and as Waller described the lode as a loose, open formation, there is a possibility that it has been affected by post-mineralization faults striking NNE in a similar direction to the orebody.

Workable ore was found in south drives on both No. 3 and No. 4 lodes, and as ore reserves became depleted a lower level was essential. To avoid the expense of deepening the main shaft and putting in long crosscuts, an adit (No. 2 level) was driven from the surface near the shaft east for 240 feet at which point an auxiliary shaft was sunk to the 122 foot (No. 3) level, below which a winze was cut through to the 160 foot (No. 4) level. No. 3 lode was driven on for 136 feet north and 165 feet south, and though it ranges up to about 6 feet thick, ore is patchy and low grade. A short crosscut was put through from the south drive east to No. 4 lode which was driven on for 80 feet north and 53 feet south. The lode was reported to range up to 5 feet in width with bands of galena up to 2 feet wide, but was generally unpayable. When the No. 6 Argent company ceased work in 1923, tributors operated for a few months on No. 4 lode at No. 4 level and on No. 3 lode between No. 3 and No. 4 levels in the northern workings.

TABLE 26—Production—No. 6 Argent

	Ore (Tons)	Lead Content (Tons)	Silver Content (Ozs)
1920	} Est. 2,300	491.7	70,385
1921		237.3	35,010
1922		76.1	14,961
1923		585.8	62,671
1924		5.3	635
1925		1.7	101
	2,300	1,397.9	183,763

Note: Figures for Mount Zeehan (Tasmania) prior to 1912 may include production from No. 6 Argent.

No. 1 *Argent Shaft*

Levels were opened up at 72 feet, 132 feet and 190 feet by the Mount Zeehan (Tasmania) company and two lodes—No. 4 and No. 6—were worked before about 1895. The orebodies strike NNE with steep easterly dips and, though well-defined, they proved to consist of barren or poorly mineralized siderite formations containing shoots of galena ore interbanded with pyrite, sphalerite and siderite (Montgomery, 1895). Waller (1904, p. 73) commented that No. 4 lode contained a rich shoot of ore 75 feet long which was workable only down to No. 2 (132 foot) level. No. 6 lode was stoped down to No. 2 level and workable ore was reported to have been left. The workings were drained to a depth of 150 feet when the north drive on No. 2 lode at the 150 foot level in No. 5 shaft was connected to the No. 1 shaft workings, but no further work appears to have been carried out in the latter.

Production from No. 1 shaft is unknown as it was included in the returns for Mount Zeehan (Tasmania).

BALSTRUP'S MINE

The portal of the main adit lies on the lower NW slope of Manganese Hill. Lease 1209M of 80 acres was pegged by P. M. Balstrup in 1885. The wide outcrop of manganiferous gossan on Manganese Hill was compared by Thureau (1888b) with similar outcrops at Broken Hill, N.S.W. and it was confidently expected that in depth below the zone of oxidation the gossan would pass down into a rich orebody. Balstrup's Manganese Hill Silver Mining Co. N.L. was formed in 1890 and a long adit was driven for 940 feet SE. The orebody was intersected in a crosscut and driven on for about 280 feet, but was still almost completely oxidized. Another adit was cut for over 1000 feet from the NE side of the hill with disappointing results. The company went into liquidation and in 1892 the lease was bought by Mount Zeehan (Tasmania) Silver-Lead Mines Ltd., though exploration was confined chiefly to that part of the lease north of Manganese Hill (No. 5 *Argent shaft*). In 1924, the gossan outcrop attracted attention as a possible source of iron ore and leases 9262-9267M totalling 35 acres were taken up by the Hoskins Iron and Steel Co. Ltd. which at that time was exploring the Tenth Legion iron ore deposits. There is no record of any activity by this company, nor by Australian Iron and Steel Ltd. to whom the leases were transferred in 1929. The sections became void in 1937 and were taken up in the same year by J. D. Paterson as leases 11867-11872M. Tasmanian Iron Ltd. was formed in 1938 but the leases were relinquished once more in 1941.

GEOLOGY

Manganese Hill is a prominent landmark rising to an altitude of 1050 feet south of the Austral Flat. The country rocks are fissured and sheared purple, red and green greywacke, siltstone and mudstone or shale assigned to the Cambrian Crimson Creek Formation. The beds are intensely weathered and tend to decompose into stiff yellowish-brown clay littered with fragments of manganiferous limonite gossan.

The massive gossan outcrop trending SE across the hill consists of limonite and some pyrolusite with up to 10 ounces of silver per ton and is probably partly derived from the oxidation of manganiferous siderite and pyrite. The Cambrian sediments contain substantial amounts of iron which oxidizes to limonite and other

iron oxides so that ironstone outcrops may be in part due to local concentration and consolidation of this material. Waller (1904, p. 78) thought that surface outcrops sometimes resemble bog iron ore deposits which may cut out on a flat floor 30 or 40 feet below the surface. The line of gossan has been regarded as the capping to Balstrup's lode, which strikes NW and dips steeply to the NE. The lode was found by the original leaseholder in a trench a few yards from the Silver Queen Extended boundary. It was 2 feet wide and contained *embolite* (Ag (Cl, B)), bulk samples of which were said to assay up to 598 ounces of silver per ton (Tilley, 1891).

WORKINGS

North Western Adit

The adit was driven for a total of 940 feet SE from the lower slope of Manganese Hill, near the boundary of former Silver Queen Extended lease 189-87M. At 340 feet, No. 1 crosscut was put in north-eastwards, and an orebody was intersected 18 feet from the adit. The orebody is 6 feet wide, consisting of siderite and galena and a winze was sunk to 45 feet. There are conflicting reports on the quality of ore in the winze. Tilley (1891, p. 49) stated that canary ore (yellow earthy argentiferous lead oxide) assayed 59% lead and 888 ounces of silver per ton, gossan with native silver contained 27% lead and 830 ounces of silver per ton, galena assayed 76% lead and 178 to 198 ounces of silver per ton, while a bulk sample of gossan and galena gave a return of 119 ounces of silver per ton. In contrast, Waller (1904, p. 78) merely commented that "nothing very rich was found but the lode was worked for some distance by a party of tributors".

At the point of intersection, an air shaft was put up 131 feet to the surface. The lode was driven on for a total of 280 feet before the workings were abandoned. It is generally between 6 feet and 8 feet thick, increasing to about 15 feet 245 feet from the crosscut. Though at least 200 feet below surface at the end of the drive, the orebody is apparently extensively oxidized to limonite with pyrolusite and cerussite.

At 780 feet from the portal of the adit, No. 2 crosscut was driven NE for 393 feet, probably without intersecting ore.

North-Eastern Adit

Little is known about this adit crosscut. The portal is on the lower slope of the hill near the branch track leading from the Argent Flat to the Spray mine and the old Comstock tram. Waller (1904, p. 78) commented briefly that it is over 1000 feet long, and though several gossan formations were cut, none were driven on.

PRODUCTION

No production has been recorded from the workings of Manganese Hill.

SPRAY MINE

Lease 195-87M of 80 acres claimed in 1887 by E. Firman, and lease 196-87M (80 acres) taken up in the same year by E. Clark were transferred to E. J. Freeman in 1888. The Silver Spray Silver Mining Co. N.L. was floated in 1889, and Montgomery (1890) remarked that an adit had been driven for 265 feet without much success on an orebody averaging 3 feet in width. The leases were taken over in 1890 by the Mount Zeehan (Tasmania) Silver-Lead

Mines Ltd. whose work for several years was concentrated in other parts of their extensive holdings. Attention was focussed on the Spray section by the discovery about 1900 of antimonial silver-lead ore (jamesonite), some of which assayed over 2000 ounces of silver per ton (Twelvetrees, 1901, p. 22). On section 196-87M, the Spray Main lode was found by tributors Page and McDermott in "C" and "D" adits, and during the next few years, the mine became one of the most important in Zeehan. The main adit ("A" tunnel) was cut 500 feet south of Page and McDermott's workings, and No. 2 (Adit) shaft was sunk to a depth of 450 feet below the adit. Between 1905 and 1908, No. 1 shaft was sunk to about 390 feet and No. 1 lode was developed at No. 2 (380 foot) level, at the same depth as No. 5 level in the Main shaft. However, the shaft was closed in 1909 because of flooding and work stopped in No. 2 shaft owing to the unprofitable nature of ore in the lower levels.

Nye (1931c) recommended the drilling of a borehole from a point near the entrance to "A" adit, declined at about 45° to the SW and designed to intersect the Main lode 250 feet below No. 6 level (700 feet below the adit level). The hole was completed in 1932 and the orebody was intersected at the calculated depth after a drilled distance of 930 feet, but it consisted only of siderite and pyrite with traces of jamesonite.

Between 1936 and 1939, G. Heywood held lease 11676M of 10 acres south of the main shaft and a considerable amount of shallow exploration on gossan formations was carried out by the leaseholder and J. Cornish. Samples were found which assayed as much as 500 ounces of silver per ton but the average grade was too low to be workable. In 1949, the old Spray workings were pumped out by Zeehan Explorations, and a geological investigation was made, supported by sampling. A borehole declined at 69° was drilled to test the Main lode below No. 6 level but it was abandoned after a drilled length of 234 feet. Mineralization consisted merely of numerous stringers of siderite or quartz with a little pyrite and jamesonite.

GEOLOGY

The orebodies are well-defined fissure lodes striking NNW and dipping steeply within fractured Oonah Quartzite and Slate. To the north, Austral Creek flows SE near the boundary with Cambrian greywacke, dolomitic siltstone and shale believed to be part of the Crimson Creek Formation. In the Austral Valley, east of the workings, poorly exposed Cambrian beds appear to overlie the Proterozoic quartzite and slate with no evidence of an angular unconformity, while to the north and NW the formations are brought into contact by the Balstrup Fault. Waller (1904, p. 79) stated that although the lodes were productive only within the quartzite, the Main lode continues north through the plane of contact into the Cambrian rocks, but the only workings here are shallow and the orebody is completely oxidized.

The most important orebodies are No. 1 (Main) lode, and No. 3 (Gurnie's) lode 584 feet to the SW. Ore-shoots of galena and jamesonite occur within a gangue of pyrite, siderite and quartz. According to Waller (1904, p. 80) the shoot of ore in the Main lode was up to 16 feet wide, of which about two-thirds was galena, while for a considerable distance from 3 feet to 5 feet of ore was

present. In the quarter ending December 31st, 1900, 652 tons of concentrates were produced by the Mount Zeehan (Tasmania) company, of which a large proportion came from the Spray mine. The concentrates yielded 443 tons of lead and 65,232 ounces of silver, representing a recovery of 67.9% lead and a little over 100 ounces of silver per ton. In the first quarter of 1901, 1047 tons contained 656 tons of lead (62.7%) and 107,104 ounces of silver (102.3 ounces per ton).

WORKINGS

The following account is condensed from lengthy descriptions by Waller (1904) and Twelvetees and Ward (1910), supported by the company's mine plans.

Page and McDermott's Workings

The portal to "E" adit lies immediately east of the old tram, about 300 yards south of the tunnel under the Comstock tram. The Main lode was cut and driven on for 400 feet south. "C" adit is 75 feet higher on the lower slopes of Spray Hill. The Main lode was driven on for 390 feet south and a rich shoot of ore was stoped out between 150 feet and 390 feet.

Main Workings

"A" adit crosscut was driven a total of 1100 feet SW from a point 500 feet south of "E" adit, on the northern bank of a small tributary of Austral Creek. The Main lode was cut at about 500 feet, where it was described by Waller (1904) as one of the richest ore-shoots in the Zeehan district. In the adit level, the ore-shoot was nearly 400 feet long of which about 200 feet was rich. No. 2 (Adit) shaft was sunk to 450 feet, and 5 lower levels were opened up. "A" adit was extended SW beyond the Main lode for a total length of about 1100 feet. No. 3 (Gurnie's) lode was intersected 584 feet from the Main lode and was payable for several hundred feet northwards. In the south drive, the orebody probably splits and becomes unworkable. Gossan in the outcrop of the vein at the top of Spray Hill was rich in silver chloride and native silver, and was originally worked in Gurnie's adit.

Below the adit level, levels were put in at 50 feet (No. 1); 130 feet (No. 2); 213 feet (No. 3); 269 feet (No. 4); 370 feet (No. 5); 450 feet (No. 6). The account by Twelvetees and Ward (1910, p. 110) is therefore incorrect. Between No. 5 and No. 6 levels, ore became low-grade and unworkable though small patches of rich ore were picked out. Above No. 5 level, there appear to have been two main irregular lenses or shoots of ore which have been worked out, separated by relatively barren lode material. Little is known about No. 3 lode in depth.

No. 1 Shaft Workings.—No. 1 (Main) lode was driven on for about 60 feet on No. 2 (380 foot) level which is at the same depth as No. 5 level in the Main shaft. There is no record of values encountered before the shaft closed because of a considerable influx of water.

PRODUCTION

Total production is not known, but a large proportion of the ore produced by the Mount Zeehan (Tasmania) company between 1900 and 1909 came from the Spray mine. Between 1933 and 1934, concentrates containing about 28 tons of lead and 3000 ounces of silver were extracted by prospectors.

BRITANNIA MINE

The old shaft and adits lie 250 to 300 yards south of the Comstock tram, about $\frac{1}{2}$ mile west of the junction with Grubb's tram and $\frac{1}{4}$ mile east of the Boss mine. The ground was originally covered by lease 994-87M of 80 acres, taken up by E. C. Mace in 1888 and transferred to the Britannia Proprietary Silver Mining Co. N.L. in 1890. Pyritic orebodies striking NNE were explored in trenches, shallow shafts and adits but deeper sinking was prevented by inflow of water. The Mount Zeehan (Tasmania) company took over the lease in 1890 but relinquished it in 1896. The property was pegged once more as section 1512-93M by F. J. Bailey in 1896, passing to A. J. Dolan in 1899, and to the Mount Zeehan (Tasmania) company again in 1900. During this period further shallow exploration was carried out with little result, and in 1913 at least 1300 feet of trenches were cut by the government prospecting party. A pyritic orebody 32 feet wide revealed in trenches near the south boundary of the section was tested in 3 shallow adits and a shaft 10 feet deep, and from 1914 to 1917 tributors extracted up to about 20 tons of payable ore per month from the Britannia section. About 1921 the lower adit was extended by the company to cut an orebody which had been worked by a tribute party at the surface, and though mineralization proved to be erratic, substantial amounts of galena, both hand-picked ore and milling ore, were taken out. After the liquidation of the Mount Zeehan (Tasmania) company in 1923, the lease was let to tributors for a short period, but there was no notable production after 1924. Since 1948, the ground has been part of Consolidated Lease 123-47M of 359 acres held by the Electrolytic Zinc Co. of Australasia Ltd.

The orebodies are contained within faulted and sheared Proterozoic micaceous quartzite, siltstone and slate or phyllite which is faulted against Cambrian greywacke and shale a short distance south of the Comstock tram. The lodes are irregular veins and masses of pyrite and sphalerite with impersistent bands or disseminations of galena. Sphalerite may be locally absent.

Cowan's shaft was sunk 40 feet to No. 2 adit, below which a winze was put through to No. 1 adit, about 80 feet below, but there is no record of quantity or grade of ore below stopes at the 40 foot level.

Production is included in the total shown for the Mount Zeehan (Tasmania) company between 1914 and 1923.

TABLE 27—Production—Mount Zeehan (Tasmania) Silver-Lead Mines Ltd.

	Ore (Tons)	Lead Content (Tons)	Silver Content (Ozs)	Remarks
To 1893	605			
1898	950			
1899	1,686			
1900	2,290			
1901	4,461			
1902	6,020			Some gossan
1903	6,763			
1904	6,752			
1905	7,206			
1906	8,898			
1907	6,685	Est. 41,170	6,400,000	
1908	4,422			
1909	1,647			Includes 162 tons gossan
1910	1,647			Includes 1204 tons flux
1911	1,184			Includes 108 tons pyrite
1912	2,449			Includes 2200 tons flux and tailings
1913	1,567			Includes 1237 tons flux and tailings
1914	458			Mainly tributors
1915	366			
1916	808			
1917	437			
1918	777			
1919		286	28,650	
1920		34	8,489	
1921	Est. 880	38	4,130	
1922		118	9,912	
1923		54	5,493	
	68,958	41,700	6,456,674	

Notes:—

1. Between 1898 and 1901, parcels totalling 2326 tons of ore yielded 1524 tons of lead and 228,537 ounces of silver; i.e., 65% lead and 95 ounces of silver per ton.

2. Figures include production from Argent, Silver Queen Extended, Balstrup, Spray and Britannia mines (q.v.).

3. Ore includes 63,329 tons of galena ore; 108 tons of pyrite, 4641 tons of flux and tailings; and 162 tons of gossan.

TABLE 28—Total Production—Mount Zeehan (Tasmania) Group of Mines

	Ore (Tons)	Lead (Tons)	Silver (Ozs)
No. 5 Argent (State Argent Flat)	1,889	1,100	170,000
No. 2 Argent	2,917	1,750	207,347
No. 6 Argent	2,300	1,398	183,763
Spray, Britannia (see Mount Zeehan (Tasmania))	.....	.....	.....
Mount Zeehan (Tasmania)	68,958	41,700	6,456,674
	76,064	45,948	7,017,784

Notes:—

1. Much of production shown as Mount Zeehan (Tasmania) came from the Spray mine.
2. Production from Britannia mine probably did not exceed about 400 tons of ore.

CONCLUSIONS

Mount Zeehan (Tasmania) Silver-Lead Mines Ltd. appears to have been one of the most efficient companies to work the Zeehan field in that active development and exploration kept well in advance of current mining. Thus, when the richest parts of the Argent lodes had been worked out, the company was able to put the Spray mine into production. Flooding in the Spray shafts in 1909 would have entailed the installation of a more expensive pumping equipment, but at the same time the orebodies became poorer and uneconomic in depth. The Britannia mine was then opened up but orebodies are small and of low grade overall so that the company was finally forced to close down.

Most of the area has already been prospected exhaustively with discouraging results and drilling at the Spray mine has shown that there are only traces of mineralization in depth below the Main lode. However, the puzzling gossan formations on Manganese Hill invite further testing in depth by drilling.

RECOMMENDATIONS

A borehole should be sited on the NE slope of Manganese Hill, about 150 yards west of the track leading to the Spray mine, and SW of the portal of the North-eastern adit. A hole declined at 45° SW should reach the line of the Balstrup lode after 400-500 feet about 150-200 feet vertically below the North-eastern adit, or 400-500 feet below surface.

Silver Queen Extended (Nike) Mine

The Silver Queen Extended Prospecting Association N.L. was formed in late 1887 to work leases 187-87M of 76 acres originally taken up earlier in the same year by E. Mace, lease 188-87M of 80 acres (T. Lee) and lease 189-87M of 80 acres (E. Clark). Development was at first mainly confined to section 189-87M which was transferred in 1890 to the Mount Zeehan (Tasmania) Silver-Lead Mines Ltd., and was eventually worked as the No. 2 Argent mine (see pp. 162, 165).

The Silver Queen Extended company ceased work about 1892 and the two remaining leases were let to tribute parties who worked numerous veins of galena in adits and shallow shafts to depths of about 40 feet. During the government prospecting programme in 1913 a total of 2231 feet of trenches was cut in the area.

In 1914 the leases were taken up by the Nike Mining Co. N.L. and were combined as Consolidated Lease 7456M of 157 acres from 1916. The main lode was intersected in Quigley's adit, from which a rise was cut through to the surface to be used as a main shaft. The mine was developed to No. 4 (280 foot) level before being abandoned in 1925. Lease 7456M was surrendered in 1927, and although a 20 acre block was held by the company from 1929, first as lease 10269M and subsequently as lease 10481M, there is no record of exploration or production, and the ground was finally relinquished in 1942.

During 1947/48, two boreholes were drilled by Zeehan Explorations as part of their prospecting programme. The first hole was a short distance SE of the entrance to Quigley's adit and was declined at 45° to the NE. The hole hit metal in the old workings at 281 feet owing to deflection to an angle of 41°, so a second borehole was drilled at the same site in a similar direction, reaching a measured length of 612 feet at an angle of 50°. No mineralization was found, except for occasional stringers of quartz, siderite, pyrite, galena and sphalerite within grey quartzite, shale and phyllitic slate.

The old Nike workings were included in Consolidated Lease 77M-48 of 2926 acres taken up in 1948 by H. Allport, W. E. Cox and H. Dobson. The lease was transferred to C. L. Hills in 1950 and then to Zeehan Mines Pty. Ltd. but was finally surrendered in 1954.

GEOLOGY

The main workings lie within shattered and fissured pale grey quartzite, dark grey siltstone and black slate or shale regarded as part of the Proterozoic Oonah Quartzite and Slate. The valley of a small SE flowing creek south of the workings marks the faulted contact with deeply weathered Cambrian greywacke, red and green siltstone and mudstone.

OREBODIES

The orebodies are steeply dipping irregular fissure veins of galena and sphalerite in a gangue of siderite and quartz, trending between NW and NE. The outcrops were usually marked by argentiferous gossan which was followed down in shallow workings. Little is known of the nature of the lodes in the old workings.

WORKINGS

Nike Mine (Details from company plans)

The main shaft is on the southern slopes of Queen Hill, about 1½ miles SW of Zeehan post office, and a short distance NW of the old Silver Queen Extended shaft. The mine was worked on the Adit (76 foot), Intermediate (115 foot), No. 2 (160 foot), No. 3 (230 foot) and No. 4 (280 foot) levels. The main shaft ended as a sump a few feet below No. 3 level, and No. 4 level was opened up by a winze sunk from this level. The Adit level was driven approximately 600 feet NNW on the course of the Main lode, presumably No. 1 lode of Waller (1904, map). The Intermediate level is a short drive 42 feet long connected by a vertical rise to the Adit level, and by a winze to No. 2 level. No. 2 level drive is about 240 feet long, north and south of the shaft. About 30 feet north of the shaft, a crosscut was driven 110 feet NE and a lode formation was apparently intersected as a drive about 560 feet long was cut. No. 3 level was driven a total of 280 feet north and south,

and a NE crosscut extends at least 80 feet from a point 40 feet north of the shaft. About 300 feet south of the shaft, a winze 50 feet deep was sunk from which No. 4 level was driven at least 60 feet south. The orebody was stoped over a length of about 80 feet on the Adit and Intermediate levels, and about 180 feet between No. 2 and No. 3 levels, but for only 40 feet above No. 4 level, so mineralization was probably in the form of an ore shoot plunging steeply south and petering out in depth.

Featherstone's Workings

These are approximately 200 yards NW of the Nike mine. According to Waller (1904), the workings were then inaccessible, but a lode striking NNW had been exploited some years previously by the Featherstone brothers. A number of orebodies in the vicinity have been explored at different periods in adit drives and crosscuts, but were apparently small and irregular. The "pug lode" mentioned by Waller (1904) may be a NW striking post-mineralization fault.

Fahey's Workings

Fahey's lode crosses Queen Creek about 550 yards NNE of Featherstone's workings, and it was worked about 1896 by the Fahey brothers (Waller, 1904). Large quantities of argentiferous galena were extracted from the upper levels; in depth, though galena was produced, nothing is known of values. Further west, a number of small veins were also exploited in shallow workings with some success. In this locality, spillite flows are interbedded with dark slate and pale grey quartzite, and the ground is faulted or shattered.

TABLE 29—Production—Nike Mine

	Ore (Tons)	Lead (Tons)	Silver (Ozs)	Zinc (Tons)	Remarks
1896	5				
1897-1914	.....			
1915	157.75	} Est. 580	60,800		
1916	592				
1917	211.06				
1918	368	221	23,338		63.4 ozs of silver per ton; 60% lead
1919		258.4	27,648		
1920		253.5	29,419		
1921		171	18,453		
1922		240.9	22,249		
		31.6	3,464		
1923	Est. 2,017	72.6	7,515		J. Colston's tribute
		20.3	1,997		J. Colston's tribute
1924		136.5	13,881		
1925		77.8	7,980	7.82	(Zinc)
1928		1.5	166		
1954	138 (concs.)	83.8	8,920		Dumps
	<u>3,578.81</u>	<u>2,148.9</u>	<u>225,830</u>	<u>7.82</u>	

Note: Production figures 1897-1914 included in Mount Zeehan (Tasmania) mines.

CONCLUSIONS

The orebodies have proved to be small with irregular oreshoots or masses of galena and the ground is highly faulted. The borehole drilled near Quigley's adit reached a vertical depth of 530 feet (about 250 feet below No. 4 level) but little mineralization was found.

Further exploration is not encouraged.

Colonel North Mines

The Colonel North Mines and Railway Co. N.L. held at different periods leases totalling 540 acres south of the Spray mine and north of the Swansea mine. The chief workings are Grubb's, Colonel North, Victoria-Zeehan, Silver Foam, Silver Wave and Silver Beach.

In 1888, W. Fisher pegged lease 1562-87M of 80 acres and section 1580-87M, also of 80 acres, was taken up by W. C. Grubb. Grubb's Silver Mining Co. N.L. was formed in 1890, a main shaft was sunk and Montgomery (1893b) regarded the mine as one of the best in the Zeehan field. In 1894, the company's ground was extended by the acquisition of lease 1674-87M (60 acres) from the North Grubb's Silver Mining Co. N.L., but the mine closed down about 1896 because of financial difficulties. Leases 1562-87M and 1674-87M were taken over in 1903 by the Colonel North Mines and Railway Co. N.L. which was working orebodies further north.

In 1892, the Queen and Balstrup's Junction Silver Mining Co. N.L. had pegged two 80 acre leases, 1584-91M and 1585-91M, but little development took place until 1894 when the leases passed to the Colonel North Silver Mining Co. N.L.

Section 861-93M of 80 acres was taken over from H. D. Marsh in 1897 and lease 4316-93M of 80 acres was taken up in 1899. The company was re-organized as the Colonel North Mines and Railway Co. N.L. in 1900 and the main shaft was sunk to a depth of 200 feet, but much of the work on the leases appears to have been carried out by tribute parties. The old Grubbs sections were acquired in 1903.

In 1906, the Victoria-Zeehan Silver-Lead Mining Co. N.L. was formed to work sections 1585-91M and 861-93M which were transferred from the Colonel North Company and between 1907 and 1908 a shaft was sunk to 310 feet. Pumps were inadequate to control the inflow of water and the company abandoned the leases in 1910. Meanwhile, the Colonel North company and tribute parties worked the old Grubbs mine down to No. 4 (320 foot) level. In 1909 the two remaining leases 1562-87M and 1674-87M were combined in Consolidated Lease 4056M of 140 acres which was surrendered in 1911.

There has been little activity since. During the government prospecting campaign under H. Conder in 1913, deep trenches totalling 257 feet were cut in gossan and a pyritic formation near the old Victoria-Zeehan mine but nothing of value was found.

GEOLOGY

Fissure veins of galena with sphalerite in a gangue of siderite, pyrite and quartz are emplaced within folded and disturbed shale, slate and pale quartzite or sandstone which are part of the Oonah Quartzite and Slate. The lodes trend chiefly NW or NNW and are reported to be up to about 8 feet thick in the underground workings. The sulphides occur as impersistent bands or masses or are disseminated throughout the gangue. Twelvetrees and Ward (1910,

p. 143) recorded barytes in quartz in a crosscut on No. 4 level in Grubbs main shaft. A small vein of galena and jamesonite was found in the Silver Foam adit (Waller, 1904, p. 85).

Recorded assays of the galena sold ranged from about 20% to 80% lead and from 20 to 120 ounces of silver per ton. The highest values appear to have been found above the 200 foot level in the workings.

WORKINGS

Victoria-Zeehan Shaft

The shaft lies about 300 yards NE of the Colonel North shaft and was sited to allow east crosscuts to intersect the possible southern extension of the Spray No. 1 lode, while west crosscuts were expected to cut the Spray Nos. 2, 3 and 4 lodes. By 1908, the shaft was completed to a depth of 310 feet, or about 275 feet under the Silver Foam adit. At the 300 foot level a crosscut was driven east for 215 feet and at 184 feet from the shaft a lode formation up to 6 feet wide was intersected, consisting of a little galena in a gangue of siderite and quartz. The formation was driven on north for 150 feet and 45 feet from the crosscut a thin vein of galena was found in a rise 30 feet high. Further driving was halted by a sudden inrush of water which flooded the lower part of the mine. More powerful pumping equipment was installed but an attempt to drain the shaft in 1909 was unsuccessful.

Silver Foam Adit

The Silver Foam Tributing Co. held an extended tribute from the Colonel North Co. on lease 1585-91M before the section was taken over by the Victoria-Zeehan company. In 1901-1902 the tributors drove an adit for 600 feet NE from a point near the Colonel North shaft in order to investigate the probable southern extension of the Spray No. 1 lode. It is possible that the lode channel was intersected but records are confusing. According to Waller (1904, p. 85) the lode was cut 300 feet from the portal, while Twelvetrees and Ward (1910, p. 115) stated that the intersection was at 400 feet. The latter figure appears to be more accurate as a brief reference in the Progress of Mineral Industry of Tasmania for the quarter ending 31st March, 1902 noted that the "Spray lode" was cut at 416 feet. The lode was driven on for 80 feet north but only a little pyrite was found. Patches of galena with jamesonite were discovered in a winze sunk over 60 feet, but results in a vertical shaft sunk 100 feet from the adit were disappointing, and only traces of galena were found near the hanging wall of the formation. From the shaft, a crosscut was put in 75 feet eastwards and the lode channel was driven on for the same distance without success. At the 50 foot level, the Victoria-Zeehan company later uncovered a small vein of jamesonite and galena which was followed for 25 feet in a south drive.

Colonel North Shaft

The shaft was sunk by the old Colonel North company to a depth of 200 feet in the northern part of lease 1585-91M, near a small tributary of McLean Creek, about 300 yards NE of Grubbs tram. Twelvetrees and Ward (1910, p. 118) had been informed that from the bottom level, a crosscut was driven NE, by the Colonel North company, being extended later by the Silver Beach tribute party and then the Victoria-Zeehan company to a total length of 450 feet. Two barren lodes of siderite and quartz were cut towards the end of the crosscut.

Silver Beach ("Office") Adit

About 200 feet SE of the Colonel North shaft, the Silver Beach tribute party drove an adit about 600 feet NE, at a level about 150 feet above the bottom of the shaft. Several siliceous gossan formations were intersected within decomposed slate but not mineralization of importance was found.

Chloride Lode

The lode contains bands and nodules of hematite and limonite bearing silver chloride and native silver which were worked about 1900 by tributors in shallow adit workings NE of the Colonel North shaft. Small patches of high grade ore are said to have assayed up to 1000 ounces of silver per ton, but ore in the stopes averaged only about 40 ounces per ton.

Silver Wave Workings

These are located near the SW corner of the former lease 861-93M, a short distance north of the Nubeena workings. At least one orebody striking NNW and dipping east was explored by the Silver Wave Tributating Co. before 1900, and by later tribute parties, in a shaft and several adits. Galena occurs with sphalerite but the veins appear to have been small and rapidly worked out.

Grubb's Shaft

This is sited on the east side of McLean Creek, about half way between the Nubeena and Swansea mines, in the centre of lease 1562-87M. The original company built a tramway 3 miles long to connect the mine with Zeehan. By 1901, the shaft was sunk to 330 feet and according to Waller (1904) levels were opened up at 30 feet (Adit level), 90 feet (Intermediate level), 130 feet (No. 1), 200 feet (No. 2), 250 feet (No. 3) and 320 feet (No. 4). No. 3 level was reported to be at 273 feet by Twelvetrees (1901) and at 270 feet by Twelvetrees and Ward (1910, p. 141).

No. 1 (130 foot) level. In the north drive, the orebody averaged 3 feet in width with high-grade galena for 70 feet, passing north into 50 feet of intermixed galena and sphalerite about 15 inches wide which pinched out northwards.

About 70 feet north of the crosscut from the shaft, a crosscut was put in for at least 300 feet SW through shattered and disturbed quartzite and slate. Grubbs West lode was intersected at 290 feet and was driven on north and south for about 60 feet. Although thin seams of galena and sphalerite were found in the crosscut, they were apparently unworkable.

An east crosscut passed through 54 feet of hard mineralized quartzite.

The main south drive is over 300 feet long along an irregular lode channel from 2 feet to 5 feet wide carrying a succession of small lenses of galena and sphalerite.

No. 2 (200 foot) level. From a short crosscut west from the shaft, a level was driven 200 feet NW and 240 feet SE. In the north drive, the lode formation is up to 8 feet wide, with a 5 inch vein of galena and sphalerite on the hanging wall side (west) and another about 3 inches wide near the footwall. The orebody was stoped out up to No. 1 level and down to No. 3 level.

No. 3 (270 foot?) level. The main lode channel was driven on for 235 feet north but little galena was found and at the end of the drive the formation is barren. Masses of sphalerite were cut in the south drive which extends 330 feet from the short crosscut west from the shaft, but the lode is apparently barren at the end of the drive.

No. 4 (320 foot) level. The north drive is on barren lode material which appears to end against an east striking fault (Waller, 1904, p. 88). A sphalerite vein was intersected in a short west crosscut but it is of little value. The main lode is faulted off at the end of the south drive and is barren, though a shoot of galena ore was worked from No. 3 level to within 10 feet of the drive.

TABLE 30.—Recorded Production—Colonel North Mines

	Ore (Tons)	Silver Content (Ozs)	Lead Content (Tons)
Grubbs and Colonel North			
1890-1893	587	40,465	376
1895 ¹	748	45,000	490
1900-1909 ²	1,044	41,760	668
	2,379	127,225	1,534
Victoria-Zeehan	43	850	15
Total	2,422	128,075	1,549

1. Based on estimate of 65% lead and 60 ounces of silver per ton. Cf. Montgomery (1893b).

2. Metal content based on estimate of 64% lead and 40 ounces of silver per ton. Cf. 110 tons of ore in 1901 which contained 71 tons of lead and 4400 ounces of silver.

CONCLUSIONS

Although the orebodies in the Colonel North leases may be the southern continuation of the mineralized belt worked in the Spray mine, it is difficult if not impossible to correlate them with specific Spray lodes. That there has been post mineralization faulting which has dislocated orebodies is demonstrated in the description by Waller (1904) and Twelvetrees and Ward (1910) of workings which are now inaccessible. Mapping at the surface shows also that the host rocks are frequently shattered and disturbed.

Galena and sphalerite are present in bands and shoots within a sideritic or pyritic gangue. Twelvetrees (1901, p. 23) advanced the opinion that the main shoot in the upper levels of Grubbs mine plunges to the south.

In the lower levels, the proportion of sphalerite to galena apparently increases and while it is possible that bands or lenses of galena might reappear in depth, no evidence can be offered to support further underground work.

Small amounts of galena might be obtained from shallow workings in the mineralized zone north of the Colonel North shaft and south of the Spray mine, but this area has been thoroughly prospected in the past.

Nubeena Mine

The old workings are on Nubeena Hill, about $\frac{3}{4}$ mile SE of the Spray mine and may be reached by a short branch line leading NE from the former Grubbs Tram.

The original lease was section 2230-87M of 80 acres which was taken up by E. Mace in 1889, being transferred to the Nubeena Silver Mining Co. N.L. in 1891, and the New Nubeena Silver Mining Co. N.L. in 1893. At least 3 orebodies were explored and although a few tons of galena ore were produced, there was little underground work and the lease became void in 1895. The property was pegged again several times in the next few years and in 1903 was charted as lease 5115-93M of 79 acres in the name of A. Shillington. The section passed to A. J. Parker in 1906 and was later worked by the Venezia tribute party which produced a considerable proportion of the mine's total output of ore from a number of adits. The lease was relinquished in 1913 and was held by R. F. Clabburn as lease 6241M between 1913 and 1915. In 1928, the Perry brothers produced ore containing 32 tons of lead and 1535 ounces of silver and a small amount was extracted by prospector Higginson in 1936.

GEOLOGY

The host rocks are folded and disturbed shale, slate and pale grey saccharoidal quartzite which are part of the Oonah Quartzite and Slate, of Upper Proterozoic or Lower Cambrian age.

The orebodies are fissure lodes containing irregular veins and aggregates of galena, pyrite and a little tetrahedrite in a gangue of siderite and quartz. The lodes strike generally NNW except the western orebody (old Nubeena lode) which has a NNE trend. Published assays of the galena range from 37.3 to 100 ounces of silver per ton and 56.5% to 70% lead.

WORKINGS

The workings were described at length by Waller (1904) and Twelvetrees and Ward (1910) upon whose work the following summary is based.

Nubeena Lode

The orebody is near the western boundary of the lease. It was worked about 1894 in an old adit drive along a vein of galena 4 to 5 inches thick. In 1910, the Venezia tribute party opened up a drive above the old workings. The galena was said to assay 78% lead and 95 ounces of silver per ton but the deposit was small.

Venezia Main Adit

The adit is a crosscut driven eastwards from a point near the Nubeena lode, and both Jaeger's and Barnet's lodes were intersected.

Jaeger's lode. In the adit about 6 inches of galena ore was cut within an ore channel 4 to 5 feet wide which was driven on for 60 feet north and 70 feet south. A little galena was stoped out but it was irregularly distributed in a gangue of siderite, quartz and pyrite. The ground appears to be shattered and faulted.

No. 1 Lode. A thin vein was intersected 180 feet from the portal and driven on for short distances north and south. Only a little galena was found in the north drive while the south drive is in barren slate.

Barnet's lode. This was intersected 200 feet east of Jaeger's lode. The ore channel consists of 4 to 5 feet of quartz and slate with patches of ore, and bands up to 6 inches wide near the foot-wall. Galena occurs with pyrite and traces of sphalerite and assays of ore sold ranged from 56.5% to 60% lead, and 37.3 to 42.85 ounces of silver per ton. The orebody was driven on for at least 170 feet, and was stoped to a height of 100 feet over a length of 150 feet.

The lode had been explored before 1904 in an adit about 20 to 30 feet below the outcrop.

Llewelin's Lode

This lode was not reached in the Venezia workings. It was worked about 1904 in two adits, the upper of which lies about 130 feet below the summit of the hill while the lower adit is about 40 feet lower still. Ore proved to be patchy, but an irregular shoot up to about 40 feet long and up to 18 inches wide found in the upper adit was described by Waller. A mass of galena 4 feet wide was uncovered in a winze, but it narrowed to only 8 inches in depth, above the lower adit.

PRODUCTION

A total of about 500 tons of concentrates was extracted from the Nubeena mine, containing approximately 325 tons of lead and 42,000 ounces of silver.

CONCLUSIONS

The country rocks are highly fissured and faulted and galena is erratically distributed throughout the ore channels. In the district, post-mineralization faults may have dislocated the lodes and caution must be used in correlating them with orebodies in the Spray mine as did Waller (1904) and Twelvetrees and Ward (1910). Workable ore appears to be concentrated in small irregular masses or bands whose behaviour is difficult to predict, and the orebodies are therefore of doubtful economic interest.

SOUTH NUBEENA PROSPECT

Lease 1735-87M of 72 acres lying south of the Nubeena section was pegged by J. Duncan in 1888. The property changed hands a number of times and little work was done until 1903 when it was taken up by G. E. Butler as lease 667M of 77 acres. An orebody was driven on which was thought to be the southern extension of Llewelin's lode. Only 1 to 2 inches of galena was found within a highly shattered and faulted zone but it is reported to have assayed 70% lead and 100 ounces of silver per ton.

Between 1906 and 1913, about 77 tons of ore were sold containing about 50 tons of lead and 7000 ounces of silver.

Austral Valley Group of Mines

There are a number of old workings in the upper reaches of the Austral Valley between Manganese Hill and the ruins of the smelters about $1\frac{1}{2}$ miles to the SE. The most important are those of the *Central Balstrup, Montagu No. 1, Maxim, North Austral, Watt and McAuliffe's* and the *Austral* mines.

CENTRAL BALSTRUP MINE

The original lease 741-87M of 80 acres was taken up by J. J. Martin in 1888 and was transferred to the Balstrup Central Silver Mining Co. N.L. in 1891. No. 1 adit was driven on the continuation of Balstrup's lode for 185 feet and the main shaft was sunk a short distance south of the Comstock tram in the SW corner of the lease, reaching a depth of 110 feet and connecting with the adit at the 85 foot level. Three other adit drives were cut as well as shallow prospecting shafts and trenches but by 1893 the workings were abandoned and the shaft was flooded. In 1894, the section passed to G. Fitzgerald and W. Hart but little work was done. About 1904 a tribute party obtained a small amount of ore from Cashbolt's lode near Austral Creek, about 200 yards SE of the main shaft. The lease was transferred to J. J. Walshe in 1908, being re-charted as section 4467M of 79 acres in the following year, but it was relinquished in 1915. During this period a number of shallow shafts were sunk on outcrops of orebodies but deeper sinking was prevented by flooding and lack of pumping equipment.

GEOLOGY

The area is highly disturbed. Silurian Crotty Quartzite is faulted to the west and south against deeply weathered greywacke and shale of the Cambrian Crimson Creek Formation. The southern dislocation is the Balstrup Fault, one of the major faults in the Zeehan district, which was regarded by Waller (1904, pp. 32-37) as a large lode formation. However, most of the known orebodies strike NNW while the fault zone trends a few degrees north of west or NW. It is suggested that the Balstrup Fault may be Tertiary or Jurassic though detailed examination is hampered by deep weathering and downwash.

The lodes are fissure veins of siderite with impersistent bands and masses of galena. Twelvetrees and Ward (1910, p. 123) recorded that in a shallow shaft south of Austral Creek unoxidized ore was found containing nicolite and ruby silver together with galena and jamesonite in a gangue of siderite. Assays ranged up to 530 ounces of silver per ton and 30% nickel but inflow of water prevented further exploration.

PRODUCTION

It is doubtful if more than 25 tons of ore were sold, containing about 12 tons of lead and 1250 ounces of silver.

MONTAGUE No. 1 MINE

The property was explored between 1887 and 1894 by a number of prospectors and in 1895 section 249-93M of 40 acres was pegged by H. O'Rourke. According to Montgomery (1896), O'Rourke's shaft and workings were a short distance east of the old South Balstrup shaft about which little is known. On the north bank of Austral Creek an adit was driven on the course of O'Rourke's lode, yielding 200 tons of first class ore from 3 parallel veins of galena which were worked down to a level 21 feet below the adit drive. An underlay shaft was sunk in the footwall 30 feet below the adit.

In 1896, the Montagu No. 1 Silver Mining Co. N.L. was formed to work the orebody in depth. Waller (1904) stated that a main shaft was sunk and at the 100 foot level a crosscut was driven eastwards to cut the orebody but results were unsatisfactory. It is possible that the lode intersected was not O'Rourke's but another further west.

In 1901, the Montagu company relinquished the lease which was taken up in 1902 as section 306M by N. B. Currie who found two other lodes west of O'Rourke's. The first was cut in an eastern crosscut in the mine, probably at the 100 foot level, and a shoot of ore 30 to 40 feet long containing 2 inches to 12 inches of galena was stoped. Another orebody was intersected in an adit near the level of the shaft collar and a winze was sunk on 6 to 9 inches of galena to connect with the crosscut. Waller remarked that there were several other lodes on the flat to the south but pumping equipment would be essential to develop them.

There has been little activity or production since. The lease passed to H. E. Quigley in 1910 and during a government prospecting programme an adit was cut in 1913 for 476 feet to intersect the northern extension of the lodes worked in the mine but nothing of value was found. The lease was relinquished in 1916. Between 1954 and 1961 it was charted as section 19M-54 in the name of C. L. Hills.

GEOLOGY

The Balstrup Fault zone strikes a few degrees north of west across the northern part of the lease, bringing shattered sandstone and grit of the Crotty Quartzite in the north against decomposed greywacke and siltstone of the Crimson Creek Formation.

PRODUCTION

Figures are incomplete but production is estimated at about 230 tons of galena ore containing 115 tons of lead and 1500 ounces of silver.

MAXIM MINE

The main shaft is south of Austral Creek and about $\frac{1}{4}$ mile south of the Montagu No. 1. Lease 924-87M of 80 acres was taken up by F. G. Duff in 1888 and was transferred in 1890 to the Maxim Prospecting Association N.L. The main orebody was explored in trenches and pits and after satisfactory metallurgical tests, the property was bought by the New Maxim Silver Mining Co. N.L. in 1892. The main shaft was sunk, but no details are on record and the mine appears to have been abandoned before 1893. In that year the lease was sold by public auction to J. C. MacMichael but it lapsed in 1894. J. Weber pegged 40 acres of the ground in 1895 as lease 275-93M and worked an orebody (Weber's lode) about 150 yards east of the main lode. Water apparently prevented deep sinking and the lease became void in 1901. Between 1902 and 1910, the block was held by M. Glock as section 412M and during this period about 118 tons of galena were extracted.

The lease was transferred several times in later years and from 1912 to 1915 was charted as 6194M in the name of J. H. S. Munro.

GEOLOGY

Much of the lease is on a flat worn across decomposed greywacke and siltstone of the Crimson Creek Formation which overlies Proterozoic quartzite and slate outcropping to the south. The Cambrian beds are largely blanketed by alluvium and downwash. Four parallel NNW striking orebodies have been recorded in which galena occurs within a siderite gangue. The most westerly is the Main lode on which the old main shaft was sunk to an unknown depth. Tilley (1891, p. 52) quoted a report by W. F. Petterd in which the orebody was described as a well-defined formation about

4 feet wide containing bands of galena of variable width. Waller (1904) commented on 3 lodes further east: Glock's West lode yielded a small parcel of ore assaying 108 ounces of silver per ton; Weber's lode carried a shoot of workable ore to a shallow depth but lack of pumping plant probably prevented deeper mining; Glock's East lode was described as "a seam of black pug about 9 to 14 inches wide containing about 50% galena".

PRODUCTION

About 120 tons of concentrates have been extracted containing about 60 tons of lead and 10,000 ounces of silver.

WATT AND MCAULIFFE'S AND NORTH AUSTRAL MINES

The lodes strike between NNW and NNE, lying partly within the former lease 3686-93M of 59 acres (North Austral) and partly in lease 288-93M of 34 acres (Watt and McAuliffe's). The old workings lie near Austral Creek NW of the small bridge on the Smelters road. The ground was prospected about 1887 by T. L. Fowler, J. Robinson and W. Dixon. In 1895, Section 288-93M was taken up by G. Badenach and T. Watts and ore was extracted from a shallow adit and shaft, though work was hampered by water. By 1902, No. 1 shaft was sunk to a depth of 60 feet, while 250 feet further south, No. 2 shaft was put down to 40 feet and by the end of 1905, 522 tons of ore had been produced. In 1906, both leases were taken over by the Austral Valley Silver-Lead Mining Co. N.L. and in the following year were incorporated as part of consolidated lease 2851M of 192 acres which became void in 1915.

GEOLOGY

The country rocks resemble those in the Maxim mine and are faulted to the north against shattered Devonian Florence Quartzite. Waller (1904) recognized 7 lodes of which No. 2 was the principal ore producer.

PRODUCTION

Between 1901 and 1905, 522 tons of galena ore was produced, containing about 250 tons of lead and 50,000 ounces of silver. After 1907, part of the recorded production from the Austral Valley Mining Co. was probably from these workings.

AUSTRAL VALLEY MINE

Lease 547-87M of 74 acres was taken up by T. L. Fowler in 1887 and was eventually transferred in 1890 to the Austral Silver Mining Co. N.L. but work had ceased before 1893. The property was held as lease 329-93M by R. A. Dunn between 1895 and 1898, and as lease 3687-93M by T. W. Watts from 1899 to 1900. The section was included in Consolidated Lease 2851M of 192 acres held by the Austral Valley Silver-Lead Mining Co. N.L. between 1907 and 1915. Between 1947 and 1950, about 5 vertical and inclined boreholes were drilled by Zeehan Explorations near the flux quarry west of the Smelters road. The highest assay indicated 13% lead over a width of 16 feet in limestone locally replaced by galena and calcite, but the results generally were disappointing.

GEOLOGY

The host rocks are disturbed and faulted grits and quartz conglomerate of the Ordovician Moina Sandstone which is overlain east of the road by silicified Gordon Limestone. To the north, the Ordovician rocks are faulted against weathered Cambrian grey-wacke, siltstone and shale. The flux quarry is excavated in a large

outcrop of ferromanganiferous gossan about 25 feet wide which was used as a flux in the smelters between about 1909 and 1913. According to Twelvetrees and Ward (1910), the gossan contained about 50% iron and manganese and 6% to 8% silica. If screened, it would assay about 5% lead, with $1\frac{1}{2}$ ounces of silver per ton.

PRODUCTION

Quarterly returns of the mineral industry of Tasmania show that from 1907 to 1913, 862 tons of galena ore, 4224 tons of flux, 100 tons of sphalerite and 9 tons of pyrite were produced from the Austral Valley workings. Metal content is estimated at 800 tons of lead, 50 tons of zinc and 33,000 ounces of silver.

CONCLUSIONS

In the Austral Valley, there are numerous orebodies which have been exhaustively explored and tested in the past. Galena occurs within a sideritic gangue as short and irregular bands or shoots which were rapidly worked out above water-level. On the flat, the orebodies must be exploited in shafts and the small companies at work on the field appear to have lacked funds to install the pumping plant necessary to control the heavy inflow of water. The lodes are small and scattered, and do not encourage deeper sinking.

SILVER KING MINE

The old Silver King main shaft is about 150 yards west of the Zeehan-Strahan railway line, some 700 yards south of Zeehan station. The South King (or Fahey's) workings are about half a mile SSE, immediately north of the Zeehan Bell mine. Lease 223-87M of 80 acres on which the main shaft was sunk was first taken up by W. Strickland in 1887 and lease 222-87M of 40 acres where the South King workings were later developed was pegged by L. Susman in the same year. These and neighbouring sections were transferred in 1888 and 1889 to the Silver King Prospecting Association N.L. whose holdings totalled 352 acres SE of Zeehan.

At surface the main lode was reported by Montgomery (1890) to strike NW with a SW dip, and to consist of galena and sphalerite in sideritic gangue up to 3 feet wide. It was explored in shafts and surface trenches and about 1890 the main shaft was started, being eventually sunk to a depth of 250 feet with levels at 106 feet, 176 feet and 246 feet. Shallow shafts were also sunk on No. 2 lode (200 yards SW of the main shaft) and on No. 3 lode (300 yards SW of the main shaft) but operations here were discontinued because of flooding. Tilley (1891) recorded that on Section 222-87M, an adit had been driven 200 feet on the course of the main lode, north of the Bell workings. The orebody ranged between 5 feet and 8 feet wide and included a shoot of ore over 200 feet long. Except for the installation of a concentrating plant little activity took place until 1895 when a tribute party worked the shoot in shallow workings, but the King main shaft was apparently flooded. In the following year vigorous development took place, though chiefly by parties of tributors. The South King workings were connected with the Zeehan Bell mine, while in the King main shaft much stoping was done on the 106 foot and 176 foot levels. From 1900 to 1901 Fahey and party produced a considerable tonnage of ore from the South King workings down to stopes above No. 3 (258 foot) level, but exploratory crosscuts in the main workings intersected little workable ore and by the end of 1902 the mine closed

down. During the next few years, tributors obtained useful amounts of ore from the South King area and elsewhere on the leases, but only minor quantities have been extracted since 1908. Leases were taken up in 1937 by C. Macdonald (11976M and 11977M) and J. H. S. Munro (11801M) but were relinquished in 1939 and 1940. In 1947, 3 boreholes were drilled by Zeehan Explorations below the main workings and another was put down near the South King workings but results were not encouraging.

GEOLOGY

The host rocks are grey and green fossiliferous shale or slate, siltstone and pale grey sandstone forming the lower part of the Devonian Bell Shale, near the western limb of the Zeehan Syncline. The beds strike NW and dip steeply NE or are vertical.

OREBODIES

The orebodies are fissure lodes trending NW in a similar direction to the axis of the Zeehan Syncline, but with SW dips. Galena occurs with sphalerite, pyrite and chalcopyrite in a gangue of siderite but as in other Zeehan mines, profitable ore is mainly concentrated in small and irregular shoots or masses and much of the lode material consists of relatively low grade milling ore. The silver content of the galena averaged between about 25 and 36 ounces per ton in the main workings, and up to about 45 ounces per ton in the South King workings; it is therefore somewhat lower than in other Zeehan mines.

WORKINGS

Main Shaft

The main shaft was sunk to 250 feet and the mine was worked on No. 1 (106 foot), No. 2 (176 foot) and No. 3 (246 foot) levels.

No. 1 (106 foot) level. Waller (1904) reported that the King main lode was driven on for 240 feet north of the crosscut from the shaft and for 285 feet south. The south drive continued a further 120 feet south in barren ground east of the lode. A crosscut was driven westwards for 900 feet, recorded in error as an east crosscut by Waller (1904, p. 99). At 250 feet a lode carrying 3 feet of sphalerite and pyrite lying below gossan was driven on and stoped over a length of 50 feet. No. 2 lode was intersected at 634 feet and consisted of 7 feet of siderite with a little galena. No. 3 lode was cut at 900 feet and although 2 feet 6 inches wide was found to be barren.

No. 2 (176 foot) level. The main King lode was driven on for 140 feet north of the crosscut and 400 feet south. Waller noted that about 250 feet had been stoped but a large quantity of second class ore had been left.

No. 3 (246 foot) level. The orebody was driven on for 130 feet north and nearly 500 feet south. According to Waller (1904), the lode turns westwards at the south end of the drive and is 20 feet wide with disseminated galena throughout, and about 8 inches of galena in the hanging wall. The galena assayed 25 ounces of silver per ton and 70% to 75% lead.

SOUTH KING WORKINGS

The orebody was originally worked by Burrige and party from No. 1 level in the Zeehan Bell mine, the shoot being described by Waller as "one of the most massive bunches of galena which have been mined in Zeehan". It ranged up to about 14 feet wide

and yielded 1882 tons of ore assaying about 45 ounces of silver per ton and 70% lead, but appeared to cut out against a fault near the Bell boundary. The lode was found south of the fault but is low grade.

About 1900, Fahey and party worked a large formation of gossan 122 feet long, 400 feet north of the Bell boundary. The gossan averaged 90 ounces of silver per ton and also yielded 25 tons of copper ore assaying 17% copper. At a depth of 30 feet the body was 21 feet wide but passed downwards into 4 feet of galena assaying 100 ounces of silver per ton which continued to a depth of 90 feet. Waller (1904) suggested that the orebody pitches south to join that worked by Burrige and party. The South King main shaft reached a depth of 258 feet. At 100 feet, a cross-cut was driven east, intersecting first the main lode and then a small but rich lode (the Sunrise lode). In the 258 foot level, the main orebody was relatively poor but was workable in stopes above the level. Fahey and party produced 7488 tons of ore between the surface and the stopes above the 258 foot level.

MISCELLANEOUS WORKINGS

About 1890 and again in 1907, shallow shafts were sunk on No. 2 and No. 3 lodes but work was short-lived because of flooding. The lodes appear to be of relatively low grade. Water also prevented deeper sinking in a pit excavated in 1904 on the line of the King main lode about 700 feet south of the King main shaft.

PRODUCTION

Recorded production is 11,336 tons of ore, of which at least 9370 tons was extracted from the South King workings. Metal content is estimated at about 5000 tons of lead and 350,000 ounces of silver as well as about 4 tons of copper.

CONCLUSIONS

In the Silver King workings, the richest oreshoots appear to have been worked out, though there may be considerable reserves of low grade galena ore. The lack of efficient milling and concentrating plant was an important factor in the failure of the mine earlier this century, while inadequate pumping equipment prevented the exploration and development of the King main lode between the King and South King workings, and of No. 2 and No. 3 lodes.

In a series of boreholes drilled by Zeehan Explorations in 1947, little mineralization was found. The most notable intersection was over a width of 1 foot 6 inches which assayed 47.5% lead, 5% zinc, 0.06% antimony and 17.6 ounces of silver per ton, about 10 to 20 feet below No. 3 (246 foot) level and 150 feet south of the King main shaft.

SILVER KING EXTENDED PROSPECT

The property formerly consisted of lease 804-87M of 80 acres which was pegged in 1888 by C. Curtain and transferred to the Silver King Extended Silver Mining Co. N.L. in 1889. The prospect lies SSE of the old Despatch mine and the western portion of the lease included part of the township of Zeehan north of Wilson Street and SE of Frederick Street. Two NW trending lodes were explored in shallow shafts, costeans and adits but inflow of water

presented a problem. Little development took place and the lease became void in 1893. In subsequent years, the lease was taken up a number of times without much success and it is of insignificant economic value. Mineralization occurred within Ordovician Gordon Limestone which is faulted to the west against shattered Devonian Bell Shale. Tilley (1891) quoted assays ranging from about 40% to 50% lead and 35 to 80 ounces of silver per ton, but no production has been recorded.

Zeehan Bell Mine

The property formerly included leases 298-87M and 480-87M with a total area of 158 acres south of the Silver King mine. The shaft and main workings lie within section 480-87M, part of which was last pegged in 1937 as lease 11800M, of 39 acres by J. H. S. Munro, but relinquished in 1940. The old mine is $1\frac{1}{2}$ miles SE of Zeehan post office, between the Smelters road and the Little Henty River.

Section 480-87M was first taken up by S. Hall in 1887, being transferred to Lt.-Col. W. Collard Smith of Ballarat, Victoria in 1888 and then to the Silver Bell Silver Mining Company N.L. in 1889. Block 298-87M lying to the NE across the Little Henty River was held by J. Adams in 1887 and by W. T. Bell in 1890; it was taken over by the Silver Bell company in 1891.

The main orebody is apparently an extension of the NNW trending lode worked in the South King workings, and was tested in a shaft 40 feet deep sunk a few yards south of the boundary (Montgomery, 1890). Another shaft was put down 43 feet on the lode about 200 yards further south. About 50 yards south again, an adit drive was cut for 629 feet north on the lode, which was reported by Tilley (1891, p. 59) to be well-defined with an average of up to 3 feet 6 inches of galena. A total of 16 assays of ore averaged 47% lead and 45 ounces per ton of silver.

Little work was done in the next two years and in 1892 the leases passed by order of the Sheriff of Tasmania to W. H. Dickson, and were later transferred to R. T. Moore. Towards the end of 1892, the New Silver Bell Silver Mining Company N.L. was formed. Montgomery (1893b) remarked that although a main shaft had been started and a winding and pump engine partly erected little development had taken place. Ore obtained from the adit proved poorer than at first estimated, and 450 tons treated in the Mt Zeehan company mill yielded 116 tons of concentrates assaying 70% lead and only 30 ounces of silver per ton.

About 1895, the mine was let to a large tribute party and much exploration was done with disappointing results. At the 115 foot level, the lode was driven on for a total of 700 feet but was generally poor, with patches of good galena near the Silver King boundary. In conjunction with a tribute party working the Silver King leases, the party later sank a winze at the boundary to a depth of 50 feet below the 115 foot level and in the meantime the company was reconstructed and renamed the Zeehan Bell Silver Mining Co. N.L. The mine was practically idle until early 1901 when Twelvetrees reported that a lower level was being driven at a depth of 180 feet for 270 feet from the crosscut. The 115 foot level had been connected with the South King workings and a winze was being sunk to meet a rise from the 180 foot level. Work underground

was apparently brought to a standstill shortly afterwards as Waller (1904) recorded that the mine was pumped out about 1902 by a tributing company but payable ore was not found and work ceased after a few weeks.

GEOLOGY

The host rocks are grey and greenish-grey fossiliferous calcareous shale and siltstone with bands of pale weathering sandstone forming part of the Devonian Bell shale. The orebodies are fissure lodes containing irregular bands and aggregates of galena with sphalerite and pyrite in a gangue of siderite and a little quartz. The silver content is relatively low and does not appear to exceed 45 ounces per ton of galena concentrates. An oreshoot worked profitably in the South King workings is presumably faulted off a short distance south of the boundary (Waller, 1904) and in depth the orebody worked in the Zeehan Bell mine was low grade.

In 1947, 6 inclined boreholes were drilled by Zeehan Explorations from the surface for drilled distances ranging from 330 feet to 514 feet. Mineralization was poor, the highest assay being 13% lead, 12.9% zinc and 4.3 ounces of silver per ton over a drilled width of 4 feet.

PRODUCTION

Between 1890 and 1908, a total of 916 tons of concentrates was produced, containing about 600 tons of lead and 27,500 ounces of silver.

CONCLUSIONS

Although patches of first class ore were found near surface, the orebody deteriorates in depth and is generally low grade. The lack of milling and concentrating plant was a major factor leading to the failure of the Silver Bell and Zeehan Bell companies. It is doubtful if the mine could ever be worked profitably.

Sunrise Mine

The old workings lie near a bend in the Little Henty River about $\frac{1}{4}$ mile SE of the Zeehan Bell mine. The two shafts have been flooded for many years.

Lease 534-87M of 20 acres was pegged by J. R. Cahill in 1888 and a few months later the Sunrise Prospecting Association N.L. took over to work the orebodies. Montgomery (1893a) noted that tributors were raising payable galena ore, presumably from shallow workings. In spite of drainage problems a shaft was later sunk to 26 feet (Montgomery, 1893b) on an orebody about 2 feet wide containing up to 8 inches of galena and believed to be an extension of the King lode. The lease was relinquished in 1895 after yielding about 35 $\frac{1}{2}$ tons of ore averaging from 69% to 73% lead, with 80 to 90 ounces of silver per ton. The property was taken up again in 1897 as lease 2235-93M in the name of S. Burton, but was transferred to J. Coleman in 1898 and then to G. E. Butler in 1902. About 10 tons of ore was produced in 1910, but the lease was finally given up in 1912.

Twelvetrees and Ward (1910, pp. 124-125) described the workings up to that date. The original shaft within the bend of the Little Henty River was sunk to 50 feet at which depth crosscuts intersected the Sunrise lode 45 feet to the west of the shaft and the Bell lode 80 feet to the east. An ore shoot in the Sunrise lode carrying 9 inches of galena over a length of 50 feet was stoped out to the surface. The lode was barren for 30 feet north, after which a shoot 16 feet long was found but apparently not worked.

In order to test the Sunrise lode in depth, a second shaft was sunk west of the river and 124 feet from the old shaft. At a depth of 107 feet the orebody was intersected in a crosscut 50 feet east of the shaft. The vein was reported to be 4 to 5 inches wide and picked samples containing fahl ore assayed 50.6% lead, 9.02% copper and 404 ounces of silver per ton. The lode was driven on for 36 feet north and 13 feet south, and a few inches of ore were found on the hanging wall side. Two parcels of ore totalling 8½ tons assayed 57.3% and 39% lead, with 104 ounces and 106.7 ounces of silver per ton.

GEOLOGY

The lodes are fissure veins of siderite with irregular bands of galena, striking NNW within Devonian Bell Shale as in the Zeehan Bell mine.

PRODUCTION

Between 1892 and 1910, about 56 tons of galena was produced, containing about 36 tons of lead and 4760 ounces of silver.

CONCLUSIONS

Although the silver content is high, galena ore is concentrated in small shoots or bands and reserves are low. The property is of little economic importance.

Oceana Mine

The first lease was taken up by S. Hall and W. T. Bell in 1887 and was transferred to E. H. Whiteman in 1891. The Oceana Silver Mining Co. was formed in 1892 to exploit the orebody below the prominent manganiferous gossan outcrop containing cerussite, which had been discovered at the surface. Reid (1927c) recorded that 40 tons of oxidized ore was railed daily to the old Argenton Smelting Co., about 1½ miles away, until the smelters failed in 1893. Montgomery (1893b) described the workings. Three prospecting shafts were sunk and connected by 700 feet of drives on the orebody, and a main shaft was put down to 45 feet, with a level at 32 feet. No work was being done in 1893 and the leases were later relinquished, in 1895. In 1896, the Oceana Proprietary Co. Ltd. deepened the shaft to 145 feet, and a lower level was cut at 80 feet, but in 1899 the top 40 feet of the shaft caved in and the mine was abandoned once more. In 1909, R. Fox and party mined small amounts of galena from stopes above water level, and a few tons were produced in 1925 by E. St. Clair, D. Mather and B. Grabe.

After exploration in the Zeehan district by North Broken Hill and Broken Hill South between 1946 and 1948, Zeehan Mines Pty. Ltd. was formed in 1950 to reopen the mine. Much development and driving was done in 1952-1953 and 128,000 tons of ore was produced between 1954 and June, 1960 when the mine closed.

The company held lease No. 17M/54 of 613 acres, about 3¼ miles south of Zeehan. The following condensed account of the mine is based on a detailed report by Jack (1961).

OREBODIES

The orebodies consist of galena, with minor amounts of pyrite, sphalerite and chalcopryrite, erratically distributed throughout a gangue of manganiferous siderite. Mineralization took place in Devonian times within a prominent shear zone which strikes NW and dips steeply to the NE. The ore occurs along two major shear planes and within tension fractures between them, and there has

also been some selective replacement of limestone. Where the mineralized fractures were of sufficiently high grade and close together, the orebodies along the two main shears were mined as one stope. The ore zone has a maximum width of 60 feet and is up to 350 feet long, but workable ore was not more than 30 feet wide and 260 feet long.

The host rocks are part of the Ordovician Gordon Limestone, striking NW with steep NE dips, between the underlying Moina Sandstone on the west and overlying Silurian quartzitic sandstone to the east. There is good evidence of post-ore faulting which has displaced the orebodies. The water-bearing fault zone met in the north drives in the upper levels is probably related to the Oceana Fault north of the mine. This is a NE trending dextral wrench-fault which has shifted the north block about $\frac{1}{2}$ mile to the east. Jack (1961) mapped small low angle thrust faults striking NNW with overthrust to the east, above No. 1 and No. 2 level stopes.

WORKINGS

The main shaft was sunk to a total depth of 648 feet, the lowest working level being No. 6 (640 foot) level. Crosscuts were driven west from the shaft to intersect the orebodies which were driven on north and south. On No. 1 (150 foot) level, the south drive was extended 210 feet south of the shaft to work a small lens of ore which was shown in drill holes to be uneconomic in depth and consequently was not worked in lower levels. The north drive was continued for 600 feet north of the shaft. The drive was inaccessible beyond 160 feet but was reported to have intersected a lode 40 feet wide and 120 feet long, averaging only 5.5% lead, thought by Jack to be an extension of the main ore zone displaced eastwards by thrusting. On No. 2 (300 foot) level, a north drive was cut in an attempt to test this orebody in depth but was abandoned at 160 feet because of inflow of water and mud. A fault zone carrying much water was intersected at 290 feet in a north drive on No. 3 (420 foot) level. No. 4 (450 foot) level is a sump. The main orebody was driven on for 115 feet south and 130 feet north in No. 5 (540 foot) level. On No. 6 (640 foot) level, the lode was intersected at 80 feet in a crosscut from the shaft but is reported to be narrow and of relatively low grade.

RESERVES

The company used a cut-off grade of about 11% lead owing to high operating costs. Based on this grade, Jack (1961) calculated that only 9250 tons of probable ore, and 3000 tons of possible ore remained in the main orebody to a depth of 50 feet below No. 6 level where the lode shows a marked decrease in size and value compared with the higher levels. The exhaustion of reserves of workable ore led to the closing of the mine. Other factors included:—

1. *Fall in metal prices.*—The average price for lead in the first quarter of 1955 was £A124 17s. 6d. per ton. In the second quarter of 1960, it was worth only £100 per ton.

2. *Inflow of water.* The mine lies in a valley flanked by hills of steeply dipping conglomerate, grit or sandstone to the west, north and east, in a region which receives 97 inches of rain annually. The surface drainage was led away by a channel cut round the lower slopes to the north and west but much water finds its way underground through the relatively porous and fractured sandstone and grit. About $2\frac{1}{2}$ million gallons were pumped out of the mine daily. In the valley, the water-table was originally near surface but was

lowered by drainage of the mine, causing widespread caving of the thick clay pug derived from decomposed limestone. This factor was responsible for the collapse of the old shaft in 1899. The resulting "badlands" topography provides innumerable openings for further inflow of water and mud, while much of the water pumped out seeps back into the mine. It is clear that this is an inevitable process which is difficult if not impossible to prevent.

TABLE 31—Production—Oceana Mine

Year	Ore (Tons)	Concen- trates (Tons)	Silver (Ozs)	Lead (Tons)	Zinc (Tons)
To 1893 ....	....	1,000	14,500	390	....
1898 ....	....	517 Est.	10,000 Est.	250	....
1909 ....	....	23 Est.	300 Est.	9	....
1925 ....	....	Est. 21	230	8	12.8
		1,561	25,030	657	12.8
1954	7,977	1,221	41,247	893	....
1955	15,680	2,793	81,375	2,031	....
1956	15,442	2,356	71,334	1,732	....
1957	17,916	2,073	76,818	1,958	....
1958	22,662	3,402	95,646	2,434	....
1959	30,336	4,282	134,013	3,142	....
1960	18,164	2,883	89,518	2,055	....
	128,177	19,010	589,951	14,245	....
	128,177	20,571	614,981	14,902	12.8

Mariposa Mine

(including old Alameda, Martini and South Nevada Prospects)

The workings lie about $\frac{1}{2}$ mile west of the Queenstown road and about $\frac{1}{2}$ mile south of the bridge over the Dundas Rivulet. They are now partly buried by landslips but on the dumps may be seen fragments of limonitic gossan, quartzitic limestone with stringers of calcite and calcareous quartzite with galena. Between 1890 and 1892, a mineralized line, $\frac{3}{4}$ mile long extending from near the Dundas Rivulet SSE to Mariposa Creek, was explored by the *Alameda* (Leases 1410-87M and 2243-87M each of 40 acres), *Mariposa* (2415-87M and 2416-87M, each of 40 acres), *Martini* (3325-87M of 22 acres) and *South Nevada* (2446-87M of 80 acres) Silver Mining companies. Adits were driven west into the ridge of Crotty Quartzite by the Alameda and Martini companies and although about 100 tons of low grade ore was extracted, the leases were abandoned before 1893. Lease 1410-87M was transferred to the Mariposa company in 1894.

The Mariposa workings were more extensive. The main shaft was sunk to a depth of 144 feet in Gordon Limestone and at 130 feet a crosscut was driven east for 50 feet. At 20 feet in the crosscut a lode formation 4 feet wide was cut which consisted of low grade galena ore with siderite and calcite. It is not certain if the orebody is the same as that uncovered in opencuts at the surface were up to 8 feet of limonitic gossan with cerussite and galena was described by Montgomery (1893b). A shallow adit was driven 350 feet westwards but no details have been recorded. The Mariposa company apparently ceased work about 1901.

Between 1905 and 1911, F. Borley produced a considerable tonnage of low grade ore, gossan and flux, and no production has since been recorded. Lease 8988M of 5 acres was held by the Dunkley brothers from 1923 to 1924, while L. J. Bryant pegged section 10065M of 10 acres between 1927 and 1931. Shortly after World War II, diamond drilling by Zeehan Explorations revealed no encouraging indications of mineralization.

GEOLOGY

The orebodies are fissure lodes striking NNW with westerly dips within decomposed Ordovician Gordon Limestone near the junction with the overlying pale sandstone and shale of the Silurian Crotty Quartzite which forms a prominent ridge to the west. About 200 yards to the east, outcrops of quartz with a little pyrite trending NNW mark the faulted junction with greywacke and conglomerate of the Cambrian Dundas Group. Recorded assays of the galena ore sold varied from 33% to 65% lead, with 12 to 26 ounces of silver per ton, so that the grade is lower than in the Zeehan district generally.

TABLE 32—Production—Mariposa Group of Mines

	<i>Ore (Tons)</i>	<i>Lead Content (Tons)</i>	<i>Silver Content (Ozs)</i>	<i>Remarks</i>
Mariposa	1,254	412	21,250	1893-1911
Alameda	80	27	1,350	1893
Martini	20	7	340	1893
	<hr/> 1,354	<hr/> 446	<hr/> 22,940	

Based on assay values of 33% lead and 17 ounces of silver per ton. Cf. Twelvetrees and Ward (1910, p. 154).

CONCLUSIONS

Mineralization along the Mariposa line is low grade and inconsistent; further development is not warranted.

TABLE 32A—Total Production—Zeehan Field

<i>Mine</i>	<i>Lead (Tons)</i>	<i>Silver (Ozs)</i>	<i>Zinc (Tons)</i>	<i>Copper (Tons)</i>
Zeehan-Montana	49,580	7,058,122		
Mt Zeehan (Tas.)	45,948	7,017,784		
Zeehan-Western	26,300	4,800,000		
Zeehan-Queen	16,532	1,973,746		
Oceana	14,902	614,981	12.8	
Oonah	11,724	2,050,135		941
Florence	10,200	1,400,000		
Silver King	5,000	350,000		4
Montana Silver-Lead ..	2,304	279,348		
Nike	2,149	225,830	7.8	
Colonel North	1,549	128,075		
Mt Zeehan	1,540	166,850		
Austral Valley	800	33,000	50	
Zeehan Bell	600	27,500		
Mariposa, &c.	446	22,940		
Nubeena and Sth Nubeena	375	49,000		
Tasmanian Crown	113	15,738		
Sunrise	36	4,760		
Junction	15	8,728		
	<u>190,113</u>	<u>26,226,537</u>	<u>70.6</u>	<u>945</u>

SOUTH ZEEHAN: COMSTOCK DISTRICT TO McLEAN CREEK

A number of old mines and prospects lie in a belt of country about 3 miles long from the Comstock district SE to McLean Creek. They may be reached by way of the Trial Harbour road and the minor gravel road which was formerly the Tasmanian tram. They include the Comstock and South Comstock mines, North Comstock, Silver Stream, Boss, Susannite (Britannia Extended), Sylvester, T.L.E., Stonehenge, North Tasmanian and Swansea mines and the Doric and Silver Duke prospects. Most of the workings are within intensely faulted and disturbed quartzite, slate, phyllite and schist assigned to the Oonah Quartzite and Slate which in the south were brought against Cambrian conglomerate, grit, mudstone and gabbro by the NW trending Tenth Legion fault zone.

Comstock and South Comstock Mines (see Figure 13)

An 80 acre lease, No. 712-87M, was taken up by W. Barlow in 1888 and was transferred to the Comstock Mining Co. N.L. later that year. The orebodies contain a high proportion of sphalerite for which there was no market in the early days of mining so galena was extracted and the sphalerite left until about 1900 when outlets were found for zinc ores. The lodes were exploited in deep trenches and shallow workings, and about 1890 the Lower Adit was driven NE from the east side of Comstock Creek in order to test No. 1 (Main) lode in depth. By 1891, the adit had been advanced 600 feet; it was later extended to 660 feet to cut the lode which proved disappointing where intersected, and was driven on for only a few feet before work stopped. Until about 1895 the property was worked mainly by tribute parties who were handicapped by primitive equipment and heavy inflow of water into the workings which were eventually abandoned.

To the south, section 803-87M of 80 acres had been pegged by W. H. Foley in 1888 and transferred to the South Comstock Silver Mining Co. N.L. in 1889. A drive was put in on the continuation of the Comstock Main lode near the boundary of the properties, but operations were short-lived and work ceased before 1890. The section was taken up as lease 966-93M in 1896 by F. O'Neill and W. Flaherty. The Comstock Main lode was mined in a large open-cut with shaft workings about 80 feet from the floor of the cut. In 1901, the mine was bought by Zeehan South Comstock Ltd. who took over the old Comstock mine in 1903. In the next few years, a considerable amount of development took place and zinc ore was exported profitably to European markets while a smaller quantity of galena was produced by the company and tribute parties. After the end of 1907 much of the shallower ore became worked out and production dropped. The Broken Hill Proprietary Block 10 Co. Ltd. took an option in 1910 on both leases which were transferred in 1912, and the properties were abandoned once more in 1916. Small leases were taken up in 1924 by H. Tomkins and R. Clarke, and by J. A. Cornish. The latter held a 5 acre lease, 9140M, over the Comstock East Lode which was later worked in 1928 by Allison's Comstock Lead Zinc Co. N.L. and in the following year by the Lucknow Prospecting Syndicate. Between 1926 and 1937, J. Dunkley and party extracted small but significant amounts of argentiferous galena from workings at the northern end of the Main Lode.

In 1935, three men were employed by the government to extend the old Lower Adit to a total length of 1909 feet but no payable ore was found. This and other drives and crosscuts near Allison's workings were described by Blake (1936b). The prospecting programme near the Comstock mine and eastwards towards the old Boss mine was continued until 1940 without revealing mineralization of economic importance.

Consolidated lease 123-47M of 359 acres in the Comstock district was taken up by M. C. Howard, R. M. Waller and E. Tomkins in 1947, and the workings were re-opened. The lease was acquired by the Electrolytic Zinc Co. of Australasia Ltd. in 1948 and a geological survey was carried out, supported by diamond drilling. Tributators produced small amounts of lead and zinc ore in 1951/52 since when there has been little further activity.

5 cm

SKETCH PLAN COMSTOCK AND SOUTH COMSTOCK MINES

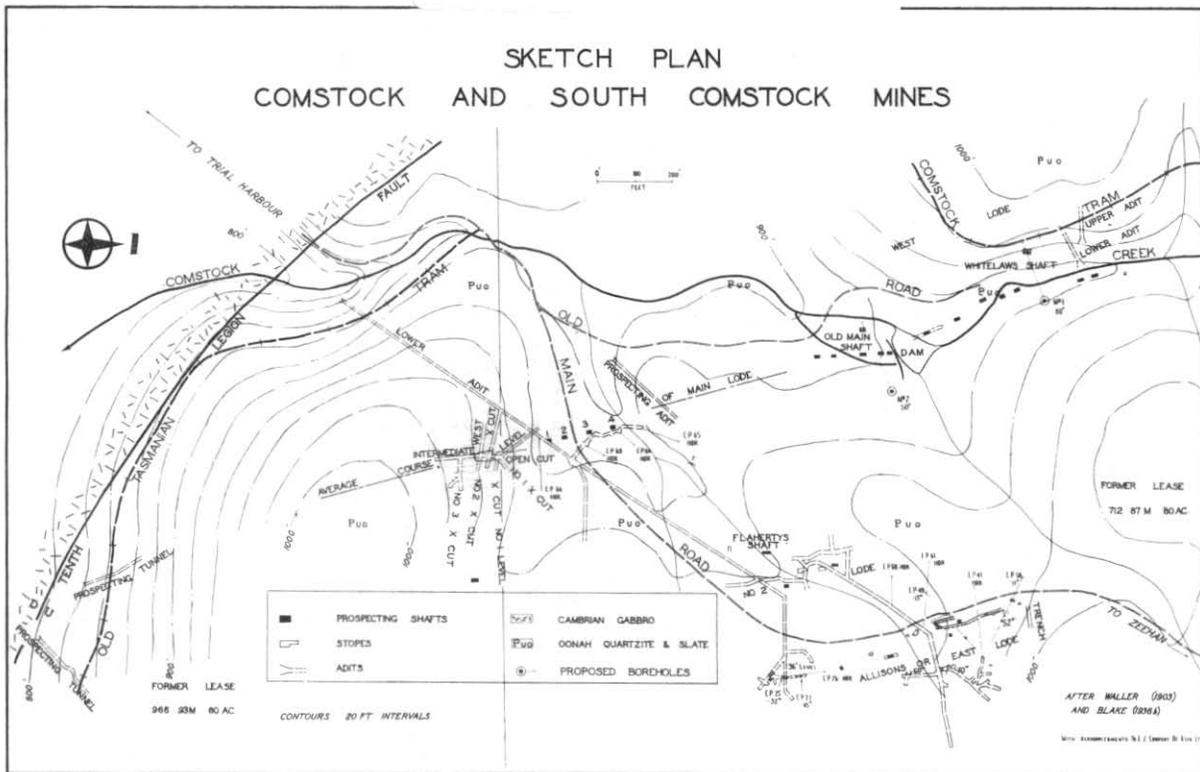


FIGURE 13.

GEOLOGY

The host rocks are a variable succession of disturbed and contorted mica-schist, phyllite and slate with quartzite and sub-greywacke. Dark grey limestone and calcareous siltstone are locally developed near the Comstock Creek north of the Trial Harbour road. The rocks, which are believed to be the upper part of the Oonah Quartzite and Slate, are faulted against Cambrian gabbro a short distance west of the bridge over Comstock Creek.

OREBODIES

The lodes are fissured veins or irregular lenses of sphalerite and galena and a little chalcopryite in a gangue of pyrite, siderite and quartz. The Main lode is reported to have been up to 50 feet wide in the opencut on the old South Comstock lease (Waller, 1903, p. 22). Four lodes were worked trending NNW and dipping steeply to the east:—No. 1 (Main) lode, the West lode, No. 2 lode and the East (Allison's) lode. In general, the sphalerite and galena do not form an intimate mixture and may be separated with little difficulty.

WORKINGS

No. 1 (Main) Lode

The orebody has been worked over a total length of at least 1500 feet north from the old South Comstock opencut workings south of the Trial Harbour road, and a detailed description was presented by Waller (1903, pp. 22-29), though at that time some of the stopes were inaccessible. In the opencut, the lode at the surface was about 50 feet wide, consisting of irregular masses of sphalerite with pyrite and galena within decomposed limestone and slate, and it was driven on for about 150 feet in the Intermediate level about 20 feet below the floor. Three east crosscuts about 50 feet apart were driven across the lode in which masses of sphalerite ranged up to about 20 feet in thickness. A crosscut was driven 80 feet west and at 40 feet a formation 30 feet wide was intersected which carried masses of pyrite and sphalerite. It was planned to work by opencut down to this level in a series of benches. The Main Lode was also cut 90 feet below the Intermediate level about 660 feet from the portal in the Lower Adit driven by the old Comstock company. At this point the orebody was poor and it was driven on for only a few feet. No workable ore was found when the adit was extended to 1909 feet in 1935.

North of the opencut, 4 small underlay shafts were sunk by tribute parties on the line of the Main lode. Nos. 1 and 2 shafts are immediately south of the Trial Harbour road and workable galena was stoped in them for short distances north and south. No. 2 shaft is said to be 80 feet deep. The orebody is poor in Nos. 3 and 4 shafts, north of the Trial Harbour road, and in a prospecting adit west of No. 4 shaft and east of the track to the northern workings. About 400 feet north of the prospecting adit, an oreshoot

was stoped to a depth of 35 feet over a length of 180 feet in 5 shafts near Comstock Creek. The old Comstock Main shaft lies a short distance west of the creek. Twelvetrees (1901, p. 35) recorded that the shaft was sunk to 100 feet; levels were driven at 45 feet and 100 feet, and a sphalerite lode was cut in an east crosscut 43 feet long. Further north, an oreshoot was stoped from the surface for over 100 feet and up to 2 feet of galena was worked to a depth of 30 feet from 3 shallow shafts. On the west side of the creek, Whitelaw's shaft was sunk to a depth of 100 feet about 500 feet north of the Main shaft. The lode was found in a crosscut from the bottom of the shaft and contained up to 14 feet of sphalerite which was driven on north and south. In 1905, the level was extended 40 feet and a rise was put up 17 feet on 3 feet 6 inches of sphalerite with about 10 inches of galena.

West Lode

The lode was first found in a cutting on the old tramway about 100 feet NW of Whitelaw's shaft and was tested in 2 adits between the tram and Comstock Creek. In the upper adit, a pyritic formation carrying some sphalerite and galena was cut and patchy galena occurs in the lower adit, but no important discovery was made.

No. 2 Lode

A pyritic orebody with bands of galena and sphalerite was exposed in several shallow shafts north of the Trial Harbour road on the former Comstock lease, about 200 yards NE of the South Comstock opencut. Montgomery (1895) noted that O. Meredith had sunk an underlay shaft to 30 feet on a lode channel of shattered country rock 4 feet wide carrying pyrite and a little galena. Waller (1903, p. 28) stated that a crosscut had been driven from the Lower Adit towards the line of No. 2 lode but it is not known if it was cut in this or in the later extension of the adit towards Allison's lode.

East (or Allison's) Lode

Massive sphalerite mixed with small quantities of pyrite and galena was mined in shallow workings over a length of about 200 feet east of the Trial Harbour road, about $\frac{1}{4}$ mile NE of the South Comstock opencut. The lode is reported to range up to about 14 feet wide (Waller, 1903, p. 28), and was first worked in surface stopes. A level was later opened up from the bottom of a vertical shaft 47 feet deep but little is known of the orebody. Blake (1936b) remarked that it was exposed only at one place (17 feet north of the ladder shaft) where 6 inches of galena was visible within 18 inches of mixed sphalerite, galena, pyrite and gangue. A picked sample of galena assayed 81.3% lead and 24.9 ounces of silver per ton.

TABLE 33—Production—Comstock and South Comstock

	Galena Ore (Tons)	Zinc Ore (Tons)	Lead (Tons)	Silver (Ozs)	Zinc (Tons)	Remarks
1888-1900 ..	600	....	300	36,000	....
1901 ..	308	} 1035				
1902 ..	24					
1903 ..	11		392			
1904 ..	46		84			
1905 ..	618		343			
1906 ..	535		467			
1907 ..	81		179			
1908 ..	22		....		
1910 ..	80		10	N.A.	N.A.	
1911 ..	42		....			Also 459 tons of pyrite
1912 ..	159	....			Also 256 tons of pyrite	
1913 ..	42	....			
1914 ..	396	....			
1915 ..	711	....			
1924 .. Est.	10	25	5	544	12	
1928 .. Est.	200	300	119	9,977	167	
1929 ..	76	....	54	4,725	....
1933 .. Est.	60	....	34	3,415	....
1947 ..	....	110	10	770	30	
1948 ..	....	194	15	1,230	45	
1951 ..	....	50	4	205	10	
1952 ..	....	56	Est. 4	Est. 230	Est. 11	
	<u>4021</u>	<u>3245</u>				

Notes:—

Total content of ore produced is estimated at 1625 tons of lead, 165,000 ounces of silver and 2100 tons of zinc.

According to Montgomery (1893b) the average assay of 298 tons of galena ore was 50% lead and 60 ounces of silver per ton. Twelvetrees (1901, p. 34) stated that 287 tons averaged 52% lead and 63 ounces of silver per ton. Samples taken from Allison's lode contained 58% and 81.3% lead, and 35.9 and 24.9 ounces of silver per ton (Blake, 1936b).

NORTH COMSTOCK

North of the Comstock holdings, lease 824-87M of 62 acres was taken up in 1888 by J. Adams who transferred it to H. Nickolls later that year. Twelvetrees (1901, p. 39) commented that £1200 had been spent on surface and shallow prospecting without result and the section became void in 1892. The ground has been held intermittently since then, and was last charted as lease 4572M in the name of J. Riley between 1909 and 1910.

In the south of the section, several shallow adits were cut across the line of the Comstock Main lode but little mineralization was found. On the slopes of the hill of Proterozoic quartzite and slate near the northern boundary, Twelvetrees recorded a north

trending and westerly dipping vein, 16 inches thick, of quartz impregnated with pyrite and galena. A shaft 20 feet deep was sunk on the swampy buttongrass flat south of the ridge and penetrated gossan with traces of pyrite and galena within slate.

There is no record of any production from the prospect, though a small amount of galena may have been extracted.

SILVER STREAM MINE

The property lies between the Tenth Legion mine and the Comstock mine and was prospected in 1888 by E. Dardus who pegged lease 1642-87M of 62 acres. The Silver Stream Mining Co. N.L. was formed in 1890 to develop the orebodies, and was superseded by the New Silver Stream Mining Co. in 1891. The ground was exposed in a shallow shaft and two adits but the company lacked capital to install pumps necessary to sink deeper on the lodes. In 1893, the mine was let to the O'Neill tribute party for three years and the main shoot of galena in the lower (No. 2) adit was probably stoped out during this period.

The section was relinquished in 1897, but was held between 1897 and 1900 as lease 2223-93M by A. P. Anderson, being taken up once more as section 5142-93M in 1900 by W. Thomas, probably on behalf of the Kynance Prospecting Association. Waller (1903, p. 18) stated that the old adit workings had collapsed and the Kynance P.A. had recently crossed the north drive in the lower adit in a new crosscut. There is no record of production, and in 1911 the lease passed to the Kynance Prospecting Syndicate N.L. which also took over the adjoining easterly lease 661-M of 30 acres held by W. Thomas since 1903. Some underground exploration and surface prospecting was done from time to time in the next 20 years with little reward and the leases were surrendered in 1940.

GEOLOGY

The country rocks are intensely disturbed and highly weathered schist, slate and sandstone of the Oonah Quartzite and Slate lying in the Tenth Legion fault zone. The Main lode strikes NE and is reputed to be up to about 40 feet wide in the lower adit, consisting of limonitic gossan with bands and patches of galena, sphalerite and pyrite within rotten slate and steatite. The gossan contains only from $1\frac{1}{2}$ to $3\frac{1}{2}$ ounces of silver per ton. SW of the main workings, the "copper lode" was cut in an adit and was reported to consist of 60 feet of kaolin, steatite and gossan stained with copper carbonate. A bulk sample taken over a width of 3 feet 6 inches gave a return of 9.3% copper but only about 2 ounces of silver per ton (Waller, 1903).

WORKINGS

A shaft was sunk 50 feet from the surface to No. 1 adit and was then continued as a winze through to No. 2 adit, 28 feet below. No. 1 adit was driven 252 feet on the supposed course of the main lode and a vein of galena within a lode up to 3 feet wide was cut in the winze to No. 2 adit. Workable ore was stoped out to the surface above the adit.

No. 2 adit is 28 feet lower and was driven for 596 feet. Montgomery (1893b) noted that a lode containing galena and sphalerite with a little chalcopyrite and pyrrhotite was cut at 532 feet and a similar orebody at 546 feet, "and from this onwards to the end

of the tunnel a more or less broken mullocky lode mass was passed through". He also commented on the stream of water flowing from the lode so that it is possible that here the orebody has been shattered by later faulting.

About 1902, the Kynance Prospecting Association drove a new crosscut in No. 2 adit and crossed the old north drive, at which point the orebody consists of 40 feet of gossan and weathered country rocks with bands of galena and sphalerite (Waller, 1903, p. 18). The north drive followed the lode NE for 90 feet, but the sulphides petered out and the face is in hard quartzite. At the end of the south drive, the orebody is said to be about 5 feet wide, consisting of sphalerite with some galena and pyrite.

PRODUCTION

About 400 tons of galena are reported to have been produced by the Silver Stream company and tribute parties (Waller, 1903, p. 18). The metal content is estimated at 9200 ounces of silver and 165 tons of lead. Production since that date is not known, but was only a few tons.

BOSS MINE

Lease 1240-87M of 80 acres was taken up in 1888 by M. H. O'Neill, east of the Comstock and South Comstock sections. In 1890, the Boss Silver Mining Co. N.L. was formed and several outcrops of gossan were explored in trenches, shallow adits and shafts. Topography is unfavourable for the driving of adits and as the company did not have the capital necessary for deep sinking and control of water, work came to a standstill before 1893. The ground was charted as lease 2073-91M between 1893 and 1908, at first in the names of F. K. Fairthorne and R. Quiggan and then R. Quiggan alone. It was taken up as section 3914M by J. Dunn in 1908. About 660 tons of gossan was produced for fluxing ore in 1910, and the lease passed to the Broken Hill Proprietary Block 10 Co. Ltd. in 1913 but became void in 1916. Since 1948, the property has been part of Consolidated Lease No. 123-47M of 359 acres held by the Electrolytic Zinc Co. of Australasia Ltd.

The host rocks are disturbed Proterozoic quartzite, slate and phyllite lying south of the Balstrup Fault. Three orebodies are known, of which the most important is the NE trending Main lode in the west of the section. This lode consists of pyrite with sphalerite and galena and is reported to range up to 16 feet wide (Waller, 1903, p. 30), though it does not appear to have been tested below a depth of about 30 feet. The West lode is a gossanous formation striking NW near the boundary of the Comstock section which had been cut at a shallow depth by an old adit, abandoned and collapsed prior to 1903. The East lode of Twelvetrees (1901) contains about 2 feet of sphalerite, pyrite and galena and strikes NNE near the eastern boundary of the former lease 3914M. An adit was driven westwards about 200 feet to cut the orebody about 40 feet from the surface but it is not known if the intersection was made. Thin veins of galena were driven on with little success and Twelvetrees commented on the absence of definite lode channels in this part of the property.

PRODUCTION

About 700 tons of low grade ore and flux were produced, containing about 70 tons of lead and 6500 ounces of silver.

SUSANNITE (BRITANNIA EXTENDED) MINE

This is east of the Boss mine, and also south of the Balstrup Fault. The ground was first taken up in 1888 as lease 1589-87M of 62 acres by J. Spencer, and it changed hands a number of times before 1910, being charted in succession as section 2630-87M, 3728-93M, 831M and 1929M, while from 1913 to 1915 it formed part of Consolidated Lease 6565M of 100 acres in the name of H. D. Marsh. A tribute of 10 acres was later granted to J. J. Walshe under the Aid to Mining Act of 1912, and between 1919 and 1923 pyrite was mined and an unknown quantity of ore assaying 42% sulphur was shipped to the Mt Lyell company's plant at Yarraville, Victoria. Since 1948 the southern part of the block has been part of Consolidated Lease 123-47M of 359 acres (Electrolytic Zinc Co. of Australasia Ltd.).

The property takes its name from the presence of *campylite* (lead chloro-arsenate) which was at first thought to be *susannite*, a modified variety of *leadhillite* (lead sulphato-carbonate). No company was formed and all development was carried out by successive tribute parties with scanty resources who were restricted to shallow adit workings.

Two parallel orebodies striking NW were explored. The western lode was cut in an adit drive about 200 feet long and consists of up to 18 feet of pyrite with galena and cerussite. Waller (1903, p. 31) stated that two types of galena are present: a dense fine-grained variety assaying about 50 ounces of silver per ton and cubical ore carrying over 100 ounces of silver per ton. About 70 yards further east, a long adit had been driven NE and east but was blocked in 1903 about 120 feet from the portal. The eastern lode was cut about 100 feet below an outcrop of gossan and was reported by Twelvetrees and Ward (1910, p. 140) to include a broad band of loose pyrite, and 12 feet of gossan containing cerussite and campylite. Twelvetrees (1901, p. 49) was informed that the ore assayed up to 116 ounces of silver per ton. According to Waller (1903, p. 31), 20 to 30 tons of ore from this adit had been sold. In the Annual Report of the Secretary of Mines for 1921, it was recorded that a lower adit was being driven under the existing workings in the search for galena and pyrite but no details were given.

PRODUCTION

It is doubtful if more than about 40 tons of silver-bearing ore has been extracted. The metal content is estimated at 3500 ounces of silver and 20 tons of lead.

SYLVESTER MINE

In 1891, the Sylvester Silver Mining Co. N.L. held a total of 273 acres of ground on both sides of the Trial Harbour road between the North Comstock and Silver Queen Extended leases. Section 1855-91M of 40 acres north of the main workings was acquired in 1893, being part of lease 1446-87M (80 acres) which had been explored by the Kennan Prospecting Association in 1888.

At first, the company's chief workings were on section 820-87M north of Queen Creek near the boundary with the Silver Queen Extended block (187-87M). About 1893 an orebody of gossan and pyromorphite striking NNE and dipping east was cut in an adit 74 feet from the portal, and was driven on for about 290 feet. The gossan was barren at first, but passed into ore carrying much pyromorphite and cerargyrite (silver chloride) and 38 tons assaying 40% to 50% lead and 76 ounces of silver per ton were taken out (Montgomery, 1893b). At the end of the drive, gossan passed into siderite. The adit crosscut was extended to a total length of 300 feet without encountering further mineralization. A vein of galena and siderite 18 inches wide was uncovered in a winze from the adit and was reputed to contain over 100 ounces of silver per ton. A short distance to the east of the adit, a shaft was sunk to 106 feet (46 feet below adit level). There is no record of subsequent development and the workings were full of water by 1895, though Waller (1904, p. 66) remarked that the orebody had been practically worked out above the water-table.

South of this lease, a NNW striking orebody was explored in an adit and shaft south of Queen Creek on lease 1852-87M by the Sacramento Silver Mining Co. N.L. about 1890 but no details are available. The section passed to the Sylvester company in 1899 and was presumably considered unimportant. The host rocks are shattered Proterozoic slate and quartzite lying north of a branch of the Balstrup Fault.

The main Sylvester workings are near the Trial Harbour road, in the NE corner of the former lease 878-87M (28 acres) which was prospected by R. Ritchie and A. N. Allison in 1888 and transferred to the Sylvester company in 1891. Tributes were let and in 1893 two parties were at work on orebodies of galena mixed with pyrite which posed a problem in dressing. By 1895, the property was deserted and attracted little interest until the Sylvester leases were taken up by the Tasmanian Smelting Co. Ltd. in 1899. Long and deep trenches were cut in several directions but nothing of economic value was found. A tribute party obtained quantities of ore and gossan from the Main lode, a large NNE trending formation of pyrite with galena and sphalerite which had previously been worked in shallow stopes and shafts, near the Trial Harbour road (Waller, 1904). About 900 yards to the east, an adit was started with the object of draining the Main lode when intersected, and also to explore the intervening country, but the project was stopped after 100 feet. A deep trench was cut at the surface along the line of the proposed adit with disappointing results.

A total of 366 acres was held between 1909 and 1912 by A. Dobson and H. A. Smart as Consolidated Lease 901M, and leases have subsequently been taken up at intervals over different parts of the old Sylvester holdings without much success. From 1958 to 1961, 80 acres near the main workings were charted as lease 22M-58 in the names of W. C. Robinson and E. A. Tomkins. Shallow trenches and pits were cut in hard slate or shale, quartzite and greywacke forming the top of the Oonah Quartzite and Slate in the low-lying ground west of the Main lode. Several veins of quartz with pyrite, galena and sphalerite were uncovered but water prevented deeper exploration. There has been post-mineralization brecciation and movement throughout the district.

TABLE 34—Production—Sylvester Mine

	Ore (Tons)	Lead (Tons)	Silver (Ozs)	Remarks
To 1893 ¹ ..	38	17	2,888	
1898 ² ..	207	66	4,630	
1899	192			
1904	36			
1906	516	} Est. 190	19,000	Ore & gossan Ore & gossan
1907	150			
1908	50			
1950	3			
	<u>1,192</u>	<u>274</u>	<u>16,560</u>	
		<u>1</u>	<u>42</u>	

Notes:—

1. According to Montgomery (1893b), 38 tons of ore assayed from 40% to 50% lead and 76 ounces of silver per ton.

2. The Progress of the Mineral Industry of Tasmania for the quarter ending 31st December, 1898 stated that 100 tons of second class ore crushed at the Silver Queen mill yielded 20 tons of concentrates assaying 49% lead and 29 ounces of silver per ton; 82 tons of oxidized ore sold to the Tasmanian Smelting Co. contained 13.8% lead and 15 ounces of silver per ton; 25 tons of sulphide ore sold at the mine gave a return of 24% lead and 20 ounces of silver per ton.

DORIC PROSPECT

This is about $\frac{3}{4}$ mile NW of the Sylvester mine. From 1892 to 1893, leases 1563-91M and 1187-91M, each of 80 acres, were held by the Doric Silver Mining Co. N.L. Veins trending NW and NE were explored in a series of shafts and trenches about which no record is available. The area has been prospected at intervals since the company ceased work but the only record of production was in 1928 when 30 ounces of silver and 0.44 ton of lead was extracted. The host rocks are sheared black slate and pale quartzite of the Oonah Quartzite and Slate on the northern limb of an E-W anticline plunging to the east. Fragments of galena and pyrite may be seen on the old dumps but the orebodies appear to have been small and unworkable.

T.L.E. MINE

This is south of the Boss section. The old workings are near the Tasmanian tram formation, about $\frac{1}{2}$ mile east of the junction with the Trial Harbour road. An 80 acre lease, 1848-87M, was taken up in 1888 by V. Ellis but was relinquished in the following year. Later in 1889, the same area was pegged as section 2277-87M by W. W. Lamb who transferred it to the Tasmanian Land Exploration Co. Ltd. in 1891. The Main (No. 1) lode was at first worked in a shallow adit, and a main shaft was later sunk to about 110 feet at which level the lode was driven on. No. 2 lode was worked in an adit crosscut and a shaft, and the orebody was explored by trenching and pitting. Twelvetrees (1901, p. 43) was informed that hoisting equipment appeared to have been inadequate, and the company ceased work in 1894. The ground was held as lease 905-93M and 4094-93M in later years but there was no significant activity until about 1906 when C. Brumby and A. Nicholas pegged the 40 acre lease 1244M round the old workings. Taylor (1953a) noted that at this time a tributary (Hughes) obtained profitable amounts of high grade silver-lead ore from stopes in No. 2 lode, while in 1908

the Thurston tribute party discovered No. 3 lode to the west of No. 1 lode. Lack of suitable plant made it difficult to drain the workings and the lease was relinquished in 1912, to be held briefly at intervals up to 1916. The government prospecting party cut 2724 feet of trenches in 1913 near the T.L.E. and Britannia sections without success. In 1920, R. B. Hill applied for lease 8551M of 10 acres and the Z.L. Syndicate was formed locally in 1924 to dewater the workings. In the main shaft, the Main lode was examined but was found to be unworkable. A few tons of ore was raised in 1925, probably from Hughes's old workings on No. 2 lode. The area was held as the 40 acre section 32M-51 between 1951 and 1959 by R. B. Hill.

GEOLOGY

The country rocks are greywacke-conglomerate, grit, greywacke and shale considered to be part of the Cambrian Crimson Creek Formation. A short distance north of the workings, the Tenth Legion fault zone separates the beds from shattered Oonah Quartzite and Slate. To the east No. 2 lode may occupy a NNE trending fault zone.

The lodes are fissure veins of galena and sphalerite, but the latter appears to have been easily separated in mining. Assays quoted by Twelvetrees and Ward (1910, p. 145) ranged from 75.4% to 76.5% lead, and between 105 ounces and 111.8 ounces of silver per ton. Assays from No. 2 lode are reputed to have been 80% lead and 130 ounces of silver per ton (Taylor, 1953a).

WORKINGS

Main (No. 1) Lode

The orebody strikes NNE and was originally worked in an adit where it was stoped out 40 feet up to the surface. A main shaft was later sunk to 110 feet and a crosscut was driven 15 feet east to the lode. Twelvetrees (1901, p. 43) was told that the lode had been driven on north and south for a total of 275 feet and ore had been stoped out to the surface at the south end. However, Taylor (1953a) noted that, according to R. B. Hill, a drive had been put in 200 feet north of the shaft only, and no stopes were cut. Three feet of good milling ore high in silver content was recorded.

No. 2 (Hughes's) Lode

The orebody is about 220 feet east of No. 1 and is parallel with it. The workings were discussed briefly by Taylor (1953a). The lode was worked in an adit crosscut, and later from the main shaft (Taylor, 1954b). A drive 200 feet long was cut along the orebody which was stoped out to the surface, and ore with a high content of silver and no sphalerite is said to have been extracted.

No. 3 (Thurston's) Lode

The Thurston tribute party worked No. 3 lode about 1908. The orebody strikes NNW and lies west of No. 1 lode. A crosscut was driven to it from the old No. 1 lode adit, and a shoot of ore 70 to 80 feet long was worked, but nothing is known of the output.

PRODUCTION

Up to 1911, at least 300 tons of galena was extracted from the T.L.E. workings, containing about 200 tons of lead and 30,000 ounces of silver. In 1954, R. B. Hill produced 5.43 tons which included 2.8 tons of lead, 0.74 ton of zinc and 31 ounces of silver.

STONEHENGE MINE

This is situated on the flat about 200 yards south of the T.L.E. main shaft. An 80 acre lease 1886-87M was marked out by W. E. Brooks in 1888 and in 1893 the Stonehenge Silver Mining Co. N.L. was formed to work the property. Twelvetrees (1901) remarked that 3 lodes bearing NNE had been found, but only one was exploited in a shallow shaft and drive, and the company ceased work in 1894. Between 1896 and 1902, the property was re-charted three times but little work was done. A 40 acre section 3106-M was taken up in 1907 by C. Brumby and A. Nicholas, and the shaft was deepened to 60 feet. The workings were described in detail by Twelvetrees and Ward (1910, pp. 145-146). The orebody is nearly vertical, but with a variable dip, and contains pyrite and sphalerite with some chalcoppyrite, in which galena appears in bands or blebs. The gangue is of quartz and siderite. The 30 foot level was driven north and south for about 200 feet on an irregular lode formation containing an ore-shoot 5 to 6 inches wide. At 35 feet north of the shaft, the drive crossed a fault striking a few degrees north of east with a steep northerly hade which had displaced the northern part of the lode 4 or 5 feet eastwards. Some stoping was done, and almost reached the surface south of the fault. South of the shaft, the level was driven 25 feet south of the connection with an old shaft, and a shoot of galena ore a few feet long and 10 inches wide was found.

The 60 foot level was driven 110 feet north and 40 feet south and several small shoots of sphalerite and galena were cut, but work was hampered by a considerable inflow of water. The fault was also crossed in the north drive on this level.

PRODUCTION

About 45 tons of ore were raised, containing some 30 tons of lead and 2700 ounces of silver.

NORTH TASMANIAN MINE

The old workings are NE of the former Tasmanian tram, about $\frac{1}{2}$ mile SE of the T.L.E. mine. The original lease 1470-87M of 73 acres was pegged by J. J. Martin in 1888, and passed to the McClean Prospecting Co. N.L. in 1889. In the following year, the section was taken over by the Tasmanian Silver Mining Co. Ltd. as part of their extensive holdings between the T.L.E. mine and McLean Creek. Two parallel NNW striking lodes about 250 feet apart were found and exploited in shallow workings and a main shaft was sunk to 190 feet on No. 1 lode with a level at 100 feet. Pumping equipment was inadequate to control water at this depth and about 1896, the company let the lease to tribute parties who tested the lodes in trenches and shallow adits during the next few years with discouraging results. Lease 1295M of 40 acres surrounding the main workings was taken up by P. Lloyd in 1905 but was relinquished in 1910. A 10 acre block (9035M) was held by G. V. Williams, C. R. Bowling and W. Flaherty from 1923 to 1926 and the ground was last charted in the name of R. B. Hill as lease 18M-51 of 40 acres between 1951 and 1960.

GEOLOGY

The orebodies are fissure veins of galena and sphalerite in a gangue of pyrite, quartz and siderite which trend NNW through contorted and shattered shale, siltstone and quartzite of the Oonah Quartzite and Slate. Between the main shaft and the tram, the rocks are faulted against Cambrian greywacke, grit and shale.

MAIN WORKINGS

The following account is based largely on the detailed description made by Taylor (1953a) and also the report by Twelvetrees (1901, pp. 44-46).

No. 1 (North Tasmanian) Lode

In the early days of mining, a shallow adit was cut for about 200 feet and ore was stoped out to the surface. The main shaft was sunk to 190 feet with a level at 100 feet and though no details are available, Twelvetrees (1901) reported that a good shoot of galena and sphalerite was taken out up to the surface. Assays of ore sold to the Queensland Smelting Co. ranged from 61% to 76% lead, and from 44 ounces to 75 ounces of silver per ton. It is possible that the lode may have been cut in a prospecting adit about 240 feet south of the shaft, but values were poor. Taylor (1953a) was informed that in 1925, the adit was extended by A. Hill for several hundred feet past No. 1 lode and a lode was intersected which is about 2 feet wide with traces of sulphides (No. 5 lode).

No. 2 Lode

About 200 feet SW of the main shaft, No. 2 lode was worked in an adit and shallow stopes over a length of about 200 feet parallel with No. 1 lode. Twelvetrees (1901) suggested that as the NE dip is shallower than the dip of No. 1 lode, the two may join in depth and proposed that a west crosscut should be driven from the bottom level on No. 1 lode.

Horton's No. 1 Adit

The adit is 180 feet long and was driven eastwards from a point about 400 feet east of the main shaft to intersect a gossan formation about 40 feet below the outcrop. The trace of the lode was cut but nothing of value was found.

Horton's No. 2 Adit

About 500 feet north of the main shaft, the adit was driven 430 feet westwards to cut the line of No. 1 lode, without reward.

Riley's Workings (No. 3 Lode)

The lode was intersected in an adit crosscut driven 140 feet NE by the Riley tribute party about 1894 from the end of a long trench about 80 yards NE of the tram. The ore averaged only 20% lead and 40% zinc and a 16 ton parcel, when sold, failed to pay cartage costs because of the high penalty for zinc. The workings were re-opened about 1900 by two tributors who stoped out the lode to surface over a length of 80 feet. Taylor (1953a) noted that R. B. Hill and A. Hill had recently cleared a shallow shaft near the intersection of the orebody in the adit where the lode is 9 feet wide and vertical. The lode had previously been driven on for 40 feet south, beyond which point a small fault off-sets it several feet to the east. The north drive was cut 60 feet with a maximum of 30 feet of backs decreasing northwards, and in the face the lode is 2 feet 6 inches wide.

No. 3 lode may be the faulted southern extension of No. 2 lode. A series of 9 assays listed by Taylor (1954b) gave returns of 6.5% to 70.4% lead, 0.7% to 37% zinc and 1.3 ounces to 8.2 ounces of silver per ton. When sold, 5 tons 13 cwts of picked ore assayed 52.9% to 52.2% lead, 13.2% to 13.7% zinc and 5.9 ounces to 5.7 ounces of silver per ton. The ore is therefore low grade.

In 1957, 3 boreholes were put down below Riley's workings by the Department of Mines for drilled lengths of 97 feet, 98 feet and 103 feet at an angle of 55°. A few veinlets of galena, sphalerite and pyritized argillite were cut which had been displaced by post-ore faulting, and the results do not encourage further exploration here.

Government Prospecting Trench

About 80 yards north of the main shaft, a trench 1200 feet long trending N 70° E was cut across the line of No. 1 lode, probably during the government prospecting programme in 1913. Weathered micaceous shale and quartzite are exposed but no mineralization of value was found.

PRODUCTION

The amount of ore raised from the North Tasmanian mine is unknown and is included in the figures for the Tasmanian mine.

TASMANIAN MINE

The old main shaft is about 700 yards SE of the North Tasmanian workings and a short distance north of the tram. Lease 1469-87M of 65 acres pegged by L. Susman in 1888 was transferred to the McClean Prospecting Co. N.L. in the following year and in 1890 to the Tasmanian Silver Mining Co. Ltd.

The mineralized zone running NNW from the Swansea mine was explored and an adit was driven for 210 feet on an orebody. Montgomery (1890) reported that broken country was encountered at 120 feet and "the lode was not found to rise into this". Masses of galena up to 5 feet thick are said to have been uncovered. The main shaft was sunk to 72 feet, or 60 feet below the adit from which a winze was also sunk to the 72 foot level. The orebody ranges in thickness from a few inches up to 4 feet (Montgomery, 1893b) and was stoped out between the levels, but ore is patchy and contains much sphalerite. The company let the mine to a tribute party in 1895 and the shaft was sunk deeper to work a new ore shoot but work ceased a few months later.

The ground was charted several times until 1908 with little important development. In 1923, the area was taken up as section 8950M of 40 acres by the Swansea Prospecting Syndicate N.L. which was working the old Swansea mine to the south. There is no record of the activities of this group on the Tasmanian lease nor of the Swansea Silver-Lead Mining Co. N.L. which took over between 1927 and 1931. J. Hill pegged the 40 acre lease 1146M in 1933 and until he relinquished it in 1941, much exploration was carried out in trenches, shallow adits and prospecting shafts. Several small orebodies carrying up to about 5 inches of galena were exploited and useful quantities of galena ore extracted. Between 1942 and 1961, the section was held by J. J. Hill as lease 19M-42 and small amounts of ore were produced.

The northern part of the workings lies within sheared and shattered Proterozoic quartzite, siltstone and shale, which are faulted to the south against Cambrian chert-conglomerate and siltstone overlain by small patches of Permian tillite.

TABLE 35—Production—Tasmanian Mine

	Ore (Tons)	Lead (Tons)	Silver (Ozs)	Zinc (Tons)
To 1893 ¹ ..	957	Est. 575	28,700	
1933 Est.	5	3.0	282	
1934 Est.	20	13.2	1,106	
1935	11.8	8.2	823.9	
1936	37.4	27.1	2,592	
1937	24.5	17.7	1,749.8	
1938	17.4	9.2	859.5	
1940	31.4	21.3	1,731.8	
1947	20.3	9.1	625.6	4.8
1948	34.4	24.1	2,085.2	
1950	4.5	3.1	250.6	
1951	14.6	5.1	236.2	3.0
1953	5.7	3.9	256.5	
	1,184	720	41,299.1	7.8

¹Montgomery (1893b). Includes production from North Tasmanian mine and probably also from Swansea area. Average assay 64% lead and 36 ounces of silver per ton (Montgomery, 1893a).

SWANSEA MINE

This is situated about $\frac{1}{2}$ mile SE of the Tasmanian mine and about 200 yards north of McLean Creek. East of lease 1467-87M, then being explored by the Tasmanian Silver Mining Co. Ltd., section 1950-87M of 54 acres was held by H. White and M. Doody between 1888 and 1892. The section was taken up as 4007-93M by R. B. Montgomery in 1899 and it is likely that the orebodies later worked in the Swansea mine were discovered at this time. The lease was transferred to the Swansea Mining Co. N.L., in 1901 but was given up in the following year. A 10 acre lease 633M was pegged by C. Burslan in 1903 and was made over to L. Murphy in 1908. Twelvetrees and Ward (1910, p. 145) noted that a Zeehan syndicate had driven an adit for 200 feet SE on an orebody of galena and sphalerite dipping gently NE. To the east, a small shaft was sunk 60 feet and a crosscut was being driven to cut the lode below the adit. There is no record of output and the lease became void in 1911. In 1916, J. Dunn took up section 7351M of 10 acres round the workings, and in 1918 he acquired a further 30 acres (lease 8218M). A water wheel was installed to drive the pumps and underground work was resumed down to No. 2 level. The Swansea Prospecting Syndicate N.L. was formed in 1922 and the main shaft was sunk to 130 feet but operations were frustrated by lack of capital. In 1927, the Swansea Silver Lead Mining Co. N.L. was floated; a new main shaft was sunk to a depth of 156 feet, and a level was cut at 150 feet, as well as a crosscut connection to the 110 foot level in the old main shaft. The company ceased work in 1929 owing to the slump in metal prices, the lack of milling plant and disappointing results on the 150 foot level. Between 1937 and 1961, the ground was held as lease 11888M of 40 acres by J. J. Hill.

GEOLOGY

The country rocks consist of contorted hard black shale or slate, pale fine to fairly coarse quartzite riddled with thin veins of milky quartz, and a band of pale conglomerate which is well exposed in the water wheel cutting. The "volcanic ash" with

pebbles mentioned by Reid (1925c) is probably decomposed conglomerate. The beds belong to the upper part of the Proterozoic Oonah Quartzite and Slate, or the lower part of the Cambrian Crimson Creek Formation, and have been intensely faulted and shattered. While it is possible that some movement took place before mineralization, post-ore faulting of Jurassic or Tertiary age has dislocated the orebodies, for example the displacement of Murphy's lode and the Main lode described by Reid (1922d).

OREBODIES

The orebodies are fissure lodes of galena and coarse sphalerite, with chalcopyrite and a little tetrahedrite in a gangue of siderite and quartz. According to Reid (1925c), mineralization occurs as ore-shoots up to about 110 feet long coursing obliquely across a well-defined lode channel 32 feet wide, which strikes NW. In general the different minerals are not intimately intermixed and cause little difficulty in separation. Three shoots of ore have been intersected and opened up in the main workings and similar bodies occur within the lode channel between the main shaft and a prospect shaft 1050 feet to the NW.

WORKINGS

The orebodies have been tested on 5 levels: The Adit level and No. 1 (40 foot), No. 2 (80 foot), No. 3 (110 foot) and No. 4 (150 foot) levels. The workings have been described by Reid (1922d; 1925c) and by Nye (1929b). The three most important orebodies are Hill's lode, Murphy's lode and the Main lode, all of which strike generally NW with a NE dip. The first two join near No. 2 level, and on No. 3 level the Main lode appears to split into 2 veins known as the Footwall and Hangingwall lodes, of which the former corresponds to the Main lode, while the latter is a new ore-shoot. All the orebodies join NW along the strike but do not form a well-marked or persistent lode. In the upper levels, Hill's lode and Murphy's lode also join to the SE, but the Main lode appears to diverge from them. On the 110 foot level, Hill's lode, the Main lode and the Hangingwall lode apparently follow independent and parallel courses to the SE. Only one orebody was intersected on the 150 foot level driven from the new shaft. Nye (1929b) suggested that the 3 oreshoots may have joined in depth, but the orebody is not as wide, nor as rich as might be expected in such a case. Only a small amount of development work was done at this level before the mine closed and the workings are now inaccessible. The possibility of later faulting cutting out the orebodies at this depth cannot be ruled out.

TABLE 36—Production—Swansea Mine

	Galena Ore (Tons)	Zinc Ore (Tons)	Lead Content (Tons)	Silver Content (Ozs)	Zinc Content (Tons)	Cadmium Content (Tons)
To 1925* ..	2,000	1,000	1,200	32,000	470	40
1926 ... Est.	200	220	107	3,300	100	...
1929 Est.	20	...	12	330	...	...
	<u>2,220</u>	<u>1,220</u>	<u>1,319</u>	<u>35,630</u>	<u>570</u>	<u>40</u>

* Estimated by Reid (1925c). Parcels of galena ore sold assayed from 61.1% to 63.05% lead, 7% to 8.9% zinc and 15.55 ounces to 17 ounces of silver per ton. Sphalerite ores gave a return of 1.9% to 6.65% lead, 42.35% to 52.35% zinc and 1.2 ounces to 3.35 ounces of silver per ton.

SILVER DUKE PROSPECT

Little can now be seen of the small-scale workings about 1000 yards SE of the Swansea mine. The area was prospected about 1888 and the Silver Duke Mining Co. N.L. formed in 1890 held a total of 320 acres. On lease 1679-87M of 80 acres, an adit was driven to intersect the possible southern continuation of Grubb's lode but no mineralization was found. To the SW 2 adits were cut along a fault zone trending 20° south of east consisting of fault breccia up to 40 feet wide loosely cemented by quartz and siderite, and including fragments of galena, sphalerite, pyrite and chalcoppyrite. SW again on section 1677-87M, several shallow shafts and trenches were cut on the line of the Tasmanian Main (or McLean's) lode but nothing of value was uncovered and the company relinquished the leases in 1892 without producing ore. Section 1679-87M was taken up as lease 1298-93M by J. Robertson and J. Owen in 1896 but was later transferred to R. Beeston and surrendered in 1898.

The country rocks consist of shattered Proterozoic quartzite and slate which are faulted to the SW against Cambrian siltstone and greywacke intruded by pyroxenite, and to the south against Ordovician Mt Zeehan Conglomerate. Much of the ground is covered by conglomerate talus or Quaternary gravel, sand and clay. Reid (1922d) reported the presence of the nickel-bearing minerals *genthite*, *millerite* and *pentlandite* in the pyroxenite, but they are unlikely to be of economic interest.

TABLE 37—Total Production—Comstock District

Mine	Galena Ore (Tons)	Zinc Ore (Tons)	Lead Content (Tons)	Silver Content (Ozs)	Zinc Content (Tons)	Remarks
Comstock & S. Comstock	4,021	3,245	1,625	165,000	2,100	
Silver Stream	400	....	165	9,200	....
Boss	700	....	70	6,500	....	Low grade
Susannite	40	....	20	3,500	....
Sylvester	1,192	....	274	26,560	....
T.L.E.	305	....	203	30,031	1	
Stonehenge ..	45	....	30	2,700	....
N. Tasmanian & Tasmanian	1,184	....	720	41,299	8	
Swansea	2,220	1,220	1,319	35,630	570	Cadmium 40 tons
	<u>10,107</u>	<u>4,465</u>	<u>4,426</u>	<u>320,420</u>	<u>2,679</u>	<u>40</u>

CONCLUSIONS

In this district, lenses, irregular bands and shoots of galena and sphalerite are scattered through lode channels which may be well-defined though the ore-shoots themselves are often impersistent and variable in width. Both the galena and the sphalerite may be coarse-grained and separation would not be difficult. In most of the mines and prospects, the topography is unsuitable for adit workings, and the orebodies must be worked from shafts equipped

with adequate pumps to control the heavy inflow of water. The small companies which formerly operated on the field invariably lacked capital to install suitable equipment and the workings were therefore shallow, the deepest being the North Tasmanian main shaft (190 feet).

RECOMMENDATIONS

Comstock Mine. The south part of the Main lode and Allison's (East) lode have already been extensively explored in the workings and in boreholes, with disappointing results. Little is known of mineralization below 100 feet between the Main shaft and Whitelaw's shaft, near the northern end of the Main lode. The orebody is vertical or dips steeply to the east and boreholes should be drilled east of Comstock Creek. Suitable sites are shown on Figure 13. At No. 1 site, a hole declined at 60° south of west should intersect the line of lode at a depth of about 200 feet below the surface (100 feet below Whitelaw's shaft) after a drilled distance of about 250 feet. No. 2 hole should be drilled in a similar direction at an angle of 50°, to cut the orebody at a depth of about 200 feet after a drilled distance of 250-300 feet. If encouraging mineralization were found, a third hole might be drilled east of Comstock Creek between the first two holes.

Orebodies in other mines and prospects in this region are small and irregular and further exploration is not warranted at the present time except on the Main lode in the *Boss mine* which has not been tested below a depth of 30 feet.

NORTH ZEEHAN: MISCELLANEOUS

The area west and north of the Montana Silver-Lead mine was extensively prospected from 1888 onwards by J. J. Martin, J. Adams, W. McLoughlin, J. Clark and others. The Silver Hills Proprietary Silver Mining Co. N.L. was formed in 1888, and the Colorado Silver Mining Co. N.L. in 1890. Although their holdings were extensive, work stopped after a few years. The Silver Hills company's leases were taken over by the North Western Silver Mining Co. N.L. in 1893 but were abandoned once more in 1895 and it is not known if any ore was produced. In later years, small pyritic orebodies containing galena were discovered but only small quantities of ore were extracted. Several pyritic lodes containing little galena were discovered during the government prospecting programme in 1913 when at least 2000 feet of trenches were cut and a number of shallow shafts were sunk to about 7 feet. Prospecting continued after World War I and the Big Ben lode was discovered about 1922 while from 1935 to 1936 a prospecting party of 4 men cut over 1000 feet of trenches west of the Montana Silver-Lead mine. In 1950, the Electrolytic Zinc Company of Australasia Ltd. drilled 3 boreholes totalling 1303 feet to test the Big Ben lode but only traces of mineralization were found. Electromagnetic, self-potential and magnetic surveys supported by geochemical testing were carried out in 1954 by the Bureau of Mineral Resources, Geology and Geophysics over the country west of the Corinna road and north of Queen Hill. A number of NNE trending electro-magnetic anomalies were picked up near Barnett's and Quigley's workings but were shown by subsequent trenching to be due to graphitic slate and not mineralization.

GEOLOGY

The country rocks include sheared and faulted slate or hard shale, siltstone and pale grey quartzite assigned to the Proterozoic Oonah Quartzite and Slate. The beds are part of a complex anticlinorium which plunges to the SE, and near the Big Ben mine a thin cover of Permian tillite has been preserved in a down faulted block. The orebodies are irregular veins or lenses of pyrite with galena or sphalerite in a gangue of quartz and siderite striking generally north or NNE with steep dips. Recorded assays of the galena ore gave returns of about 60% to 70% lead and from 42 ounces to 111 ounces of silver per ton.

WORKINGS

The most important workings were the Big Ben mine, Barnett's prospect and Quigley's prospect. About ten years ago, several adits and costeans were cut by S.A. Clark on lease 101M-47 (20 acres) in an unsuccessful search for the possible southern extension of the main lode in the Montana Silver-Lead mine.

BIG BEN MINE

This is about $\frac{1}{4}$ mile west of the Montana Silver-Lead mine. The orebody was discovered by G. Clarke and L. C. Blacklow on section 8912M of 20 acres in 1922. In 1926 the lode was developed by the West Coast Silver Lead Co. in an underlay shaft 47 feet deep and a drive, but worked ceased in 1927 owing to low metal prices and the property passed back to Clarke and Blacklow. In 1928, government assistance was offered on a pound for pound basis to deepen a vertical shaft from 38 to 100 feet but the lessees were unable to take up the offer and the lease was relinquished in 1931. Special Prospecting Licence No. 221 of 1440 acres was taken up by the Electrolytic Zinc Company of Australasia Ltd. in 1950, and after geological mapping 3 holes were drilled to test the Big Ben lode to a depth of 200 feet over a length of 500 feet but the shoot of ore mined in the workings did not continue in depth.

The workings have been described by Nye (1929c) and some details were also given in the annual reports of the Secretary for Mines between 1923 and 1929. A vertical shaft was sunk through Permian tillite to a depth of 38 feet but no drives appear to have been cut from it. An underlay shaft was put down through faulted slate and quartzite to a vertical depth of 47 feet at which level the orebody was driven on for 200 feet NNE. The lode dips at 60° to the east and two shoots of ore were uncovered, each about 60 feet long and separated by 60 feet to 70 feet of faulted lode material of variable grade. South of the shaft, the orebody is said to be 3 feet wide in the face. In 1929, 37 tons of ore were extracted from a winze of unknown depth on the 47 foot level before the mine closed down.

Hanlon's adit was driven for 100 feet WNW and a winze and stopes were cut through to the 47 foot level about 20 feet below. In the adit the Big Ben lode has split into 2 veins about 10 feet apart.

TABLE 38—Production—Big Ben Mine

	Ore (Tons)	Lead (Tons)	Silver (Ozs)
1923	Est. 310	53.74	8,462.66
1924		29.72	3,209
1925		8.40	6,235.80
1926		49.25	6,200
1928		17.84	1,806
1929		37	25.00	3,127
1935	1	0.40	97
	348	184.35	29,137.46

Note: Only handpicked galena ore extracted; assayed 70% lead and from 105 ounces to 111 ounces of silver per ton (Nye, 1929c).

CONCLUSIONS

Workable ore is present only in small and irregular ore-shoots which do not persist in depth and they are therefore of low economic value.

BARNETT'S WORKINGS

These are near Barnett Creek, about 1½ miles NW of the Zeehan-Western mine. The first lease taken up in the district was section 931-87M of 50 acres charted in 1888 in the name of J. Adams. The block was acquired by the Colorado Silver Mining Co. N.L. in 1890 but was abandoned later that year. Leases were pegged between 1890 and 1897 and although much prospecting was done, no details are known. In 1898, the North Oonah Mining Co. N.L. took over section 2448-93M of 13 acres from W. F. Deeble and a shaft was sunk near the south bank of Barnett Creek, but work ceased in 1899. A 52 acre lease (3835M) was taken up in 1908 by C. H. Barnett who obtained £120 worth of ore from a SSW drive 60 feet long (Twelvetrees and Ward, 1910, p. 137). After his death, the Zeehan-Montana company carried on but results were not encouraging. A rise and winze in the drive proved that the lens of ore was not more than 30 feet long and 10 feet high, pinching out southwards into a thin brecciated pyritic vein. The lode consists of quartz, pyrite and galena with some siderite; northwards galena is replaced by sphalerite. Solid pyrite was found in a vertical shaft sunk 37 feet on the orebody.

During the government prospecting campaign in 1913, over 2000 feet of trenches were cut in the vicinity and pits were sunk on pyritic orebodies but little galena was found. One pyritic formation was intersected 18 feet below the outcrop in a short adit without success.

In later years the area was prospected by T. Brown, G. Clarke and A. Cornish, and from 1929 to 1930 the 40 acre lease 10001M was charted in the name of J. A. Duff. A tribute was held between 1933 and 1935 by C. H. Bell and S. G. Bell who sank a shallow shaft with financial assistance from the government. Lease 17M-45 of 40 acres was taken up by W. E. Higgins in 1945 and transferred to R. S. Laffer in 1949. Development work carried out in 1949-1950 was described in detail by Taylor (1950d). The adit cut in 1913

(No. 2 drive) was apparently driven a total of 200 feet and orebodies intersected at 30 feet and 176 feet were driven on for short distances. Laffer's party extended the northern drive on the latter orebody to a distance of 36 feet but little galena was found, and only traces were discovered in 3 boreholes drilled on the property. The lease was given up in 1951.

TABLE 39—Production—Barnett's Workings

	Ore (Tons)	Lead (Tons)	Silver (Ozs)	
To 1910	20	12	Est. 900	
1933 Est.	60	29	3,590	
1934 Est.	20	7.6	1,234	
1935	13.9	9.1	1,157.8	Prill ore and concs.
1949	5	2.7	350	
	<u>118.9</u>	<u>60.4</u>	<u>7,231.8</u>	

Note: Ore sold to 1910 assayed 60% lead and 45 ounces of silver per ton (Twelvetrees and Ward, 1910, p. 138).

CONCLUSIONS

The orebodies are small and irregular, with impersistent masses or aggregates of galena, and are of little economic importance. Anomalies indicated by the geophysical survey in 1954 are chiefly, if not all, due to bands of graphitic slate in the host rocks.

QUIGLEY'S WORKINGS

These are about $\frac{1}{4}$ mile NNE of Barnett's workings. The lode is up to 3 feet wide and it may be the northern extension of Barnett's lode. If so, its course has changed to a northerly direction. In 1908, lease 3797M of 40 acres was pegged by A. D. Sligo and the workings were described by Twelvetrees and Ward (1910, p. 139). An open drive was cut south of the lode for 20 yards from a track which joins the Corinna road about $\frac{1}{2}$ mile to the east. It was connected with an adit 50 feet below driven about 20 yards through black slate to intersect the orebody where some stoping was done. It was stated that 9 to 10 inches of galena were found at this point and that the ore-shoot pitches to the north. The lode appears to have been driven on for at least 40 feet but no galena was visible. The galena occurs with a little sphalerite and chalcopryrite, associated with pyrite, siderite and quartz; according to Twelvetrees and Ward (1910), the ore assayed 62% lead and 42 ounces of silver per ton.

The workings were included in lease 8896M of 40 acres between 1922 and 1930 and during this period T. Brown and G. Clark produced small quantities of ore, chiefly from shallow workings on a western vein. In Quigley's old adit, the eastern orebody was driven on southwards with poor results. The property was held as lease 11904M of 71 acres (J. H. C. Reid) between 1937 and 1939.

TABLE 40—Production—Quigley's Workings

	<i>Ore</i> (Tons)	<i>Lead</i> (Tons)	<i>Silver</i> (Ozs)
1912	8.32	Est. 5	340
1913	30	Est. 18	1,260
1925	13.43	9.47	1,154
	<u>51.75</u>	<u>32.47</u>	<u>2,754</u>

CONCLUSIONS

As in Barnett's workings, the veins are small and impersistent, and further exploration is unwarranted.

TABLE 41—Total Production—North Zeehan Area

	<i>Ore</i> (Tons)	<i>Lead</i> (Tons)	<i>Silver</i> (Ozs)
Big Ben mine	348	184.35	29,137.46
Barnett's prospect	118.9	60.40	7,231.80
Quigley's prospect	51.75	32.47	2,754
	<u>518.65</u>	<u>277.22</u>	<u>39,123.26</u>

DUNDAS DISTRICT

Introduction

The first lease was pegged in this district by G. Lambie about 1887 and the first galena discovered on New Years Day 1889 by G. Lambie and J. Davies. By 1890 when Montgomery visited the field a considerable area had been pegged but not much work had been done though a road from Zeehan was being constructed. In the next few years Dundas was connected by a branch line to the Zeehan-Strahan railway and several companies were operating mines, the most important being the Comet, Maestries, West Comet, Adelaide, and South Comet. With the exception of one mine, production on the field had practically ceased by 1913. Between 1929 and 1949 small amounts of ore were extracted from the South Comet, but elsewhere only minor activity, including retreating old mine dumps, has taken place. In recent years, A. R. Smith has produced specimens of crocoite from the Adelaide mine for sale to collectors.

Location and Access

The old mines and prospects lie chiefly on the foothills of Mt Dundas east and SE of the former township of Dundas.

Tracks or old tramway beds provide access for 4-wheel drive transport to the Adelaide, West Comet, Comet and Maestries mines but a small bridge over Comet Creek has now collapsed so that at present the South Comet mine is accessible on foot only.

General Geology

The oldest rocks are the Concert Schist (? Older Proterozoic) which is overlain, probably discordantly, by the Oonah Quartzite and Slate (Upper Proterozoic) followed, without evidence of a major

unconformity, by Cambrian purple, grey and greenish-grey siltstone, greywacke and conglomerate. The upper part of the Cambrian sequence is the fossiliferous Dundas Group, known to be Middle Cambrian at Dundas. The succession was intruded by serpentinites, probably in late Cambrian times.

During the Devonian Tabberabberan Orogeny, the beds were folded into a dome, upon which minor NNE or NNW trending folds were superimposed, both in Upper Proterozoic and Middle Cambrian formations. Mineralization was partly controlled by intense faulting and shearing along NNW and NNE trends which provided channels for mineralizing fluids. It was probably genetically connected with the intrusion of the Middle Devonian granite of the West Coast. Faulting took place during the Tertiary or Jurassic.

At Dundas, most of the orebodies are emplaced on the SW side of the dome, chiefly within Upper Proterozoic rocks, lower part of the Cambrian sequence or within dolomitized serpentinite.

Orebodies

Many of the lodes are fissure lodes occupying shear or fault zones; a number of lodes are replacement bodies in dolomitized serpentinite. The upper parts are generally oxidized to ferromanganese gossan derived from manganiferous siderite gangue.

Mineralogy

Reid (1925a) recognized two chief types of lode, though one type may grade into the other:—

1. Argentiferous galena. Low in sphalerite. Pyrite may be present. Gangue of siderite, e.g., Comet, Maestries, Adelaide, West Comet and Red Lead mines.
2. Galena-sphalerite. Gangue of siderite, (?) pyrite, e.g., S. Comet, Kosminski mines.

Mines and Prospects

COMET-MAESTRIES MINE

This is situated about a mile east of the town of Dundas, south of Maestries Station and north of Comet Creek. The Comet leases were first pegged in 1888 as sections 1794 and 1796-87M by W. Johnstone and J. Carnahan respectively. Early in 1889, J. Maestri and P. Bear found "canary ore" (mainly cerussite) on what was pegged as leases 2355 and 2356-87M, and in following it up came on a big lode of galena and cerussite with iron and manganese. Leases 2355 and 2356-87M were worked by the Maestri Broken Hill Silver Mining Company, the workings being in the SW part of lease 2356-87M. The orebody ran NNW into the NE part of lease 1796-87M where it was worked by the Comet Silver Mining Company. In 1895 the Maestries Company let their mine on tribute to the Comet Company, and in 1900 sold it to them outright. The Comet Silver Mining Company ceased operations in 1904, but the mine was worked for some years by tributors. Underground work ceased in 1907. From 1905 till 1913 the mine was worked mainly by open-cutting for ferromanganese gossan used as a flux at the Zeehan Smelters. Since then, small quantities of concentrates have been won by re-working the old dumps. In 1925, Reid (1925a) reported that part of the original leases was held as two 20 acre sections, 7632 and 7633M, by A. G. Omant and in 1947 the area was held by C. L. Hills. At present an area to the north of the old working is held by W. J. Hodge.

Montgomery (1891; 1893b; 1895) reported on the early development of the mine and the account of the Maestrie Broken Hill Company's workings given below is taken mainly from his reports. Later reports on the area were made by Reid (1925a), Finucane (1947) and McKenna (1958).

GEOLOGY

The country rock consists of dark shale, siltstone and micaceous grit, correlated with the Oonah Quartzite and Slate, which have been folded along an axis trending a few degrees west of north. Mineralization appears to have taken place in lenses along a shear zone where partly dolomitized serpentinite has suffered replacement.

MINERALOGY

The orebody consists mainly of argentiferous galena associated with secondary lead minerals, the most important being cerussite. Gangue minerals are siderite and dolomite. As the area is deeply cut by gullies, oxidization has taken place to a considerable depth and none of the mine workings appear to have penetrated below this zone.

MAESTRIE BROKEN HILL MINE WORKINGS

These consisted of a Main Tunnel which passed through the E-W spur on lease 2356-87M from south to north, an intermediate adit level and a lower level at 14 feet and 33 feet respectively below the Main Tunnel and connected with it by a winze. There were also a Main shaft which connected all levels, another shaft sunk on the gossan outcrop and a short adit about 18 feet above the Main Tunnel driven into the gossan outcrop.

Main Tunnel.—The entrance was in lode material consisting of galena and cerussite associated with iron and manganese which was stoped out for 65 feet from the portal. The adit was driven for 441 feet on a bearing of N 13° E and then branched, one branch going N 37° E for 210 feet. The other branch was driven NW for 246 feet where it connected with a shaft sunk in gossan, then N 17° W for 236 feet to daylight on the northern side of the spur. At 90 feet from the portal, a vein of galena varying from $\frac{1}{2}$ inch to 2 feet wide was driven on SE for 60 feet. At 120 feet, a band of siderite was struck running NNW, the general direction of all ore shoots met with up to that point. After passing through this band the general direction was almost E-W. In the NE branch a small lode was cut 85 feet from the end of the drive. It contained iron, manganese and a little silver and was followed almost due east for 78 feet. In the NW branch, "lodestuff" was met at 155 feet from the junction, the wall of the lode striking N 30° E. Two small seams of "canary ore" were passed through, one of which ran N 10° W across the drive.

Intermediate Level.—An adit was driven from the creek bed 14 feet below the main tunnel and connected with it by a winze put down from near the entrance of the latter. From the winze, drives went east for 30 feet and then northward, NW towards the Comet boundary, and north for 154 feet. All of these workings were in ore.

Lower Level.—This was 33 feet below the main tunnel and at the bottom of the winze. The main drive at this level ran N 30° W following a 12 feet wide shoot of ore nearly to the Comet boundary, passing under the mouth of the main tunnel. It was connected later with the No. 2 level of the Comet mine.

Other Workings.—From a point east of the main tunnel and 169 feet from its entrance, a shaft was put down and connected with the main tunnel at 93 feet and the lower level at 126 feet. It met the lode at 60 feet from the surface. Another shaft was put down in gossan and connected with the main tunnel 236 feet from its northern portal. A short adit was driven on a vein of "canary ore" which passed into galena at about 12 feet. This was about 18 feet above the main tunnel and was probably the original adit driven by Maestri and Bear.

COMET MINE WORKINGS

This mine was worked separately till 1895 and then in conjunction with the Maestrie mine. Finucane (1947) compiled a review of the workings taken from Montgomery's reports and the company's reports and plans, and his report is the main source of the following summary.

No. 1 adit (No. 1 level) was driven north for 364 feet from a point 145 feet west of the entrance to Maestrie's main tunnel on the south side of the E-W ridge crossing both properties. It was in lode material all the way and ended in a zone of very broken country rock. A winze was sunk 27 feet back from the end and connected with an intermediate level and No. 2 level, respectively 21 feet and 37 feet below.

No. 2 adit (160 foot level) was driven from the north side of the ridge southward for 712 feet without meeting the lode. At 385 feet in, a break or fault was met striking N 25° W, dipping SW and carrying considerable water. At 644 feet a crosscut was put in eastward to the winze from No. 1 adit and then on to the Maestrie's boundary. This crosscut met the lode 150 feet from No. 2 adit. Two drives went northward from the crosscut, one for 183 feet from a point 295 feet along it, and the other for 110 feet from the end of the crosscut. Both were in gossan. In the first, soft slate was met at about 140 feet and also at the end of the drive. Another drive went southward for 130 feet along the Maestrie's boundary from the end of the crosscut, meeting a shoot 3 feet wide of cerussite and "canary ore" at 50 feet. Montgomery noted that the strike of the rocks in the No. 2 adit and east crosscut was nearly at right angles to the usual strike in the district.

A *main shaft* was sunk from the top of the ridge about 35 feet SE of the junction of No. 2 adit and the east crosscut. It was connected with No. 2 adit at 160 feet and a drive went east at 260 feet.

The 260 foot level (No. 2 level) was more or less parallel with the east crosscut from No. 2 adit. It struck a burst of water at 100 feet and the lode at 190 feet. From there the lode was worked in a SE direction from stopes, winzes and an intermediate level 40 feet above the No. 2 level. The orebody extended for 250 feet from No. 1 winze to No. 4 winze and consisted of ferruginous gossan with veins, slugs and seams of solid galena. The level was extended into the Maestrie's lease and another shoot of ore appears to have been worked there. A long drive was put in to the NE from about 190 feet from the shaft. This was in gossan containing galena but no definite orebodies.

The 335 foot (No. 3) level was driven from the shaft to the SE and worked the same orebody as those worked from No. 2 level. It was extended towards Kozminsky Hill and terminated in a crosscut in dolomite. A NE crosscut in gossan in the same area as that from No. 2 level was continued on a NW bearing and considerable gossan was stoped out.

The 400 foot (No. 4) level worked an orebody intersected 51 feet below the No. 3 level while sinking the main shaft. The level was driven easterly and passed through the lode at 15 feet, from which point to 84 feet from the shaft the drive was in dolomite without mineralization. At 84 feet the drive entered the Comet-Maestries main lode and turned southward along it. It connected with two winzes from No. 3 level, but the ore was poor and after 1899 no more low level development was carried out, though work continued at higher levels and the orebody below No. 3 level was still worked from winzes and intermediate levels.

Joint Shaft.—The Comet, Maestrie's and Kozminsky Companies combined in 1893 to sink a shaft in Section 1796-87M about 38 feet SW from the SW corner of lease 2356-87M. It did not go as deep as the Comet No. 2 level and bottomed on dolomite and soft pug at 120 feet from the surface without finding mineralization.

Other Prospecting Work.—Towards the northern end of the Comet property a prospecting shaft was sunk to 70 feet and cross-cuts were driven 252 feet east and 122 feet west without finding any lead mineralization and only a little iron.

Open Cut Workings.—These consisted of two main groups, the northern Comet group and the southern Maestries open cut, extending intermittently over 1300 feet in a NNW-SSE direction. The Comet group of workings extends for 830 feet, and gossan was extracted to an average depth of 10 feet over widths ranging from 15 feet to 30 feet. About 80 feet south of this area, a shallow adit was driven into a hard gossan outcrop. The Maestries open cut is 150 feet long and two bands of ferruginous gossan have been mined to a maximum depth of 40 feet. The wider band was 40 feet wide and is separated from the narrower, western band by about 25 feet of quartzite.

PRODUCTION

Records are incomplete but statements have been compiled from various sources by Finucane (1947) and McKenna (1958). The most recent attempt at estimation, based on all previous reports, is that of MacLeod (1962) from which the following estimation is taken:—

TABLE 42—Production—Comet-Maestries Mine

	Ore (Tons)	Lead (Tons)	Silver (Ounces)
Ore of grade 26%Pb and 35 oz Ag/ton, including a small amount of grade 58% Pb and 38 oz Ag/ton	9,000	2,500	316,000
Lump galena assaying 65% Pb and 41 oz. Ag/ton	9,000	5,850	369,000
Second grade ore averaging 12% Pb and 8 oz Ag/ton	75,000	9,000	600,000
Ferromanganese gossan, mined as flux, assaying 5% Pb and 2.5 oz. Ag/ton	90,000	4,500	225,000
	<u>183,000</u>	<u>21,850</u>	<u>1,510,000</u>

RECOMMENDATIONS

A possible northern extension of the Comet-Maestries lode is indicated by the frequent wide gossan outcrops between the northern open cut and the hills north of the Dundas Rivulet. Drill holes to explore this possible extension at a depth of 150 feet below the surface should be sited between the northern open cut and the Rivulet, as recommended by MacLeod (1962).

SOUTH COMET AREA

The area, including the old Great South Comet workings, was mapped recently by B. L. Taylor (1950) and D. McKenna (1958). Much of the information in this account was supplied by Taylor.

The workings are situated on the southern slopes of South Comet Hill, immediately south of South Comet Creek and about 1½ miles south of the Maestries Station on the old Dundas Tram.

The South Comet area was first taken up by lease in 1911 when the Comet Tribute Prospecting Syndicate N.L. pegged leases 5628M and 5629M, each of 20 acres. These were consolidated by the Syndicate the next year into lease 6459M of 40 acres, which during the next twenty years was held by various interests, South Comet Lead-Zinc Mine N.L., J. McDonald and W. Hutchins, and R. V. Wilson. During 1927, a flotation plant was constructed to recover lead and zinc. This ceased in 1928 due to unsuccessful operation of the plant and lack of capital. In 1936 the lease was held by E. M. and A. A. Griffiths as 10559M. J. M. McDermott acquired the lease in 1946 as 19M/46 and in 1948 the Cuni Mining Co. commenced construction of an access road and concentrating mill. Some ore was produced in 1949 but the lease was abandoned again in 1950.

GEOLOGY

The orebodies occur wholly within the Dundas Group of Middle to Upper Cambrian age and are associated with a transcurrent fault which courses SSE. On the crest of the ridge is a prominent outcrop of breccia-conglomerate with narrow bands of sandstone and grit. The breccia passes downward into coarse and then fine greyish yellow micaceous sandstone. On the western side of the lease occur narrow banded light and dark grey siltstone, the individual layers of which show fine laminations. This siltstone is well developed along Adelaide Creek where it strikes from NE to east and dips south at 40° to 60°.

A sinistral fault runs WSW along South Comet Creek, north of which the Oonah Quartzite and Slate is moved westward.

MINERALOGY AND OREBODIES

The mineral constituents of the lodes are essentially galena and sphalerite, with minor amounts of jamesonite, pyrite and chalcopyrite, in a gangue of siderite. The galena and sphalerite normally occur in distinct bands, with practically no intergrowth and, in the past, zones of galena have been stoped out of the lodes leaving zinc-rich bands. Assays show minor amounts of silver present, but no silver mineral has been identified.

Three well defined zinc lead lodes have been developed striking NNW. In general they maintain fairly straight and parallel courses but pinch and swell in places. The walls are well defined and sometimes marked by several inches of blue pug but the ore is not always confined to the lodes, and wall rocks often contain stringers and blebs of ore.

In most parts of the mine, the lodes dip west at an average of 65° but local variations occur and in No. 1 East Crosscut, the No. 1 lode dips east at 85°. The width of the lode zone is variable and has been measured in three places as 60 feet, 35 feet and 20 feet, but the average width is probably between 40 and 50 feet. Within this zone, the individual width of the lodes also varies but the average widths are probably: No. 1 Lode, 3 feet; No. 2 Lode, 3 feet; No. 3 Lode, 4 feet. Shoots of galena, sphalerite and sometimes mixed ore occur throughout the lodes, but usually only the lead-rich shoots have been stoped.

WORKINGS

The following account of these adit workings has been taken from Taylor (1950).

No. 1 *Adit* commenced 25 feet above South Comet Creek and was driven SSE along the lode zone. At 180 feet from the portal, No. 3 lode was intersected and followed. At 850 feet in, a rise followed the lode for a vertical distance of 130 feet. Ten feet past the foot of the rise, the roof of the drive has fallen and it is not known how far the drive went past this point. At 520 feet from the portal, No. 1 *West Crosscut* was driven for 172 feet without sign of lode material. At 30 feet north of the foot of the rise, No. 2 *West Crosscut* cut No. 3 lode and continued 30 feet in country rock, but the actual length could not be measured owing to blockage. In 1950 work was in progress with the object of bypassing the blockage and driving on the main lode. No. 1 *East Crosscut* was driven 44 feet from a point opposite the entrance to No. 2 *West Crosscut*. At 18 feet from the entrance a 9 inch pyritic lode (No. 2 lode) was cut. At 34 feet No. 1 lode was cut and a north drive, 21 feet, and a south drive, 26 feet, were put in on it. Six stopes, rising to a height of 31 feet, were put in along the main drive.

No. 2 *Adit* was driven SSE for 40 feet from a point 280 feet SE of and 122 feet higher than No. 1 portal. The lode material found was very poor.

No. 3 *Adit* was driven SSE from a point 440 feet SE of and 210 feet higher than No. 1 portal. At 110 feet from the portal, No. 1 lode was cut and followed for 210 feet from which point a crosscut went west to No. 3 lode and was driven on it for 140 feet. At this point the roof has collapsed. At No. 1 lode a drive went northwards for 46 feet. Twenty feet from the end of this drive a rise was put through to the surface. The main drive followed the lode 46 feet beyond the crosscut to No. 3 lode. At 200 feet from the portal, No. 3 *West Crosscut* was driven 34 feet and revealed the presence of Nos. 2 and 3 lodes in short drives. At 320 feet from the portal, No. 4 *West Crosscut* also showed these two lodes. In 1950 a winze was being sunk to connect with the rise from No. 1 *Adit*. According to Reid (1925a) the drive went at least 145 feet beyond the point of collapse. Almost the whole length of the exposed portion of the drive was stoped out.

No. 4 Adit was driven SSE almost straight for 143 feet from a point 670 feet SE of and 350 feet higher than No. 1 portal. At 78 feet in, a chamber was cut in the east wall and a winze sunk 50 feet deep but no stoping was done.

Nos. 5, 6 and 7 Adits all occur in the lode zone at or near the level of Adelaide Creek. Nos. 5 and 6 adits are on the north side of the creek at creek level and 12 feet above respectively. They are both inaccessible but the sizes of the dumps indicate lengths of 100 feet or less. No. 7 adit was driven 30 feet from creek level into the south bank.

PRODUCTION

Total production of ore from these workings is not known but it is believed that at least 27,718 ounces of silver, 428 tons of lead and 618 tons of zinc have been produced.

KOSMINSKY MINE

This prospect, it is little more, lies between the Comet-Maestries and South Comet Mines and probably is part of the same lode system. In spite of the small extent of the workings the lease has been taken up many times since it was first pegged by James Davis and later Abraham Kosminsky in 1890 as 2297-87M of 76 acres. The following is a list of lessees since that time until 1940, since when the ground has not been held.

Lease No.	Acres	Lessee	Dates
2297-87M	76	J. Davis	1890
		A. Kosminsky	1890-1894
		New Kosminsky	
		Silver Mining Co.	1894-1909
		N.L.	
5324M	40	R. Rowland	1911-1912
7376M	74	C. W. Platt	1916-1917
		G. Ahern	1917-1924
9198M	74	J. J. Hill	1924-1926
9648M	74	J. Thurstars	1926-1927
		Washington Silver- Lead Mining Co.	
		N.L.	1927-1929
10559M	74	H. D. Marsh	1929-1931
11939M	44	E. M. Griffiths	1937-1940

GEOLOGY

The lodes occur in black graphitic slate and quartzite correlated with the Oonah Quartzite and Slate which strike at 10° and dip to the west at a high angle (Reid, 1925a). These rocks are separated from the Dundas Group rocks of the South Comet area by the fault which strikes along South Comet Creek.

OREBODIES

According to Reid (1925a) the orebodies consist of two parallel lodes striking N 35° W and dipping SW at 65°. They are terminated to the south by the fault striking along South Comet Creek and probably represent the faulted continuation of the South Comet lodes, as they are composed of galena, sphalerite, quartz, siderite,

pyrite and minor chalcopyrite. The western lode has been traced on the surface nearly twenty chains but it is erratic in width. The eastern lode is wider but the percentage of economic minerals is probably small.

WORKINGS

The western lode was opened by adits on three levels, 40-50 feet apart. The lowest adit (No. 3) is a little above creek level and is 300 feet in length. Rich ore shoots are small and erratic but the average grade improves along the adit until at 300 feet the lode is laterally displaced and its continuation has not been sought. Adits 1 and 2 are both believed to be short but it was reported (Reid 1925a) that in No. 2 a shoot of ore 18 inches wide and 100 feet long consisted of half galena and sphalerite and half quartz, mangano-siderite and pyrite. In 1890 a shaft 40 feet deep was also sunk on this lease.

PRODUCTION

Very little ore has been taken from this mine and an estimate of 20 tons containing 480 ounces of silver and 10 tons of lead in 1901 probably represents the major part.

CONCLUSIONS

The three groups of workings, Comet-Maestries, Kosminski and South Comet, should be regarded as one large low grade orebody containing ores of both lead and zinc with a variable but significant silver content. The lodes have been displaced by faulting between the various properties but within these limits efforts should be directed to proving an orebody of considerable length and width and varying grade which could be developed when the economic climate for these metals is favourable.

ADELAIDE MINE

The Adelaide Mine, with which may be incorporated the former Red Lead Mine and Anderson's Prospect, lies about 1 mile SE of Dundas township. A former small silver and lead producer, the Adelaide is now a source of the rare mineral crocoite, and specimens for collectors are currently obtained from this mine.

This area was first taken up by T. Anderson in 1890 as lease 2302-87M and next year was acquired by the Adelaide Pty. Silver Mining Co. N.L. who commenced driving on the principal lode. By 1893 a good deal of tunnelling had been done without much result so a shaft was sunk to 176 feet and levels opened at 116 feet and 170 feet.

In 1895 the mine closed down. The property was held in 1897-1900 by Adelaide Silver Mining Company, 1900-01 by C. Kingsley, 1901-14 by E. J. Burgess, 1905-06 by C. E. Riley and W. Ryan, 1906-07 by J. W. Hodge, 1907 by T. J. Dyson and 1907-1910 by Northern Territory Mines of Australia Ltd., but very little work was done. In 1908 a third level was opened at 220 feet and the shaft was sunk to 309 feet. The following year saw the extension of No. 3 level, the opening of No. 4 level at 271 feet and limited stoping between Nos. 2 and 3 levels. In 1910, No. 5 level was opened and No. 4 level was extended.

After this, the mine apparently closed down. In 1911 the adjoining property, Anderson's Section, through which passes a continuation of the same lode, was purchased and part of the workings unwatered, but very little further development occurred. There was some production of ore up until 1915, when again the mine closed. The leases have been held since by the following interests: 7755M, 10 acres, 1917-1924, Comet Tribute Prospecting Syndicate N.L.; 9827M, 10 acres, 1926-1929, South Comet Lead and Zinc Mines N.L.; and 9827M, 10 acres, 1929-1930, J. McDonald and W. Hutchins; 47M/57, 10 acres, since 1957, A. R. Smith.

GEOLOGY

The striking surface gossans which led to the development of the Adelaide and Anderson's Lode lie about the contact of an ultrabasic intrusion, now almost completely serpentinized, into the Oonah Quartzite and Slate.

OREBODIES

Like many of the orebodies of the Dundas Field, these show a very prominent surface expression of gossan and oxidation extends several hundred feet below the surface. They resemble the Comet and Maestries lodes except for the development of large masses of crocoite due to the proximity of the ultrabasic intrusion.

According to Montgomery (1890) there are three sub-parallel lodes each about 30 feet wide and containing small ore-shoots which lie at an angle to the main strike. Reid (1925a) stated that the lodes are 20 to 40 feet in width and over 400 feet in length, striking N 15° W and dipping east at 50°-65°. In the upper part ferromanganese gossan and crocoite are the chief components, but melanocroite, cerussite, dundasite, phosgenite, minium and bindheimite are not uncommon, while below the zone of oxidation the ore consists of galena, sphalerite, pyrite and jamesonite set in a gangue of mangano-siderite, associated with dolomite and serpentinite.

The lower levels are in primary ore, which is of low average grade.

WORKINGS

Apart from three short adits, the mine was worked from a main shaft of about 300 feet. Levels were opened at 117, 171, 220 and 271 feet. They were driven on the lode and ran in a general southerly direction from the shaft, the longest being No. 3 level, about 500 feet long. The lode was stoped between Nos. 3 and 1 levels, close to the shaft and a little above No. 1 level.

TABLE 42A—Production—Adelaide Area

<i>Mine</i>	<i>Ore</i> (Tons)	<i>Lead</i> (Tons)	<i>Silver</i> (Ozs)
Adelaide—			
(galena)	2,959	1,479	147,900
(flux)	2,879	144	14,400
Red Lead (flux)	2,498	125	12,500
Anderson's Lode (galena)	225	112	11,200
		1,860	186,000

Notes:—

1. Lead and silver contents estimated on the basis of an average of 50% lead and 50 ounces silver per ton for galena and 5% lead and 5 ounces of silver per ton for flux.

2. Since 1957, A. R. Smith has sold small quantities of crocoite as collectors' specimens.

CONCLUSIONS

These orebodies are very wide and persistent at the surface and although they are oxidized to a greater depth than normal, there are enrichments in the form of cross lenses of galena. However, the grade apparently deteriorated at depth and apart from a limited output of crocoite, it would appear that there are no present prospects of re-developing the orebodies.

WEST COMET MINE

After the Comet Mine, the West Comet produced more silver and lead than any mine in the Dundas Field. Formerly known as the Mt Dundas Mine (or the Dundas P.A.) and the Central Dundas Mine, two companies were amalgamated to form the West Comet Mine.

The workings are situated a mile east of the former Dundas township and were once connected to it by rail and road.

HISTORY

Two adjacent leases of 80 acres, 1724-87M and 1851-87M were taken up in 1888 by G. Lambie and W. T. Handley respectively. After passing through various hands, the former was acquired in 1891 by the Mt Dundas Prospecting and Silver Mining Co. N.L. and the latter in 1890 by the Central Dundas (Tas.) Silver Mining Co. N.L. Both these companies drove several adit crosscuts to intersect the main lode and in 1893 both apparently worked from the same shaft, 110 feet deep, located on the Central Dundas lease. In 1896 the two mines were amalgamated and became known as the West Comet Mine. The ore bodies were explored thoroughly down to water level and the principal one was found to be 50-70 feet in width and over 600 feet long. In 1903, the West Comet Prospecting Syndicate N.L. was formed and worked the mine until 1909 for ferromanganese flux which was sent to the Tasmanian Smelting Company's works at Zeehan.

The property has been held under various leases since then, the last being 10411M of 39 acres held by A. D. Sligo from 1928-1931.

GEOLOGY

The lodes occur at the contact of serpentinite with the Onah Quartzite and Slate. The main adit passed through contorted black slate for 322 feet when a very siliceous lode was intersected at the serpentinite boundary. The serpentinite is weathered near the surface to a brown pug and in some workings there is incipient dolomitization.

OREBODIES

Previous writers stressed the variety and extent of the surface outcrop of the lodes, but it should be kept in mind that some of these iron oxide bodies are due to concentration from the serpentinite and not to oxidation of sulphide bodies. The principal lode, however, follows the contact of the slate and serpentinite and appears to be a continuation of that worked in the Adelaide Mine and Anderson's Prospect. Reid (1925a) stated that in the main adit it is 43 feet wide, composed of ferromanganese gossan with crocoite, strikes at 12° and dips easterly at a high angle. Rich shoots of silver chloride and galena occur within the lode and Montgomery (1893) quoted some interesting assay values.

WORKINGS

A low level adit, 640 feet in length was driven on the No. 1 orebody in 1890, but very little ore was intersected so then attention was directed to the No. 2 orebody. A shaft was sunk on this to 200 feet, and levels opened at 125 feet and 200 feet. High grade ore was stoped between these levels and a higher adit level prior to 1898.

Later, low grade ore was mined from two small open cuts on the western bank of the creek. Most of the flux mined between 1903 and 1909 was obtained from stopes between the main adit and the surface.

On the south bank of the creek, opposite the main open-cut workings, a galena-siderite vein was opened by a small adit.

PRODUCTION

No exact figures of production are available but Reid (1925a) gave some estimated figures. Not less than 500 tons of ore of two average grades, 70% lead and 70 ounces of silver per ton, and 10% lead and 450 ounces of silver per ton, was produced. More than 60,000 tons of ferromanganese flux was mined between 1903 and 1909. The flux contained 3-6% lead, 3-6 ounces of silver per ton, 30-40% iron, 11-16% manganese and 10% insolubles.

CONCLUSION

If interest in silver production increases, the high silver content of some of the West Comet ore suggests that further investigation is warranted.

TABLE 42B—Total Production—Dundas Field

<i>Mine</i>	<i>Lead (Tons)</i>	<i>Silver (Ozs)</i>	<i>Zinc (Tons)</i>
Comet-Maestries	21,850	1,510,000	
West Comet	2,700	270,000	
South Comet	428	27,718	618.5
Kozminski	10	480	
Miscellaneous	62	7,394	11
	25,050	1,815,592	629.5

CRIMSON CREEK DISTRICT

The abandoned workings of the Owen Meredith, Bon Accord, Success and Success Extended Mines lie in the middle reaches of Crimson Creek near its confluence with Success Creek, about 2 miles NW of Renison Bell. Early development was hampered by poor communications and the high cost of transporting ore to Zeehan. About 1896 the wooden Owen Meredith tram was constructed over hilly country for 4½ miles SE to the old Zeehan track which it joined near the present site of the Argent Tunnel. A track cut across to the tram in recent years from the Argent Dam, a short distance west of the present Queenstown road, reduces the distance to 2½ miles, and provides access on foot. The area

may also be reached from Zeehan by way of Dunkley's Tram, an old timber tramway which was extended after 1917 from the head of Crimson Creek to within $\frac{1}{2}$ mile of the Owen Meredith shaft, and $\frac{1}{2}$ mile from the Success Extended and Bon Accord workings. Taylor (1954c) recorded that in 1917 the last shipment of ore from the district was sent over Dunkley's Tram to Zeehan, 18 miles to the SW. As it has been neglected for many years, it is partly overgrown, frequently swampy, and a number of small bridges have collapsed, allowing access only on foot.

HISTORY

The first leases were pegged on 12th May, 1890, by Owen Meredith and they later passed to the Success and Owen Meredith Mines. Towards the end of 1890, F. Burns and J. M. Robertson marked out an 80 acre lease, which was transferred to the Bon Accord Prospecting Association N.L. in 1891; another section pegged by J. G. S. Fawns was taken over by the Success Extended Silver Mining Co. N.L. in the same year. Most of the development took place between 1890 and 1893, but in 1910, E. Ryan and D. Smith leased 40 acres which included the old Bon Accord and Success Extended workings. In the next few years, a considerable amount of work was done in the Success Extended main adit. Operations ceased in 1917, since when there has been no further production.

In 1950, the field was investigated by Zeehan Explorations, and in 1953-1954, B. L. Taylor of the Department of Mines carried out a regional geological survey prior to geophysical surveys by the Bureau of Mineral Resources, Geology and Geophysics in 1954. Self-potential electrical and electro-magnetic methods were used; magnetic readings over the orebody were unsatisfactory so this method was discontinued.

GENERAL GEOLOGY

The country rocks include hard purple and green mudstone with bands of greywacke and siltstone, and grey to black shale. They are part of the Crimson Creek Formation, which is probably of Lower to Middle Cambrian age. There is evidence of a post-mineralization fault trending a few degrees north of west, south of the Success workings, and a similar fault, which apparently shifts the north block 250 feet west, was mapped by Taylor between the Owen Meredith and Bon Accord Mines.

LODE FORMATION

All the workings appear to lie on the same lode formation which is up to about 4 feet wide, trending NW in a similar direction to the country rocks and dipping NE at angles ranging from 50° to 70°. Taylor (1954c) concluded that it is a fissure vein similar to those in the Zeehan district. The footwall is usually well-defined, and the richest ore shoots frequently occur towards the hangingwall. A slickensided plane sometimes separates the footwall and hangingwall sections which Taylor took to indicate movement during mineralization. In the southern workings, the orebody may have split. Montgomery (1893b) described 3 parallel veins, but Taylor suggested that there may have been a series of small post-ore faults which shifted a single lode.

Production was chiefly from rich ore-shoots within the lode channel which in the northern workings are reported to have varied in length from a few feet up to 44 feet.

MINERALOGY

Argentiferous galena is associated with a little pyrite, chalcopyrite and sphalerite, and occasionally stibnite and arsenopyrite. Gangue minerals are quartz and siderite. Montgomery (1893b) recorded some native silver in the Owen Meredith and Success Extended sections.

WORKINGS

The old workings have been inaccessible for many years and the following account is based on old reports, summarized by Taylor (1954c). The lode was explored and worked in shallow shafts, adits and costeans which are now collapsed or full of water. They extend over a total length of almost 4000 feet, of which the northern 600 feet and 400 feet in the south were proved to be ore-bearing. There was only surface prospecting over the 2700 feet between.

SUCCESS EXTENDED

The main workings include 4 open stopes and 2 shallow shafts. The orebody is from 3 feet to 4 feet wide with a well-defined foot-wall. The portal of an adit crosscut near Success Creek was full of water, but Taylor was informed that the lode was intersected after 300 feet. A drive north on the lode for 50 feet was in pug and was abandoned. The south drive was 400 feet long and 3 oreshoots were found within the lode. One was stoped out to the surface, and 8 inches of galena was exposed in a winze. About 250 feet south of the crosscut a drive was cut along an ore-shoot 44 feet long containing from 6 inches to 12 inches of galena, which was reported to assay 48% lead and 48 ounces of silver per ton. At the south end of the shoot, a winze was sunk 12 feet and was reported to have showed 2 feet 6 inches of clean metal. Drainage problems prevented development below adit level.

TABLE 43.—Recorded Production—Success Extended.

<i>Concentrates (Tons)</i>	<i>Lead Content (Tons)</i>	<i>Silver (Ozs)</i>	<i>Remarks</i>
30.	Est. 10	Est. 2400	To 1893
151.66	Est. 50	Est. 7500	1912-1913
<hr/> 181.66	<hr/> 60	<hr/> 9900	

Est. = Estimated.

NOTE: (Production 1913-1917 unknown).

BON ACCORD

Montgomery (1893b) remarked that no work was being carried out at the time of his visit. The lode had been tested over 2½ to 3 chains in shallow shafts and trenches and was between 2 feet and 4 feet wide, containing a vein of galena up to 10 inches thick. About 400 feet south of Success Creek, Taylor (1954c) found the portal of an adit driven SSE. The size of the dump indicated that it is probably between 400 feet and 600 feet long but no ore was seen. North of the adit, there is a trench 137 feet long and two shallow shafts in which no signs of mineralization were seen.

No production has been recorded from the Bon Accord workings.

For about 1000 feet south, a number of shallow trenches as well as two small shafts have been excavated but there is little evidence of mineralization. There has been no prospecting further south for 1300 feet until the Owen Meredith workings are reached.

OWEN MEREDITH

The shaft is located on the east side of a sharp bend in Crimson Creek, and was sunk at creek level so that it has long been water logged. According to Montgomery (1893b) the orebody was struck at a vertical depth of 38 feet and was followed on the underlay at an angle of 45°, but it appeared to pinch out in depth. A short drive was put in at the 38 foot level but the lode was poor. A different description is given by Waller (1902b) who stated that the shaft cut the lode 50 feet from the surface and was followed on the underlay for 40 feet in what is reputed to be good ore. At the bottom of the shaft, the orebody was driven on for 150 feet north and 50-60 feet south and some stoping was done. Waller reported that a total of 405 tons 17 cwt of ore was extracted, assaying between 4 and 41% lead and from 32 to 550 ounces of silver per ton; however, most parcels contained 15 to 30% lead and 60 to 110 ounces of silver per ton.

An adit drive was put in at creek level on the south bank, 35 feet upstream from the shaft. Montgomery (1893b) recorded that the lode was driven on for 470 feet south but mineralization is low grade. There are a number of shoots of galena which appear to improve in depth.

About 150 feet downstream from the shaft, an adit crosscut was cut for 78 feet SW. Although a vein up to 12 inches wide was exposed north of the portal, no further mineralization was found. Fifty feet further north, an adit 30 feet long intersected a lode which was driven on for 20 feet north and 12 feet south. A bulk sample taken by Waller over 15 feet assayed only 2.3% lead and 21 ounces of silver per ton. About 200 feet downstream, another SW adit crosscut was put in for 126 feet. The lode channel was intersected at 60 feet and was driven on for 138 feet south. A winze of unknown depth was sunk at the end of the drive. Montgomery (1893b) reported that the lode was 2 feet to 6 feet wide but poor, and no stoping had been done.

Taylor described a stope, about 150 feet NW of the portal of this adit. It is 89 feet long with an average width of about 4 feet above an old adit driven SSE from a tributary of Crimson Creek. It is not known if any ore was taken out below adit level.

TABLE 44.—Recorded Production—Owen Meredith.

Concentrates (Tons)	Lead Content (Tons)	Silver (Ozs)	Remarks
406	Est. 80	Est. 30,000	Waller (1902b)

SUCCESS

Two costeans exposed a lode channel about 2 feet to 4 feet wide striking NNW. A sample recorded by Waller gave a return of 10.2% lead and 29 ounces of silver per ton. There has been no production.

TABLE 45.—Total Recorded Production—Crimson Creek District.

	Concentrates (Tons)	Lead Content (Tons)	Silver Content (Ozs)
Success Ext.	181.66	Est. 10	Est. 2,400
Owen Meredith ..	406	Est. 80	Est. 30,000
	<hr/> 587.66	<hr/> 90	<hr/> 32,400

CONCLUSIONS

In the Crimson Creek district, mineralization is low grade, except for small and irregular ore-shoots which were exploited in the past. At the present time, the deposits appear to be of little economic value and future prospects are not encouraging.

CUNI AND RENISON BELL DISTRICTS

The McKimmie lodes were probably discovered about 1893 when the copper-nickel deposits were being explored, as they were described by Montgomery (1896). Further north, in 1909, J. and W. Wallace found the veins later developed by T. H. Vincent and subsequently by Zeehan-Dundas Mines Ltd. (a subsidiary of Mt Zeehan (Tasmania) Ltd.)

The country rocks include black, grey, green and purple shale, mudstone and greywacke, forming part of the Crimson Creek Formation, which strike N-S with steep easterly dips, swinging in the north to a NE trend and SE dip. Serpentinite and gabbro intruded in the late Cambrian outcrop to the east and have introduced copper-nickel mineralization to the west. The galena-sphalerite veins are believed to be Middle Devonian in age. They generally strike in a similar direction to the sedimentary formations. The country is relatively flat and near the water-table so that mining is handicapped by heavy inflows of water, estimated by Reid (1925a) at 60,000 gallons per hour in the Lead Blocks workings.

LEAD BLOCKS (ZEEHAN-DUNDAS MINES LTD.)

The workings are about half a mile east of Genet's Winze (See Figure 17). At least 5 veins were worked in the past, consisting of galena and sphalerite in a gangue of siderite and quartz. The shaft was sunk to about 145 feet, 62 feet below No. 1 Level, and stoping was done on 5 veins. The sulphide-bearing oreshoots appear to have been relatively short, being replaced in depth by quartz. The mine closed in 1914 after losing £13,000 in the production of about 2136 tons of ore from 1911. Tributors extracted 35 tons in 1915-1916, and small quantities of ore were won, chiefly from surface workings, in 1935-1936 and in 1947. Total production was about 2180 tons of ore with an estimated content of some 120,000 ounces of silver and 1420 tons of lead.

ALLEN PROSPECT

Shallow shafts were sunk on the same line of lode, a short distance south of Lead Blocks. Reid (1925a) remarked that galena petered out at a shallow depth and there is no record of any production.

MCKIMMIE MINE

The mine lies a little over a quarter of a mile east of the Blowfly Shaft (see Figure 17) and has been abandoned for many years. Two veins with galena were originally found in trenches. The most important lode was trenched over a length of 126 feet to a depth of 6 feet, from which 56 tons of ore were obtained (Montgomery, 1896). Waller (1902b) stated that a shaft was sunk here and crosscuts were put in at depths of 50 feet and 100 feet. At 50 feet, the vein contained about 2 feet of galena which terminated about 10 feet below. In the 100 foot level, the lode was driven on north and south, but was found to consist of siderite with only traces of galena. About 50,000 gallons of water per hour had to be pumped out: another factor leading to the closing of the mine before 1902.

Total production is unknown. The 56 tons of ore recorded contained about 3000 ounces of silver and 34 tons of lead.

Mining problems and the limited workable oreshoots in the Cuni area do not encourage future development.

ARGENT TUNNEL

Twelvetrees (1901, p. 77) recorded an east trending lode 2 feet wide at the southern approach to the tunnel. Galena is associated with a little crocoite and pyromorphite in a quartz gangue. The lode was driven on for a few feet eastwards and some galena was bagged but the deposit is of no significant economic value.

RENISON BELL

A number of lodes carrying galena and sphalerite near Renison Bell have been worked on a small scale at different periods, chiefly by tributors. According to the Annual Reports of the Secretary for Mines, 37 tons of ore were extracted in 1915-1916, containing about 2,400 ounces of silver and 21 tons of lead, but the exact location is not known. Further development is unlikely.

3. Copper-Lead-Silver &c.

NORTH DUNDAS AREA

The name "North Dundas" is applied here to the rugged country crossed by the old North-East Dundas Tram between Zeehan and Williamsford, lying south of Renison Bell and SW of Williamsford. The term is therefore used in a somewhat different sense to that of early authors who also included the Renison Bell and Crimson Creek districts. Many old mines and prospects date back to about 1891 but there has been little activity since 1920.

The country rocks are a variable succession of slate, siltstone, greywacke and breccia-conglomerate ranging in age from Younger Proterozoic or Lower Cambrian to lower Upper Cambrian. Andesitic and basaltic lavas and tuffs are interbedded with Middle Cambrian sediments on Godkin Ridge and near Montezuma Falls. Most of the ore deposits are fissure veins striking NNE and NNW in a similar direction to the trend of tight folds and intense faulting in the formations resulting from the Devonian Tabberabberan Orogeny. Post-ore faulting took place after the Permian (probably Tertiary). Mineralization is complex and though there are no abrupt changes, a number of vein types may be recognized.

1. *Tetrahedrite-Chalcopyrite* ("Fahlore") type

(Usually associated with pyrite)

Arsenopyrite, jamesonite, galena, sphalerite and bismuthinite may also be present. Gangue minerals include siderite and quartz. The ore was worked primarily for the silver content of the tetrahedrite which usually averaged between about 150 and 200 ounces of silver per ton. Ore in the Bonnie Dundee Mine is said to have assayed up to 1200 ounces per ton and picked specimens contained as much as 3000 ounces per ton (Smith, 1898). The chief mines were the Ring Valley-Fahlore Mine; the South-West Curtin-Davis; Curtin Davis; South Curtin-Davis; No. 1 Curtin-Davis. Other mines and prospects included Block 302, the Bonnie Dundee Mine and the Ramsdale prospect.

2. *Galena-Sphalerite* type

The chief mineral is galena which is associated with sphalerite and pyrite, as in the Kapi Mine. Jamesonite is also present in the Melba and Great Northern Creek Mines, while tetrahedrite has been reported in the last named. The gangue is usually siderite with some dolomite and quartz.

3. *Chalcopyrite-Bismuthinite-Pyrite* type

Pyrrhotite, arsenopyrite and galena may also occur, in a gangue of siderite as in the Hecla Mine.

4. *Pyrrhotite-Arsenopyrite-Cassiterite* type

Other sulphides include chalcopyrite and pyrite. This variety was formerly worked in the Fraser Mine.

Mines and Prospects

RING VALLEY-FAHLORE MINE

The lodes were worked by two companies from about 1893 until their amalgamation in 1901. To the north, the Fahlore Silver Mining Co. N.L. explored an orebody striking NNW near the Ring River in a shaft and pits and in two adits driven on the orebody further north, but work ceased before 1896. As the workings were full of water, Smith (1898) quoted details from an old plan. On the east bank of the Ring River, the shaft was sunk to a depth of 100 feet. Crosscuts driven west at the 50 feet and 100 feet levels cut the lode at 44 feet and 69 feet respectively. On No. 1 (50 feet) level, the orebody was driven on for 100 feet north and 50 feet south, and on the No. 2 (100 foot) level for 41 feet north and 95 feet south. The vein strikes NNW with a steep westerly dip and although some high grade tetrahedrite ore was extracted it appears to have been patchy. The mine was apparently re-opened in 1900 and details of the adit workings were given by Waller (1902b). From a point 350 feet north of the shaft, the 'main' adit was driven a total of 620 feet NNW on a body of pyrite varying in width from 1 foot to 2 feet.

At 120 feet a small shoot of tetrahedrite ore was intersected and stoped out. At 350 feet from the portal, the adit was off the course of the lode and a short crosscut was put in to the west, which cut an ore-shoot after 10 feet. The shoot was driven on for 60 feet north and south and was stoped out until it disappeared at a height of 25 feet. The lode is 4 feet wide at the bottom

of a winze 21 feet deep and includes 1 foot 6 inches of pyrite with tetrahedrite. Inflow of water prevented further sinking but Waller reported that 209 bags of ore were obtained of which 6 bags contained 762 ounces of silver per ton and 22.3% copper while the remainder assayed 198 ounces of silver per ton and 5% copper.

The adit was extended a further 270 feet but little of value was found.

The portal of the 'intermediate' adit lies 490 feet north of the main adit and the lode channel was driven on for 543 feet. For 270 feet only pyrite was found, then patches of tetrahedrite were found underfoot for 60 feet, becoming richer along the adit. A considerable amount of stoping was done about 310 feet from the portal and aggregates or veins of fahlore up to 12 inches wide are recorded. The adit was continued for a further 100 feet but the ore was poor.

A total of 95 tons of ore was produced by the company in 1900.

The southern extension of the orebody was explored by the Rich Prospecting Association. Montgomery (1893b) noted the lode was 4 feet 6 inches wide but poor in a cut in the river bank. Smith (1898) described about 2 feet of pyrite and chalcopryrite with patches of tetrahedrite in a quartz gangue, on which a shaft 33 feet deep had been sunk. South of the river, an adit had been driven on this lode but it was not examined by Smith.

The property was later taken over by the Ring Valley Mining Co. Ltd. According to Waller (1902b) a shaft was sunk on No. 2 lode to a depth of 110 feet (probably the continuation of the shaft mentioned by Smith) and at the 100 foot level, the vein was driven on southwards for 75 feet. The vein appeared to pitch to the south and only traces of tetrahedrite and chalcopryrite were found. In an east crosscut, the main lode (No. 1) was intersected 32 feet from the shaft and was driven on for 45 feet south and 120 feet north towards the Fahlore shaft. Only thin veins of siderite and a little pyrite and chalcopryrite were found. In the drive, 12 feet north of the crosscut, a rise was put through to the old adit level and an intermediate level was driven 30 feet north exposing about 14 inches of chalcopryrite with a little tetrahedrite. Most of the ore above the adit level had been extracted previously. At the end of the north drive on No. 1 lode a NW crosscut intersected a shoot of tetrahedrite and chalcopryrite containing about 150 ounces of silver per ton which was then being worked.

A west crosscut from the shaft at the 100 foot level intersected only 3 inches of tetrahedrite and pyrite in a siderite gangue (No. 3 lode).

In 1902 the Ring Valley Mining Co. bought the Fahlore mine and until 1914 the two properties were worked together. No plans are available but details given in annual reports of the Secretary for Mines indicate that the workings served by the shafts and also in the adits were extensive. Much of the fahlore had been worked out prior to 1907. In depth it is associated with complex ore containing jamesonite, galena, chalcopryrite and pyrite which could not be treated locally. A market was found in Europe in 1911 but the mine closed after the outbreak of war in 1914.

TABLE 46—Production—Ring Valley-Fahlore Mine

	Ore (Tons)	Silver Content (OzS)	Copper (Tons)	Remarks
Fahlore Mine	95	Est. 20,000	Est. 5	1900
Ring Valley-Fahlore	2,877	Est. 363,000	Est. 159	1902-1914
	2,972	383,000	164	

CONCLUSIONS

The workings have been waterlogged for many years but records and production figures indicate that tetrahedrite and chalcopyrite tend to be concentrated in short irregular veins within pyritic or sideritic lodes. The upper levels have been worked out and in depth the ore is complex. The deposits appear to be of doubtful economic value.

CURTIN-DAVIS MINES

A number of adit workings lie on Godkin Ridge between Fraser Creek in the west and Montezuma Falls to the east. Development started about 1893 and during the next few years several companies were at work. Most of them closed down before 1902 and only small quantities of ore have been extracted subsequently.

The old mines are chiefly on the precipitous north and west slopes of Godkin Ridge which, south of the North East Dundas Tram and east of Fraser Creek, rises at a slope of 1 : 1 to an altitude of about 2400 feet (1200 feet higher than the tramway). The lodes generally trend NNW and the steep slopes have favoured adit workings.

The country rocks are Middle Cambrian slate, siltstone, grey-wacke and hard chert conglomerate with interbedded lava flows and tuff bands which have been closely folded and intensely faulted.

(a) SOUTH WEST CURTIN-DAVIS MINE

This is located on the steep west slope of Godkin Ridge, overlooking the Fraser Falls. The following account of the old workings is summarized from Smith (1898). The orebody strikes NNE with a steep easterly dip and it was developed in two adits. No. 1 Adit is 50 feet below the outcrop, and the lode was cut at 90 feet from the portal, being driven on for 140 feet north and 210 feet south. In the south drive, a shoot of tetrahedrite ('fahl') ore was stoped out to the surface over a length of 50 feet. The rest of the drive was barren except for a patch of sulphides with much bismuthinite about 15 feet from the end. In the north drive, the lode was thin and unworkable for 40 feet after which 40 feet of ore was met and stoped out to the surface. The end of the drive was in barren siderite gangue.

No. 2 Adit is 96 feet lower. The orebody was intersected 265 feet from the entrance and was driven on for a total of 60 feet north and south. A winze in the north drive was sunk on tetrahedrite ore which was reported to be between 1 inch and 16 inches wide.

About 210 feet south of No. 1 Adit and 78 feet higher, a short adit (the South Adit) revealed ore 30 feet from the portal, which was driven on for a few feet south. A rise was put up and connected with a prospecting shaft from the surface in which patches of tetrahedrite ore had been discovered.

Waller (1902b) noted that the lessees, Ogden and Coady, had recently found a vein of ore 30 feet long and up to 15 inches wide above the south drive stopes (apparently in No. 2 Adit) and had extracted about 25 tons.

There is no record of any important development since. Total production amounted to about 600 tons of ore assaying between 10% and 12% copper, and 120 to 200 ounces of silver per ton, which is estimated to have contained about 65 tons of copper and 90,000 ounces of silver.

(b) CURTIN-DAVIS MINE

Prior to 1896, the orebodies on this property were worked by the Montezuma and John Godkin companies. Montgomery (1896) stated that the lease had been merged with the Curtin-Davis Extended block to the south.

The main orebody strikes NNW and outcrops on the steep northern slope of Godkin Ridge. It was worked in at least 9 adits which were described by Montgomery (1896) and Smith (1898). The highest level is about 100 feet below the surface outcrop where gossan between 2 feet and 4 feet wide was trenched. The lowest adit is 1430 feet below the surface outcrop, but mineralization proved to be poor in the lower levels. The workings are extensive and much driving, rising and winzing was done. Montgomery concluded that the orebody consisted of a number of parallel veins rather than a continuous lode. Tetrahedrite is accompanied by pyrite, bismuthinite, galena and sphalerite in a siderite gangue.

Concentrations of workable ore proved to be erratic and confined chiefly to short but rich ore shoots within the poorly mineralized siderite gangue.

East of Montezuma Falls, some driving was done on a pyrite orebody but nothing of value was found.

At the end of 1897, a bush fire destroyed the mine buildings and the mine closed after producing 427 tons of ore, assaying 3.9% copper and 32.4 ounces of silver per ton. According to Waller (1902b), parties of tributors continued to work small, rich patches of ore.

Between 1896 and 1903, 922 tons of ore were won (including 18 tons of galena and 187 tons of gossan). The ore contained about 27,000 ounces of silver, 32 tons of copper and 10 tons of lead.

(c) SOUTH CURTIN-DAVIS MINE

This is located south of the South West Curtin-Davis mine, east of the upper reaches of Fraser Creek. The main orebody strikes NNW with a steep easterly dip and was explored in 3 adits within indurated chert-grit and conglomerate. Up to about 5 feet of gossan was found in which Montgomery (1896) reported silver chloride and native silver. Tetrahedrite and galena were later worked but presumably proved unpayable as the mine was abandoned before 1898. Waller (1902b) remarked that a small syndicate had been formed and had started driving on a vein of galena up to 10 inches wide cut in one of the adits.

Production between 1899 and 1902 amounted to at least 216 tons of fahl ore and galena, with an estimated content of 35,000 ounces of silver, 35 tons of copper and about 8 tons of lead.

(d) NO. 1 CURTIN-DAVIS MINE

This is situated on the SE side of Godkin Ridge in the upper reaches of the Avon Rivulet. Montgomery (1896) mentioned a shallow adit which had been planned to cut below the outcrop of a NNW striking orebody consisting of slate, pyrite, sphalerite and galena bounded by smooth slickensided walls dipping to the east. As the adit would intersect the lode only 27 feet below the outcrop, it is not that described by Smith (1898) who noted that an adit had been driven west through coarse grit and at 93 feet had intersected a lode striking NNE which was driven on for 20 feet north and 70 feet south. At 115 feet in from the portal a 3 foot vein with pyrite and arsenopyrite was cut striking NNW, probably joining the main lode near the end of the south drive where it is 6 feet to 7 feet wide, carrying much galena. From stopes above the drive, 37 tons of ore were obtained, assaying 10% copper and 115 ounces of silver per ton. The richest ore consisted of tetrahedrite with some jamesonite, together with chalcopyrite, galena and patches of bismuthinite in a siderite gangue. In the stopes the vein was between 2 and 3 feet wide with irregular fahl ore bands up to 10 inches thick.

At the north end of the drive, the lode was barren and no ore was found in a rise put up for 77 feet.

The mine was abandoned before 1902. The 37 tons of ore produced contained 4255 ounces of silver and 3.7 tons of copper.

MISCELLANEOUS PROSPECTS

(a) BLOCK 302

In 1898, the lease was held by the Block 291 Silver and Copper Mining Co. East of Montezuma Creek, a mineralized zone up to 20 feet wide was explored in trenches, opencuts and 3 adits. The zone strikes NW and was followed SE into Block 291. The country rock has been impregnated with pyrite, and there are several veins up to 1 foot wide of solid pyrite with thin bands of galena and jamesonite in a gangue of siderite (Smith, 1898). Patches of tetrahedrite were found but the orebody is generally poorly mineralized. About 26 tons of ore were extracted, containing some 2211 ounces of silver and 1 ton of copper.

(b) BONNIE DUNDEE MINE (Section 7443 M)

This is near the Ring River, north of Bonnie Point. Fossiliferous upper Middle or lower Upper Cambrian siltstone, greywacke and conglomerate have been tightly folded, with a southerly plunge. The only description of the workings is that by Smith (1898) who recorded that from a point a few feet above the level of the Ring River, an adit had been driven southwards for about 160 feet on an orebody, and a shoot of ore had been stoped out nearly to the surface. In the stopes, the lode is vertical with a NNE strike and is about 4 feet wide. Further south along the adit, it turns to the SW, with a NW underlay. The lode carried small irregular aggregates of tetrahedrite ore up to 10 inches wide, and where oxidized, a little native silver was present. The gossan was said to assay up to 1200 ounces of silver per ton. Operations appear to have been short-lived and only small quantities of fahl ore were recovered.

(c) RAMSDALE PROSPECT (Leases 7607M and 8628M)

This is sited half a mile SE of the Hecla mine, a little north of the junction of the Carbine Track with Wallace's Tram from Confidence Saddle. Reid (1925a) stated that a gossan lode 2 feet to 3 feet wide coursing NNE had been opened up in a deep trench and a shaft, and samples assayed between 30 and 100 ounces of silver per ton. Further work was carried out in 1931 and described by Finucane (1931). Trenching and work in an adit 25 feet long had proved a quartzose lode formation over a length of about 320 feet, varying from 2 to 7 feet in width. Although small veins of pyrite, tetrahedrite and a little galena were found, they are irregular in size and value. Samples assayed up to 6% copper and 92 ounces of silver per ton. One sample contained 2.33% antimony, so that jamesonite may be present. Finucane concluded that the deposit was too poor to be workable.

(d) SVENGALI PROSPECT

This is situated SW of the bridge over Conliffe Creek on the North East Dundas Tram, in section 3275M.

Smith (1898) commented on a number of trenches and an adit driven to test a faulted zone in which there are many irregular veins of quartz and siderite within indurated and brecciated slate. Only traces of chalcopyrite were found, and the prospect is apparently of little value.

KAPI MINE

This mine is within Sections 9178-M and 9179-M, downstream from the small bridge on the North East Dundas Tram over Kapi Creek. West of the creek, black slate (Middle Cambrian) is faulted against serpentinized pyroxenite. The first lease was taken out by H. Nickolls in 1890, the property being transferred to the Kapi Prospecting Association N.L. in 1893. Small veins of galena were found, but the lease was abandoned in 1894. About 18 tons of galena were produced by tributors in 1911. The only other record is in the Annual Report of the Secretary of Mines for 1920. A little high grade ore was being extracted by tributors and in a small vein galena had been found which assayed 240 ounces of silver per ton. Total production is estimated at 30 tons of galena, containing about 4000 ounces of silver and 18 tons of lead. The veins consist of galena, with some sphalerite in a gangue of siderite or dolomite and proved too small to be workable except on a small scale. They were explored in at least two old adits and a shaft.

In 1958, two boreholes were drilled by the Department of Mines to test the fault junction between the serpentine and the slate for tin mineralization, which occurs at a similar contact in the Razor-back mine. No cassiterite was found, and although there has been some mineralization, only pyrite, pyrrhotite and traces of nickel were present (See logs).

Core Logs (After T. D. Hughes)

Kapi No. 1

Drill: Goldfields No. 10 Diamond Drill.

Driller: W. Robinson.

Commenced: 21.2.58.

Inclination: 50°.

Completed: 2.4.58.

Bearing: West.

From To

0'- 10'	Overburden.
10'- 89'	Cleaved grey and black slates; occasionally pyritic. 2" calcite vein at 88'.
89'- 92'	Fault zone. Chiefly serpentine or dolomite, some slate fragments. Quartz veining.
92'-233'	Serpentine, often dolomitized. Calcite veining between 125' and 143' 6" and 159' to 161'. Mineralized 190'-200'. Calcite 198'-199'. Pyrrhotite at 200'. Mineralized at 212'-215'.
233'-270'	Slight mineralization 215'-233'. Dolomite, with scattered calcite veins. Some mineralization 233'-251'. Sulphides 263'-267'. Traces of sulphides 267'-270'.
270'-285'	Serpentine with calcite veins.

Assays

Tin, Copper, Silver, Gold—Nil

Nickel: 67'-243' Trace

243'-263' 0.1%

263'-267' 0.15%

Kapi No. 2

Drill: Goldfields No. 10 Diamond Drill.

Driller: W. Robinson.

Commenced: 11.4.58.

Inclination: 55°.

Completed: 24.6.58.

Bearing: West.

From To

0'- 10'	Overburden.
10'-120'	Cleaved black slates; occasionally pyritic.
120'-139'	Fault zone. Mainly carbonates and serpentine. Some pyrite.
139'-281'	Dolomitized serpentine. Slightly pyritic in places. Scattered veins of calcite.
281'-333'	Carbonates. Some pyritic bands.
333'-381'	Dolomitized serpentine. Occasionally pyritic.

Assays between 281 feet and 333 feet gave a nil return for tin.

GREAT NORTHERN CREEK (OR CARBINE) MINE

This is located on the NE slopes of Carbine Hill, where Wallace's Tram crossed the headwaters of Great Northern Creek, about $\frac{1}{2}$ mile SW of the Ramsdale prospect. A number of veins have been worked in the past within Middle Cambrian dark slate, siltstone and greywacke, into which thin sills of serpentinite were intruded. They lie within Sections 8587M, 4672-93M and 4749-93M. Waller (1902b) reported that P. P. Quinn and W. J. Hodge had

been prospecting for some time and had uncovered several veins. The most important was a vertical fissure vein of banded galena and siderite about 10 inches wide striking N 60° W, from which 10 tons of ore had been extracted, assaying 64% lead and 75 ounces of silver per ton. To the NW, a lode formation 4 feet wide was found which consisted of irregular veins of galena with sphalerite, pyrite, jamesonite, quartz and siderite, separated by bands of country rock. The lessees were taking out a parcel of 10 tons of ore. Further west, a small vein containing pyrite, tetrahedrite and galena striking NW had been explored in trenches. The vein joins a north-striking pyritic body carrying a little tetrahedrite, and near the junction Waller described jamesonite intimately associated with pyrite, together with chalcopyrite and sphalerite. Trenches further north revealed only pyrite. A number of other veins were found, including a short pyritic lode 18 inches wide with arsenopyrite and a little bismuthinite.

The brief note by Reid (1925a) on the Carbine mine is a summary of Waller's report and there appears to have been no further development.

Although there are numerous veins in the vicinity, they are generally small and thin, and so of little economic value.

Total production is about 20 tons of galena ore with a content of about 1500 ounces of silver and 13 tons of lead.

MELBA MINE

This is situated in the upper reaches of Melba Creek on lease 5443M, immediately below the point where the old transmission line crosses the North East Dundas Tram. The mine was worked by the Madame Melba No. 1 Silver Mining Co. about 1891, but was abandoned before 1893. Mineralization took place entirely within sheared serpentinized pyroxenite. A vertical open stope is about 3 feet wide and 30 yards long, striking NW. The following account of underground workings is summarized from reports by Tilley (1891) and Montgomery (1893b). A short upper adit was driven NE to the lode from a point 10 feet to 12 feet below the outcrop. The lode is about 4 feet wide consisting of galena, jamesonite and sphalerite and was driven on for 72 feet NW where it pinched out. Only thin stringers of ore were found in a SE drive 8 feet long. A winze was sunk for 20 feet on 4 feet 6 inches of ore said to include 2 feet 6 inches of good galena. At 240 feet north of the adit, a shaft was sunk 70 feet on argentiferous gossan. A lower crosscut adit, 80 feet below the other, was driven 400 feet towards the shaft, cutting the lode 267 feet below the collar. The orebody was poor and no further driving was done before the mine closed down.

About 100 tons were produced from development, stated to assay up to 65% lead and 86 ounces of silver per ton, i.e., 65 tons of lead and at least 8500 ounces of silver. Montgomery (1893b) suggested that the galena generally was rather poor in silver.

Stibnite, pyrite, galena and epidote were noted on the old dumps.

A borehole was drilled by the Mines Department in 1958 to test the orebody about 150 feet below the stoped outcrop, but only slight mineralization was found. The condensed log is shown below.

Core Log

Drill: Goldfields No. 10 Diamond Drill.
 Driller: W. Robinson.
 Commenced: 28.10.58. Incline: 50°.
 Completed: 8.21.58. Bearing: 53° (magnetic).
 Logged by: A. B. Gulline and A. H. Blissett.

From To

0'-327' (end of hole)	Dark green pyroxenite, with scattered veins or stringers of quartz and magnesite. Brecciated in places.	
	3" vein of quartz with epidote.	64' 2"- 64' 5"
	Traces of pyrite and sulphides.	90' 0"- 91' 2"
	Some epidote and traces of sulphides.	100' 4"-101' 0"
	Slight mineralization (Galena, pyrite and magnetite).	107' 0"-110' 2"
	Traces of sulphides.	119' 6"-120' 2"
	Traces of sulphides.	135' 0"-139' 6"
	Traces of sulphides.	167' 5"-173' 7"
	Brecciated pyroxenite, with 18 inch vein of quartz showing traces of sulphides.	201' 8"-235' 0"
	Traces of sulphides.	266' 9"-270' 0"
	Traces of sulphides.	300' 0"-305' 0"
	Traces of sulphides.	313' 6"-315' 6"

Mineralization is therefore of limited extent and further development is unlikely.

MOORES PIMPLE MINE

The old workings lie in Section 10400M on the north and west slopes of Moores Pimple, near the Dundas-Mt Read track, and were first prospected about 1896 when the property was known as the Evenden mine. The country rocks are purple slate, dolomitic quartzite and chert conglomerate, assigned to the Crimson Creek Formation, which were intruded by dykes or sills of serpentine, now dolomitized. In the north, an adit was driven between about 1896 and 1900 for 330 feet east, the last 60 feet of which was in dolomitized serpentine. Twelvetrees (1901) reported that at 270 feet a gossan vein with a little galena 3 inches wide was intersected at the serpentine contact. The vein strikes NNW and was driven on south for 40 feet but was only 6 inches wide at the end of the drive. Some sphalerite was found in the floor of the drive. A number of trenches were cut across a dolomitic orebody at the junction of the slate and quartzite with the chert conglomerate. It contains veinlets and blebs of pyrite and a little chalcopyrite. The country rocks are impregnated with a deep green mineral which appears to be the chrome-mica fuchsite, rather than zaratite (nickel carbonate) as reported by Reid (1925a). However, bulk samples are said to have assayed between 0.15% and 0.25% nickel. The conglomerate at Moores Pimple may be equivalent to the "Fuchsitic Conglomerate" of Finucane (1932a), west of Rosebery.

Mineralization is not extensive and has little economic value. No production has been recorded.

EVENDEN PROSPECT

Reid (1925a) stated that in Section 396-93M an old adit, then inaccessible, had been driven on a galena-sphalerite-pyrite vein from the south bank of a tributary of Great Northern Creek. The silver content was reported to be low.

HECLA MINE

This is situated on the steep eastern slopes of Great Northern Creek, about 300 yards south of the bridge on the North East Dundas Tram within Section 10299M.

Smith (1898) mentioned that no work was in progress and the mine appears to have been abandoned before that date. The workings were described by Reid (1925a). Bismuthinite is either closely associated with chalcopyrite as veinlets within the siderite gangue, or as scattered crystals throughout the gangue. Pyrite is abundant and pyrrhotite is also present.

The main adit was driven over 200 feet to the SW and SSW. Shallow winzes were sunk 90 feet and 100 feet from the portal. The lode is 2 feet 3 inches wide, consisting of siderite with a little chalcopyrite and bismuthinite. Further along the adit, the orebody becomes thinner and at the end of the drift it splits into 6 inch and 3 inch veins separated by 3 feet of slate. In the adit, stopes were cut 20 feet high. The orebody was also exposed in an adit 60 feet long just above the tramway east of the bridge over the creek. At the portal it is 4 feet wide, dipping west at 82°, and is chiefly of pyrite, pyrrhotite and chalcopyrite with a little arsenopyrite and bismuthinite disseminated throughout slate and greywacke grit.

No production has been recorded from the mine and the deposit appears to be too small to be workable. A bulk sample from the dump outside the main adit was said to assay 2.85% copper, 2.77% bismuth and a little over 25 ounces of silver per ton, but assays of material taken out of the winze at 100 feet were much lower.

FRASER MINE

This was sited in the valley of Fraser Creek, below the North East Dundas Tram, partly within Section 9984-M, and partly within the 40 acre lease 12M/42 now held by F. H. G. Green. It was first prospected by L. Jolly in 1895, the property being transferred to the West Curtin-Davis Co. in 1896. The lease changed hands several times in the next few years and was held by F. Burns in 1903 when 75 tons of sulphide ore were reported to have been extracted. Between 1909 and 1913, J. Dwyer worked the orebody for its tin content after discovering a loose block of ore weighing 3 tons, said by Reid (1925a) to carry 12½% tin. R. Ruggeri took over the mine in 1913, and between 1919 and 1920 it is estimated that at least 1000 tons of arsenopyrite was produced and shipped to the Edwards Pyrites and Ore-Reduction Company's works in Ballarat. In 1920, the ore was stated to average between 16% and 18% arsenic and 2% to 3% copper.

The lease became void in 1922, but was taken up for a brief period in 1926 by T. L. Kitto.

Mineralization took place within faulted Middle Cambrian slate, siltstone, greywacke and grit which strike northwards. Reid (1925a) noted that pyrrhotite, arsenopyrite and chalcopyrite are intimately associated in irregular masses and veins within a quartz gangue. A little pyrite may be present and marcasite tends to replace pyrrhotite in the upper levels. Although fine grained cassiterite occurs, the average tin content of ore is poor.

Reid described the workings in some detail. The orebody strikes NNW with a steep easterly dip and was worked in a series of 5 adits and long drives. An average width of 2 feet was indicated over a length of 500 feet. The sulphides are concentrated in ore-shoots up to 134 feet long, separated by poorly mineralized quartz gangue, and have been mostly stoped out. Bulk samples quoted by Reid assayed 20.02%, 7.23% and 16.8% arsenic, and 0.85%, 4.08% and 0.09% copper. The silver and tin contents were low.

Future prospects for the mine are not encouraging.

Production has been estimated as 25 tons of copper and 170 tons of arsenic from 1000 tons of ore taking the contents as 2½% copper and 17% arsenic. Tin production is not known.

TABLE 47—Total Production—North Dundas District

<i>Mine</i>	<i>Ore (Tons)</i>	<i>Silver (Ozs)</i>	<i>Copper (Tons)</i>	<i>Lead (Tons)</i>	<i>Arsenic (Tons)</i>
Ring V.-Fahlore	2,972	383,000	164	....	....
South West Cur- tin-Davis	600	90,000	65	....	....
Curtin-Davis	922	27,000	32	10	....
South Curtin- Davis	216	35,000	35	8	....
No. 1 Curtin- Davis	37	4,255	3.7	....	....
Block 302	26	2,211	1	....	....
Kapi	30	4,000	....	18	....
Great Northern Creek	20	1,500	....	13	....
Melba	100	8,500	....	65	....
Fraser	1,000	....	25	....	170
Miscellaneous					
J. Griffiths	38	2,294	3.9	....	1933
C. Smith	5	292	0.6	....	1933
	<u>5,966</u>	<u>558,052</u>	<u>330.2</u>	<u>114</u>	<u>170</u>

4 Axinite-Sulphide Deposits

COLEBROOK HILL

Introduction

The copper-bearing axinite lodes at the north end of Colebrook Hill were first explored about 1896 in adits and trenches on the Colebrook, North Colebrook and West Colebrook leases. Interest was chiefly centred on the gold, silver and copper content which proved to be low. About 1898 the three properties were amalgamated

by the Colebrook Prospecting Association which held some 208 acres, and the orebodies were tested in a series of adits, opencuts and a shaft. Smith (1898) commented that although large quantities of ore had been proved, it was too poor in silver and gold to be smelted alone, suggesting that it might be mixed with the refractory zinc ore from the Rosebery mines. At this time, the New West Colebrook and Clifton sections on the western and northern slopes of Colebrook Hill were also prospected but no payable ore was found. Waller (1902b) made a close examination of the workings in which the Colebrook Prospecting Association intended to mine the richer portions of the orebodies and he emphasized the need for a thorough sampling of the orebodies in view of the spasmodic distribution of the chalcopyrite. Previous assays in the workings were unreliable, and although 5 boreholes had been drilled, values were not known.

When Ward (1909) examined the district, the leases had been abandoned and deeper excavations were waterlogged.

Between 1915 and 1917, the workings were extended and although ore containing chalcopyrite, galena and sphalerite was driven on, workable ore was apparently not found. There is no record of production, and there has been no significant activity since.

Geology

Colebrook Hill is a northerly trending strike ridge of steeply dipping purplish and grey cherty siltstone, mudstone, greywacke and greywacke breccia-conglomerate, forming part of the Crimson Creek Formation. The formation was intruded in the late Cambrian by a sill or dyke of serpentinized pyroxenite and gabbro over 200 yards wide which is exposed on the lower slopes of Colebrook Hill, about $\frac{1}{4}$ mile west of the summit and 600 feet lower down.

Mineralogy

The composition of the orebodies has been discussed at length by Waller (1902b) and Finucane (1932b). A number of massive lodes up to about 60 feet wide outcrop on the top and flanks of Colebrook Hill, generally striking N-S with the sedimentary rocks. Some veins are more irregular and trend a few degrees north of east. The most abundant mineral is axinite which with actinolite may constitute up to 75% of the orebodies. The chief metallic minerals are pyrrhotite which has been reported in bands up to 15 feet wide, pyrite, chalcopyrite and arsenopyrite. Small amounts of marcasite, galena, sphalerite and tetrahedrite were recorded by Waller (1902b). Datolite and danburite occur in vughs but are usually rare. Gangue minerals are common calcite and also quartz which together may form up to 25% of the orebodies. Assays showed only traces of gold and less than 1 ounce of silver per ton of ore, while copper generally ranged from about 0.5% to 3%.

There are two types of ore: one banded and the other massive, but there is no sharp division and the different types merge into one another. Banded ore is the more common variety, consisting of alternating bands of axinite and actinolite. Much of the sulphides and also the calcite and quartz are associated with the axinite which is often coarsely crystalline, with crystals up to $\frac{1}{2}$ inch long. The sulphides usually occur as irregular patches throughout the axinite veins, or in thin bands between the axinite and actinolite veins.

The massive ore is made up of crystals of axinite and radiating patches of actinolite, with crystalline calcite and veins or irregular patches of quartz. The sulphides, particularly pyrrhotite and chalcopyrite, occur either disseminated through the ore or as irregular veins and masses. Finucane (1932b) established the order of crystallization as:—axinite, actinolite, metallic sulphides, calcite, quartz.

The orebodies appear to be metasomatic fissure replacement veins formed by pneumatolytic or hydrothermal action on calcium-bearing rocks. While there are no impure limestones as suggested by Waller (1902b), some horizons in the Crimson Creek Formation are calcareous or dolomitic. Only small veins are known in the pyroxenite and gabbro. Finucane (1932b) suggested that some of the calcium, iron and magnesium in the actinolite and axinite may have been derived from fragments in the breccia-conglomerate. Ward (1909, pp. 57-59) described veins of axinite near Renison Bell, in Gormanston Creek, the Ring River and in the old Cornwall tin workings. The orebodies on Colebrook Hill are probably related to the cassiterite-sulphide mineralization near the Exe River and Renison Bell.

Workings

Although the orebodies have been explored in 10 adits and numerous trenches, Waller (1902b) remarked that most of the adits cross the mineralized zones diagonally and little driving was done along the lodes. The leaseholders appeared to have believed that the whole of the ridge was one large orebody which they proposed to work by open-cut. Six of the adits were driven SW or west on the east slope of Colebrook Hill; the other four were cut NE on the western flank. At least 4 orebodies were found and copper assayed up to 3.4%, though sampling was not carefully planned. The lowest adit is No. 2 (of Waller, 1920b), the portal of which lies about 600 feet NE of the top of the hill, and about 400 feet lower. Between 1915 and 1917, the adit was extended 70 feet to a length of 650 feet. At 555 feet, a north drive was cut on 1 foot of chalcopyrite which pinched out after 32 feet. The same vein was driven on south and after 12 feet it widened to about 4 feet 6 inches of sulphide ore.

Conclusions

1. On Colebrook Hill, there is a considerable quantity of ore carrying sulphides, including chalcopyrite. Owing to incomplete development and lack of systematic sampling, the amount of copper sulphide is unknown. There are at least 4 orebodies in which sulphides are present in irregular veins or patches, or disseminated throughout the massive type of ore.

Although an assay of 5.9% copper has been recorded (Waller, 1902, p. 6), values were generally less than 3% so that the deposit is apparently low grade.

2. There are only traces of gold, and only about 1 ounce of silver per ton. Tin has not been recorded.

5 Copper-Nickel

THE FIVE-MILE (OR CUNI) DISTRICT

(See Figure 17)

Introduction

The copper-nickel field lies five miles NE of Zeehan on the Emu Bay Railway, west of the Queenstown to Renison Bell road. It was described by Blake (1952), Taylor and Burger (1952b), Horvath (1957) and Robinson (1959) whose reports form the basis for the following account.

In 1893, J. Dixon was granted a reward claim for nickel, and G. E. Elburn for copper. Montgomery (1895) compared the copper-nickel ore with that at Sudbury in Canada and recorded that a small parcel had been sold profitably in Europe. Little development took place until 1909 when 5 leases were pegged, two of which were abandoned in 1911. After some development work in 1912 two of the remaining leases were transferred to the Dundas-Cuni Mining Co. Ltd. A bulk sample of ore from this mine contained 17% nickel and 6.45% copper. Before the outbreak of war in 1914 closed the outlet to the European markets, about 700 tons of ore had been shipped. The fifth lease was transferred to the Copper-Nickel Prospecting Syndicate which sold about 2776 tons of ore in the 1912-1914 period. This ore carried between 8% and 11% nickel and 4% to 14% copper.

There was then little activity on the field until early 1928 when the Imperial Geophysical Experimental Survey made electrical and magnetic surveys over the northern sector. Later in that year, the Copper-Nickel Mining Co. was formed to exploit the northern orebodies, but after ore containing 204 tons of nickel had been raised, work ceased in 1932 owing to limited capital and heavy inflow of water. The Department of Mines drilled a series of boreholes and cut a number of trenches in 1930, to follow up the geophysical survey, and more holes were drilled in 1939-1940.

The old Vaudeau workings were re-opened briefly in 1938 by Australian Nickel N.L. and in 1948 by the Lead-Nickel Mining Co. The Bureau of Mineral Resources made geophysical surveys in 1952 and 1953, using self-potential, magnetic and electromagnetic methods.

Drilling was recommended in North Cuni and 4 boreholes were drilled in 1953 by the option holders, Eagle Metals Pty. Ltd., who later relinquished the leases which reverted to Montana Silver-Lead N.L. Between 1955 and 1957 a series of 18 holes was drilled by the Department of Mines on behalf of the company which held leases over much of the Cuni district, and the results have been discussed by Horvath (1957) and Robinson (1959). The Bureau of Mineral Resources made further self potential and magnetic surveys in 1956-1957. Several hundred soil samples taken by auger were tested for copper and nickel; many were examined for lead.

General Geology

The country rocks are a highly weathered series of grey, green and purplish shale, siltstone and greywacke assigned to the Crimson Creek Formation which is considered to range from possibly Lower to Middle Cambrian. The sediments were intruded, probably in late Cambrian times, by sills and dykes of pyroxenite and gabbro, which to the east of the Cuni field have been extensively serpentinized. The beds strike generally a few degrees west of north,

and dips are vertical or steeply to the east. Northwards, the strike swings to east of north with a SE dip. The Devereaux orebody in the south has been displaced westwards by the Nevada Fault.

Mineralization

The orebodies consist of shoots in the footwall of the basic sill, or are wholly within it. Cores of the sill were examined by Roberts and Lovering (1957) who classified the rock as a metasomatized fine to medium grained dolerite consisting mainly of secondary actinolite, chlorite and penninite. Feldspar has been replaced by epidote and sericite; remnants of pyroxene and hornblende were noted.

Williams (1958) showed that there are two main types of ore:—

1. High grade pentlandite-pyrrhotite ore at North and South Cuni, and at the Vaudeau mine.

At North Cuni, nickel occurs in pentlandite $(\text{Fe,Ni})_9\text{S}_8$, which has been largely replaced by violarite $(\text{Fe,Ni})_9\text{S}_8$, forming bands and patches often intergrown with iron oxides derived from the alteration of the pentlandite. Pyrites may constitute up to 20% of the sulphides, and chalcopyrite partly replaces the other minerals.

The ore at South Cuni is similar but lower grade. Pyrrhotite is more abundant in the Vaudeau ore.

2. High grade millerite ore at the Nickel Reward and Devereaux prospects, and some low grade millerite at North Cuni.

At the Nickel Reward, the ore is intergrown chalcopyrite and millerite (NiS) . Pyrite represents from 25% to 60% of the ore, as residual grains corroded by the chalcopyrite and millerite. The ore at the Devereaux prospect is similar but the extent and grade of ore are unknown.

Williams concluded that the two ore types belonged to different phases of the same mineralization and that segregation took place in depth before emplacement.

Workings

GENET'S WINZE

The orebody was worked to a depth of only 10 feet over a length of 70 feet by the Copper-Nickel Mining Co. in 1929-1931 but the total production is not known. Five boreholes were drilled by the Department of Mines 1930, followed by two more drilled by Eagle Metals Pty. Ltd. in 1953. Another four holes were put down later by the Department of Mines (Robinson, 1959).

Robinson concluded that there may be about 15,000 tons of ore with 4%-6% nickel and 2%-3% copper indicated by drilling. Ore bottomed at 110-120 feet below surface level.

NORTH CUNI SHAFT

Between 1912 and 1914, the shaft was sunk to a recorded depth of 80 feet by the Dundas-Cuni Mining Co. Ltd. and a plat was cut at this level. The orebody was proved to be 3 feet wide,

striking north with an easterly underlay. A bulk assayed 17% nickel and 6.45% copper. Between 1929 and 1932, the Copper-Nickel Mining Co. drove along the lode northwards from the plat for 150 feet, and south about 80-100 feet. An old underlay winze on the orebody was completed through to the south drive 40 feet south of the shaft. Some stoping was done on the south drive but no record is available, nor is the total output known, although ore containing at least 204 tons of nickel was produced from North Cuni and Genet's Winze.

A borehole drilled in 1953 intersected ore above the north drive assaying 1.1% nickel and 0.82% copper over a width of 10 feet; a second hole indicated lower grade mineralization just below the end of the south drive.

Robinson (1959) suggested that there might be 2,500 tons of ore remaining above the 80 foot level, with possibly 1,000 tons below.

SOUTH CUNI SHAFT

According to Reid (1925a) the shaft was sunk to a depth of 75 feet by the Dundas-Cuni Mining Co., and the lode was driven on southwards for 96 feet. Between 25 feet and 46 feet the width varied from 4 feet 3 inches to 2 feet 6 inches and bulk analyses showed from 2.9% to 7.58% copper, and 6% to 11.72% nickel. The lode practically pinched out between 46 feet and 62 feet along the drive, but at 67 feet it consisted of 4 feet 6 inches high grade ore with 18 inches of quartz. Further south, the high grade ore on the footwall cut out at 86 feet, and the quartz or low grade siliceous ore on the hangingwall side ended at 96 feet. Reid stated that most of the ore above the drive to the surface had been stoped out. He estimated total production (i.e. from both the South and North Cuni Shafts) at 1189 tons, up to the closing of the mines in 1914. Of this quantity:—

- 420 tons contained 5.53% copper and 11.57% nickel;
- 10 tons contained 5.12% copper and 10.37% nickel;
- 59 tons contained 5.12% copper and 11.66% nickel;
- 20 tons contained 5.53% copper and 11.57% nickel.

Three boreholes drilled by the Department of Mines about 1930 to test the lateral extension of the orebody indicated that mineralization was absent about 200 feet south of the shaft and 80 feet north.

Robinson (1959) concluded that only a few hundred tons of ore might still remain below the drive.

BLOWFLY SHAFT

Taylor and Burger (1952b) recorded that the small lode was 60 feet long at the surface and 35 feet long at the bottom of the shaft. By 1914, 280 tons of marketable ore had been produced by the Copper-Nickel Prospecting Syndicate and the deposit was almost worked out.

MOSQUITO SHAFT

About 52 tons of ore were raised in 1914 by the Copper-Nickel Prospecting Syndicate but there is no record of the workings, which were probably very small. Two holes drilled in 1930 were too far south to intersect the lode.

VAUDEAU SHAFT

In 1912, W. Davie and party trenched along the orebody for 83 feet. Between 1912 and 1914, the orebody was worked by the Copper-Nickel Prospecting Syndicate, which also appears to have been called the Melbourne Copper-Nickel Co. Reid (1925b) stated that after five exploratory boreholes were drilled, the shaft was sunk to a depth of 127 feet and levels were opened up at 70 feet and 122 feet. The upper level was driven 27 feet north and 52 feet south of the shaft and the stopes yielded 2,500 tons of ore containing 10.4% copper. Ore apparently cut out in the crosscut from the shaft on the lower level and no ore was found in the north drive. In the south drive, the lode was found at 11 feet from the crosscut and was driven on for 30 feet. The orebody averaged 3 feet in width, and an 18 feet stope was taken out above this level.

After the mine closed in 1914, no important development took place until the Australian Nickel Co. re-opened the shaft in 1938 and extracted 278 tons of ore containing 19.75 tons of nickel and 11.19 tons of copper. In 1948, 750 tons were raised by the Lead-Nickel Mining Co., but no market could be found. The company completed a rise between the levels which had been started in 1914 and stoped out most of the ore between the levels south of the shaft.

About 3880 tons of ore was produced altogether, averaging about 10% nickel and 5% copper. Most of the ore in the known orebody appears to have been extracted.

NICKEL REWARD SECTION

The shaft is believed to be only 20 feet deep. Reid (1925a) recorded that small amounts of ore were produced, with values ranging from 8% to 12% nickel and 3% to 5% copper, with a little silver and a trace of gold. Two boreholes were drilled prior to 1914, but no ore of economic value was found. Blake (1952) stated that the lode was about 30 feet long with a width of 2-8 feet.

Horvath (1957) and Robinson (1959) gave detailed accounts of the results of self-potential surveys and a series of boreholes designed to test indications in the Nickel Reward area. Robinson thought that there were at least two orebodies and possibly three, with values ranging up to 6.97% nickel, and up to 3.14% copper. About half a ton of ore from a deep costean NE of the old Nickel Reward workings was assayed by the Department of Mines Laboratory in Launceston, and showed 7.23% nickel and 5.26% copper. Horvath concluded that the orebody trended easterly with a shallow southwards dip and was probably less than 100 feet long, but over 10 feet thick in the centre. The extent of ore in depth is not known.

DEVEREAUX PROSPECT

Reid (1925a) stated that a 10 acre lease had recently been granted to J. E. Devereaux. The orebody was exposed in a few shallow holes and at surface was between 1 foot and 1 foot 6 inches wide. The depth of the shaft is not known. Assays indicated 5.5% nickel and 18.1% copper. In 1956 a series of three boreholes drilled by the Department of Mines and a self-potential survey made by Horvath showed that mineralization round the prospect was low grade and of limited extent.

TABLE 48.—Production—Five-Mile District

<i>Workings</i>	<i>Ore (Tons)</i>	<i>Nickel %</i>	<i>Copper %</i>
Genet's Winze } North Cuni } South Cuni }	c.2000? (264 tons nickel recorded)	10.15	5.46
Blowfly	1189	10.37-11.57	5.12-5.53
Mosquito	280	?	?
Vaudeau	52	?	?
	3877	7.1-11.4	4-14
Approx.	7400		

OTHER OCCURRENCES

Low grade nickel mineralization within the main ultrabasic intrusion east of the Cuni orebodies was described by Horvath (1957) near Nevada Creek immediately west of the Renison Bell road. A magnetic anomaly indicated by magnetic surveys in 1957 was tested by a trench and a borehole declined at 45°. Values ranged up to about 0.36% nickel and nickel was present over a drilled length of 139 feet (equivalent to about 100 feet horizontally and vertically).

Conclusions

1. In the Five-Mile district, copper-nickel mineralization is associated with basic sills in a belt about 2 miles long from north to south.

2. Although orebodies are generally less than 150 feet long, ore is frequently of high-grade. Discontinuity is in part due to faulting. Some lodes appear to pinch out at depths of up to 120 feet, but there is no reason to suppose that there are no orebodies in depth which do not outcrop.

3. Geophysical surveys supported by drilling and trenching indicated orebodies which should be investigated further.

4. The district is low-lying and near the watertable so that all exploitation must be from shafts. Water inflow might be considerable, but should be easily controlled by pumping.

Recommendations

1. The Nickel Reward lodes should be systematically explored, first by trenching and then by drilling guided by information so gained. Robinson (1959) suggested that the margins of the orebody (or orebodies) should be sought for initially, in order to work out the trend and dip, and Horvath (1957) emphasized the need for deep trenches. When the orientation of the lodes has been determined, a drill-hole pattern should be planned to test them at depth.

2. The South Cuni western lode indicated by the geophysical survey in 1928 should be examined as suggested by Robinson (1959). Trenching and sampling would help to decide if drilling is called for.

3. A borehole might be drilled between holes EM/3 and EM/4 to test the sill below the bottom of the North Cuni shaft. It should be sited to the east and be planned to reach a depth of 150-200 feet vertically below surface level.

TRIAL HARBOUR DISTRICT

The presence of nickel in the serpentine at Trial Harbour was first discussed by Twelvetrees (1901). A shallow shaft had been sunk on the hill east of the township and an adit (No. 1 of Waterhouse, 1916) was driven into the hill from the south some 30 feet below. He noted a few bays of ore and reported impregnations of nickel-sulphide ore and a little zaratite. An adit (No. 3 of Waterhouse) had been driven south into the hill from the north slope, but Twelvetrees was unable to penetrate more than 50 feet because of water. No work was in progress. Waterhouse (1916, pp. 415-421) examined the workings in detail. The adit (No. 1) had been connected with the shaft 47 feet in from the portal. At this point a winze was sunk for 21 feet 6 inches; a west crosscut had been cut for 21 feet and another for 17 feet 6 inches to the east. Veinlets and impregnations of pentlandite were noted, as well as secondary garnierite, but no massive sulphide ore was seen. Samples from dumps assayed 18.6% and 14.6% nickel.

About 40 feet below No. 1 adit, No. 2 adit had been driven eastwards into the hill for a total distance of 157 feet. Little nickel ore was seen. Williams (1958) showed that pentlandite and minor hazlewoodite occur as granular intergrowths disseminated through the serpentine or occasionally in thin irregular bands. He concluded that the nickel minerals were segregated within peridotite before serpentinization.

The deposit is apparently of little economic value.

6 Asbestos

The presence of chrysotile asbestos in the Zeehan Quadrangle was first noticed by Conder (1918) on Serpentine Hill and near the Exe River. Reid (1925a) referred to slip-fibre chrysotile in serpentine near the Razorback mine, Dundas. Carey (1944) reported on the activities of Tasmanian Asbestos Pty. Ltd. on Serpentine Hill, whose leases were later examined in great detail by Knight (1946). Further work based on Knight's report was carried out by Taylor (1955), who also examined the Razorback and Exe River prospects. No asbestos was found in the serpentine at Trial Harbour.

SERPENTINE HILL

The only asbestos to be worked was discovered here, near the Argent Tunnel in 1940, during the construction of the road from Zeehan to Renison Bell. The deposit was investigated by the Colonial Sugar Refining Co. Ltd. in 1942 and its subsidiary, Tasmanian Asbestos Pty. Ltd., installed a pilot mill in 1943. Fibre was produced in 1944 and 1945 only. In 1944, 101.11 tons of fibre was recovered from 2207 tons of rock, and in 1945 276.36 tons of fibre from 6963 tons of rock.

The asbestos is associated with an intrusion of serpentinized pyroxenite or bronzitite, and Taylor (1955) showed that the main veins occur in zones around masses of unaltered bronzitite within massive pale green serpentinite. Veins up to about $\frac{3}{4}$ inches wide are also present in banded serpentinized pyroxenite. The asbestos is chiefly the slip-fibre variety, frequently associated with picrolite, in veins up to about $1\frac{1}{2}$ inches wide.

Taylor (1955, pp. 80-83) described the five chief workings examined by him and also by Knight (1946). All ore was removed from the *Mill Cut Orebody* above the level of the mill, and there were no partly developed reserves. Reserves in the *No. 5 Cut Orebody* were estimated at 40,000 tons with a possible grade of about 1.8%. No developed reserves remained in the *No. 4 Cut Orebody* while those in the *No. 1 Cut Orebody* were very small. There might be 35,000 tons in the *North-East Orebody*, but the average grade would not exceed 1.9% and might be as low as 1%. The grades referred to the percentage of fibre recoverable by the methods of mining and milling used in 1945. As Taylor pointed out, the inefficiency of the mill was an important factor leading to the abandonment of operations, as only 64% of the potential value of the fibre was being realized, and the actual mill efficiency was only about 55%.

Taylor made a number of recommendations for further prospecting. The lower extension of the *Mill Cut* was considered well worth investigation, either by driving (Knight, 1946) or by diamond drilling. A pilot hole 50 feet deep below the floor of the cut was proposed as a guide for other boreholes. Taylor also suggested driving or drilling through a ridge of serpentinized pyroxenite which trends NE towards the summit of *Serpentine Hill* on the east side of the road (i.e. about 800 feet SE of the *Mill Cut*). Fibre-bearing serpentine was traced over a length of 400 feet along the NW margin of the ridge, averaging 4 feet to 6 feet in width. Although 10,000 tons of fibre might be present in the *Serpentine Hill* district, any revival of asbestos mining would depend on the installation of highly efficient plant.

RAZORBACK PROSPECT

Veins of chrysotile asbestos occur NE of Mt. Razorback within serpentinized pyroxenite which is probably part of a thick sill injected into *Dundas Group* sediments of Middle Cambrian age. There are also frequent irregular bands of magnetite displaying a fibrous or striated habit, and magnetite crystals are disseminated throughout the serpentine. The prospect was examined by Taylor (1955, pp. 88-90) who recorded veins of asbestos up to about $\frac{3}{4}$ inch wide, but chiefly about $\frac{1}{2}$ inch. An adit driven westwards into the ridge on the east side along a crush zone within serpentine did not intersect the main pyroxenite mass which is exposed on the crest of the hill so that it was not known if chrysotile were associated with zones near the unaltered pyroxenite, as on the surface. Scattered veins of asbestos were exposed in the serpentine, but are mainly less than $\frac{1}{2}$ inch wide. Taylor suggested that the main value of the deposit would be as an additional source of supply if a mill were established elsewhere in the district.

Veins of slip-fibre chrysotile up to about $\frac{1}{2}$ inch wide were noted within sheared serpentine in the two boreholes recently drilled by the Department of Mines on the *Grand Prize* grid.

OTHER OCCURRENCES

There are minor occurrences of asbestos near the *Exe River* on the NW slope of *Colebrook Hill* south of the *Emu Bay Railway*; near the old *Olympic* mine on the west side of the mill; in *Star Creek* (a tributary of the *Ring River* east of *Renison Bell*); and also east of *Pine Hill*.

7 Iron

COMSTOCK DISTRICT

The presence of magnetite in the Comstock district, five miles west of Zeehan, has been known since about 1885 and the deposits were first prospected for silver-lead by the Tenth Legion Co. During 1901-1902 an adit at least 300 feet long was driven, and in 1903, Waller made the first detailed geological examination. From 1920, the orebodies were explored for about 16 years by a series of 17 adits and a number of trenches put in by G. and C. Hoskins Ltd. (later Hoskins Iron and Steel Ltd.) The leases were eventually transferred to Australian Iron and Steel Ltd. The deposits were included in a report on iron ore reserves in Tasmania by Blake (1928) and were later examined by Woolnough (1939) who recommended a comprehensive mapping and sampling campaign subsequently carried out and described by Blake (1940). The last report made was by Hughes (1959) after the completion of 2 diamond drill holes by the Department of Mines. There has been no further development but the regional geology has now been mapped.

The magnetite is associated with an intrusive mass of gabbro and amphibolite, probably of late Cambrian age, which has been partly serpentized and dolomitized. The intrusion was injected into quartzite and slate considered to be of Upper Proterozoic or Lower Cambrian age, which further south are overlain by Lower (?) to Middle Cambrian greywacke, grit and siltstone or shale. After the Tabberabberan Orogeny, the Heemskirk Granite was emplaced in Devonian times and the Tenth Legion deposit lies within its contact-metamorphosed aureole. A major fault trending NW, believed to be Tertiary, downthrows the rock against highly sheared and cleaved Proterozoic quartzite, slate and schist to the NE.

The magnetite was formerly believed to have accompanied the granite intrusion, but Hughes (1959) showed that by analogy with magnetite deposits of the Savage River in North West Tasmania, it was probably derived from the Cambrian basic intrusion.

The basic igneous rocks and the surrounding sediments were contact-metamorphosed by the Devonian granite. The chief effect was the development of calc-silicate hornfels, partly from the dolomitized serpentine, but also by the alteration of calcareous or dolomitic sediments within the sequence. Irregular patches of diopside occur within dense white calc-silicate hornfels shown by G. Everard (in Hughes, 1959) to consist of granular diopside and sericite. Other minerals include tremolite, actinolite, garnet, epidote, phlogopite, vesuvianite, chlorite and talc.

The dominant mineral is magnetite, with minor amounts of hematite and limonite, occurring as irregular lenses or zoned segregations and concentrations in the basic intrusion or the associated calc-silicate hornfels. At the surface, the ore is pure and massive and forms craggy ridges or low hillocks as the country rocks are more easily weathered. Cores from the boreholes indicated that the grade of ore deteriorates in depth, partly due to dilution within the unweathered host rocks.

OREBODIES

The Tenth Legion deposit is the most important. It outcrops along a length of about 1700 feet from east to west, with an average width of 150 feet and was explored by a series of 4 adits as well as the 2 boreholes drilled by the Department of Mines. The adits revealed a number of irregular lenses, the largest of which averaged about 49 feet of magnetite excluding bands of country rock. In No. 1 bore, the chief concentration of magnetite was 60 feet wide but in No. 2 bore, the grade was lower and the ore more disseminated. Hughes (1959) calculated reserves of about 3,000,000 tons down to 200 feet, the level reached by the boreholes.

About 150 yards NW, a smaller body outcropping over a length of 530 feet and an average width of 35 feet was described by Blake (1940). An adit 80 feet below the top of the ridge was discontinued after penetrating only 4 feet into dense magnetite, about 120 feet from the portal. Proved reserves down to adit level were calculated at 190,000 tons of ore.

The No. 3 zone of Blake (1940), which lies a quarter of a mile south of the Tenth Legion, was traced on surface for 600 feet along a NW trend, and although the maximum width was about 250 feet in the centre of the outcrops, it was much less at either end. Solid magnetite is not prominent at the surface. An adit (No. 10) driven 303 feet NE from the SW side cut 3 lenses of magnetite respectively 31 feet, 63 feet and 103 feet wide which, however, were separated by bands of country rock 43 feet and 12 feet wide. Blake estimated 270,000 tons of ore down to adit level (40 feet below surface).

In the vicinity of Kynance Creek, Blake (1940) described 9 other orebodies, 3 of which had not been explored in depth but which appeared to be unimportant. Ore proved at surface and in adits was about 767,000 tons.

In the Comstock district, total reserves proved and indicated amount to about 4½ million tons, although exploration to date has been relatively shallow with the exception of the 2 boreholes drilled in the Tenth Legion deposit to a vertical depth of about 200 feet.

Assays

The following table, based on 42 samples recorded by Blake (1940) and 2 assays by Waller (1903), shows the percentage variations in the ore.

TABLE 49—Range of Analyses

	Percentage Range %	Remarks
Fe	48.90-69.10	
SiO ₂	0.20-15.04	
Al ₂ O ₃	0.41- 3.97	
CaO	Nil - 0.34	
MgO	0.10- 3.68	
MnO	0.19- 2.84	
P ₂ O ₅	Tr. - 0.14	
TiO ₂	Nil - 0.17	
S	0.01- 1.43	Only 2 samples over 0.2%
Acid Insoluble	0.24-15.36	Only 3 samples over 10%

CONCLUSIONS

Although the deposits are small, scattered, and of overall low grade, there is no doubt that exploration in depth would add substantially to the proved or inferred reserves now totalling about 4½ million tons. Detailed sampling shows that the ore is low in titania, phosphorus and sulphur. Hughes (1959) pointed out that the orebodies would be a useful additional source of supply if larger deposits elsewhere in Tasmania were developed.

8 Miscellaneous Ores

ARSENIC

Arsenopyrite is fairly common at the Razorback mine, Dundas, and the Fraser Creek mine on the North East Dundas Tram; it also occurs in other cassiterite-sulphide orebodies, for example the old Athenic and Olympic mines on Colebrook Hill. It is usually associated with pyrrhotite, chalcopyrite and quartz and has been worked only at the Fraser Creek mine (see p. 242). Between 1919 and 1920, ore containing about 170 tons of arsenic was produced and treated at Edwards's Pyrites and Ore-Reduction Co. works in Ballarat, Victoria. In 1920, 779 tons of arsenopyrite averaged 16%-18% arsenic. Reid (1925a) reported that from No. 1 adit, a bulk sample of ore assayed 20.02% arsenic, from No. 3 adit 7.23% and from No. 4 adit 16.8%. Henderson (1935b) recorded 20.93% arsenic in a selected sample from the Razorback mine.

CHROMITE

Small crystals of chromite are widely disseminated through the serpentine, especially near Dundas and Serpentine Hill, but no deposit of economic importance has been found. Carey (1944) investigated the possibility of recovering chromite from tailings at the Tasmanian Asbestos Pty. Ltd. asbestos workings on Serpentine Hill near the Argent Tunnel, south of Renison Bell. Samples collected from the tailrace of the plant were separated with a hand magnet. The magnetic fraction amounted to 78% and consisted largely of magnetite. Assays indicated 0.9% Cr₂O₃, representing about 1.3% chromite. The non-magnetic portion which included serpentine assayed 2.7% Cr₂O₃, equivalent to 4% chromite. The whole tailings contained 1.3% Cr₂O₃, or nearly 2% chromite. Alluvial chromite is common in the valleys of tributaries of the Pieman River, for example the Ring River, and also in the Dundas Rivulet near Dundas, but it does not form workable deposits.

Decomposition of chromite subsequently led to the formation of secondary minerals such as stichtite (chromiferous serpentine) at South Dundas; crocoite (lead chromate) at the Adelaide mine, Dundas; and fuchsite (chromiferous mica) west of Rosebery and near Moores Pimple. Reid (1925a) noted that chrome-bearing cerussite is fairly abundant at Dundas. Although of academic interest, they are of no economic value, though crocoite is eagerly sought by mineral collectors.

GOLD

Although gold bullion was recovered at the Zeehan smelters in the early part of this century, the greater part of it was extracted from complex zinc-lead ore mined at the Hercules Mine near Williamsford outside the Zeehan region. Output in 1902 was about 1420 ounces.

Traces of fine alluvial gold may be found in many of the creeks flowing off the Read-Dundas Plateau, but rarely in workable concentrations. Alluvial deposits in the upper reaches of the Ring River have been worked in the past, and during the depression years about 1891 it is reputed that between 300 and 400 men produced a considerable amount of gold, although no figures are available. (Sec. Mines Rep. 1891/1892, p. 11).

The Melba Flat was worked about 1900 but production is not known. Small amounts of gold also occur in the fluvioglacial gravels bordering the Pieman River, and Blake (1931) recorded traces of fine gold and osmiridium in Farrell Rivulet and other tributaries of the Little Henty River flowing off the southern flanks of Mt Dundas. About 2 ounces were recovered from Crimson Creek and the Huskisson River in 1935.

OSMIRIDIUM

Alluvial osmiridium is derived from the intrusions of serpentine, pyroxenite and gabbro, and no concentration of economic value has been found. C. Riley and W. Kinsella discovered osmiridium in Trinder Creek, but the main part of the Wilson River Field lies beyond the northern boundary of the Zeehan Quadrangle. Traces of osmiridium occur in a number of the small south-flowing tributaries of the Pieman and Huskisson River as far west as Riley Creek. Similar disseminated osmiridium has been reported in Star Creek and the Ring River, Melba Flat, and near Dundas. In 1945, 2 men recovered about 5 ounces from the Cuni district.

TABLE 50—Total Production—Zeehan Quadrangle

<i>Field</i>	<i>Tin</i> (Tons)	<i>Lead</i> (Tons)	<i>Silver</i> (Ozs)	<i>Zinc</i> (Tons)	<i>Copper</i> (Tons)	<i>Nickel</i> (Tons)	<i>Arsenic</i> (Tons)	<i>Asbes- tos</i> (Tons)	<i>Cad- mium</i> (Tons)
Heemskirk	667.6								
Zeehan	5.3	190,113	26,226,537	70.6	945				
Renison Bell	3,372.4	1,475	125,400		159	579		377	
Five Mile									
Dundas	67.2	25,050	1,815,592	629.5					
Nth Dundas		114	558,052		330		302		
Sth Zeehan		4,426	320,420	2,679					40
Other Areas	257	367	71,523						
	<u>4,369.5</u>	<u>221,545</u>	<u>29,117,524</u>	<u>3,379.1</u>	<u>1,434</u>	<u>579</u>	<u>302</u>	<u>377</u>	<u>40</u>

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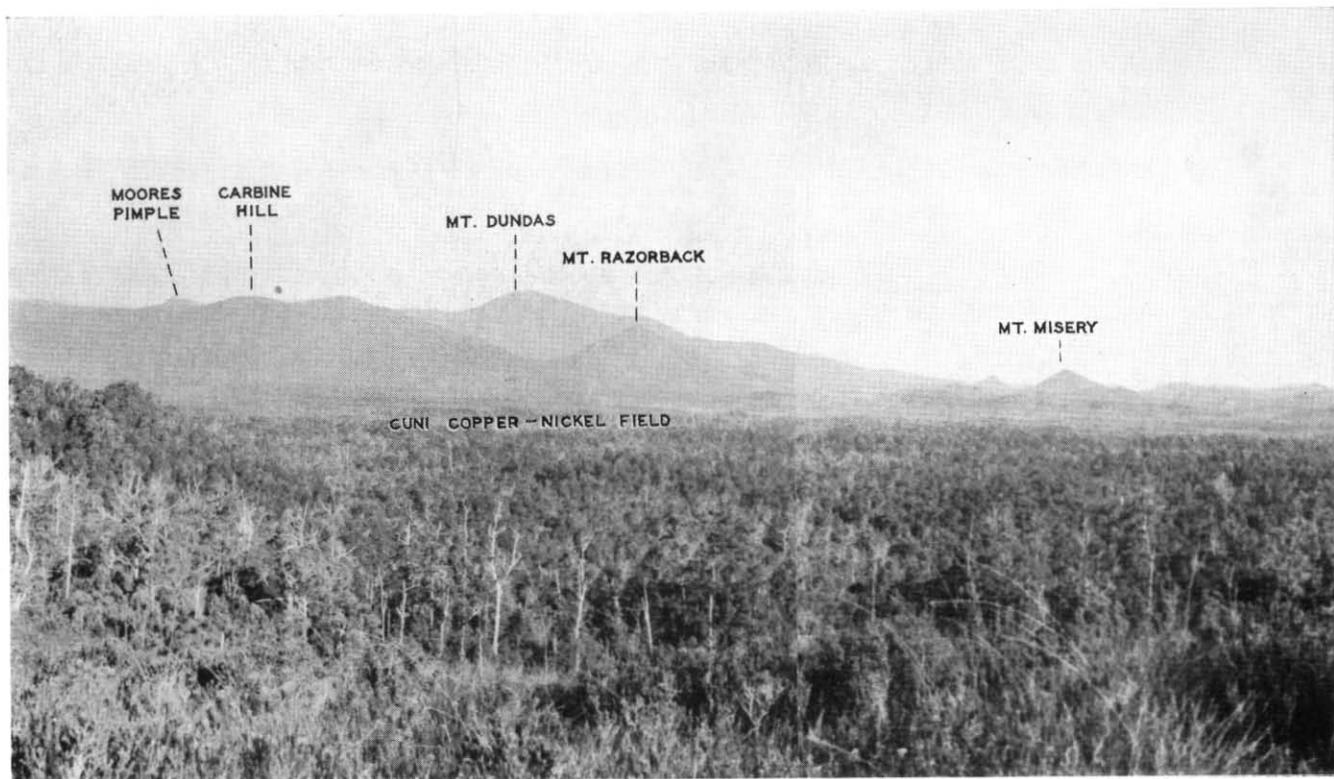


PLATE 1.—View looking towards Dundas from near Dunkley's Tram, north of Zeehan.

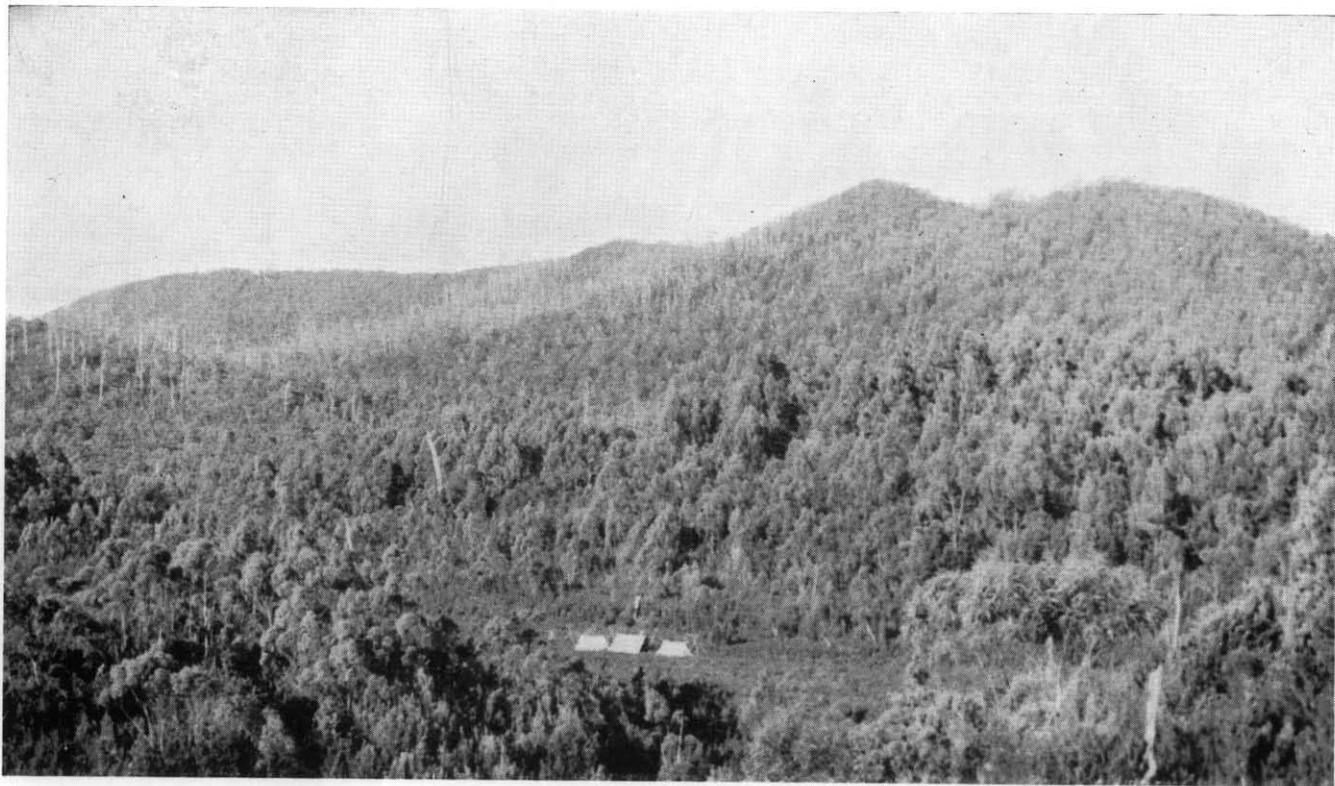


PLATE 2.—Hills of Proterozoic quartzite. Looking NE from Dunkley's Tram.



PLATE 3.—Metamorphosed Silurian Amber Slate. Beach south of Trial Harbour.

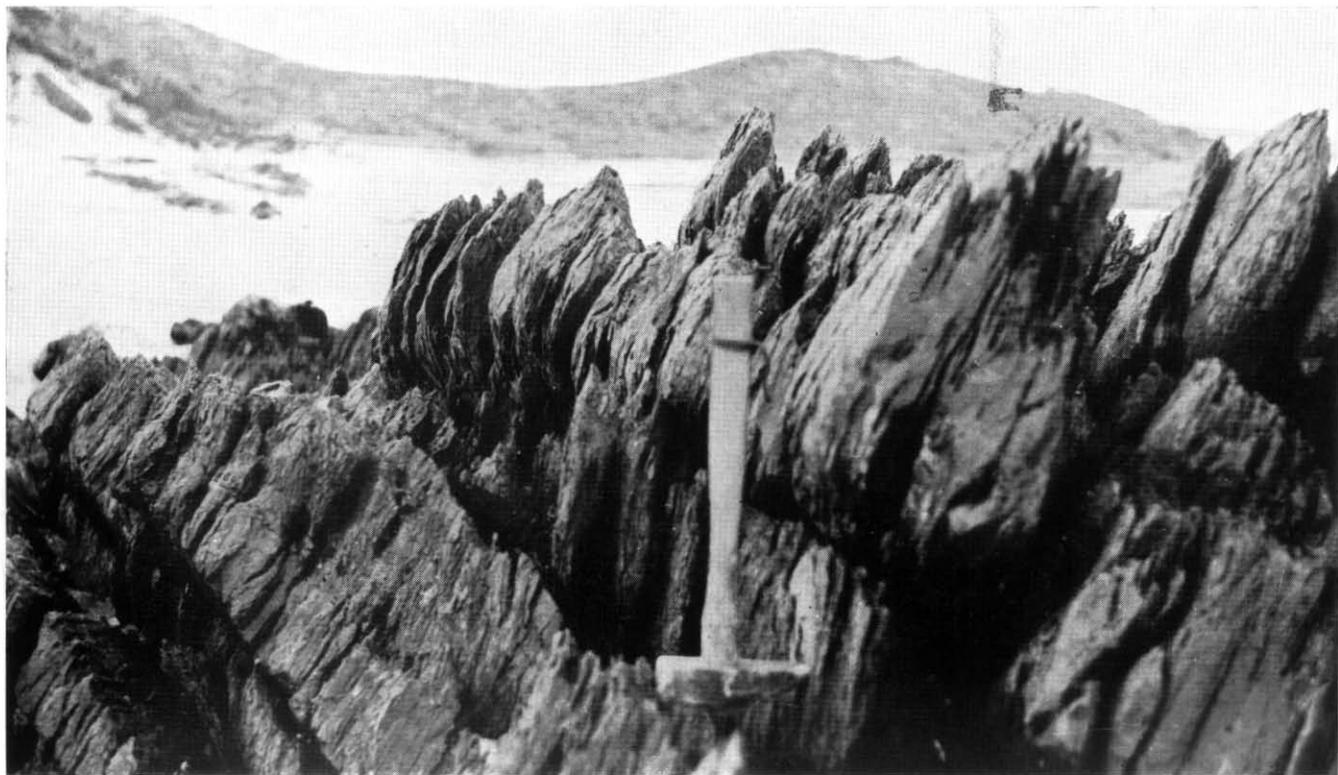


PLATE 4.—Cleaved Florence Quartzite, Duck Creek.

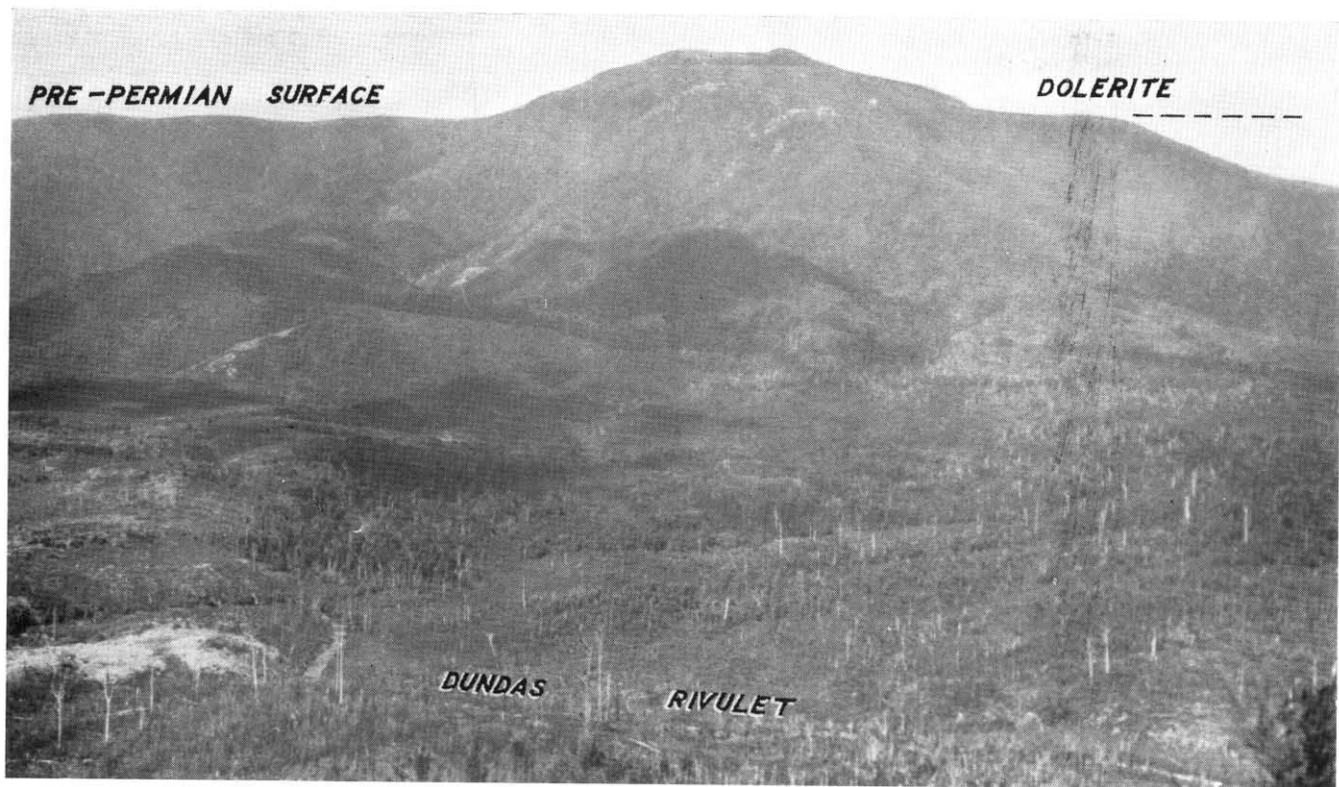
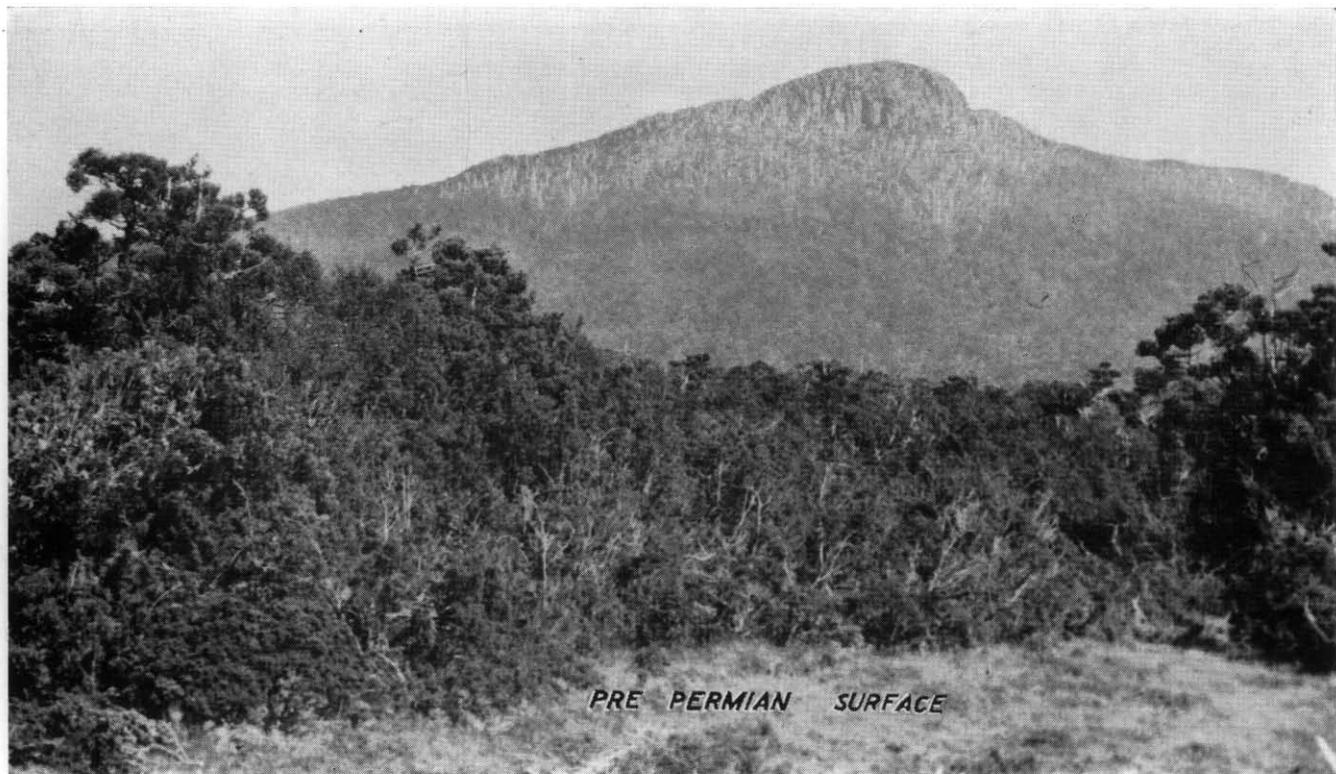


PLATE 5.—Mt Dundas from Misery Hill.



PRE PERMIAN SURFACE

PLATE 6.—East side of Mt Dundas.



PLATE 7.—Mt Zeehan Conglomerate. Little Henty River.



PLATE 8.—Moina Sandstone. Coast south of Duck Creek.



PLATE 9.—The Henty Surface and Mt Professor from the Zeehan-Strahan railway.



PLATE 10.—Glacial till near Henty Bridge.

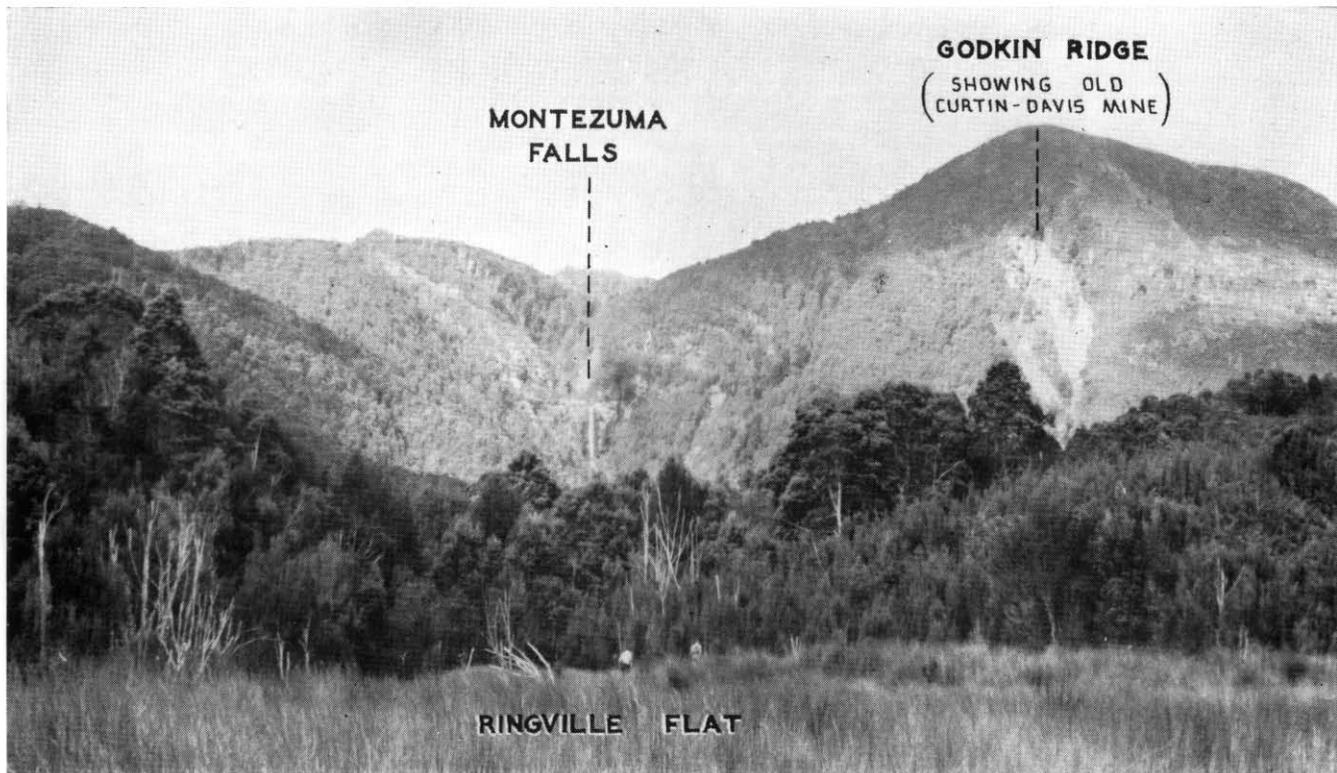
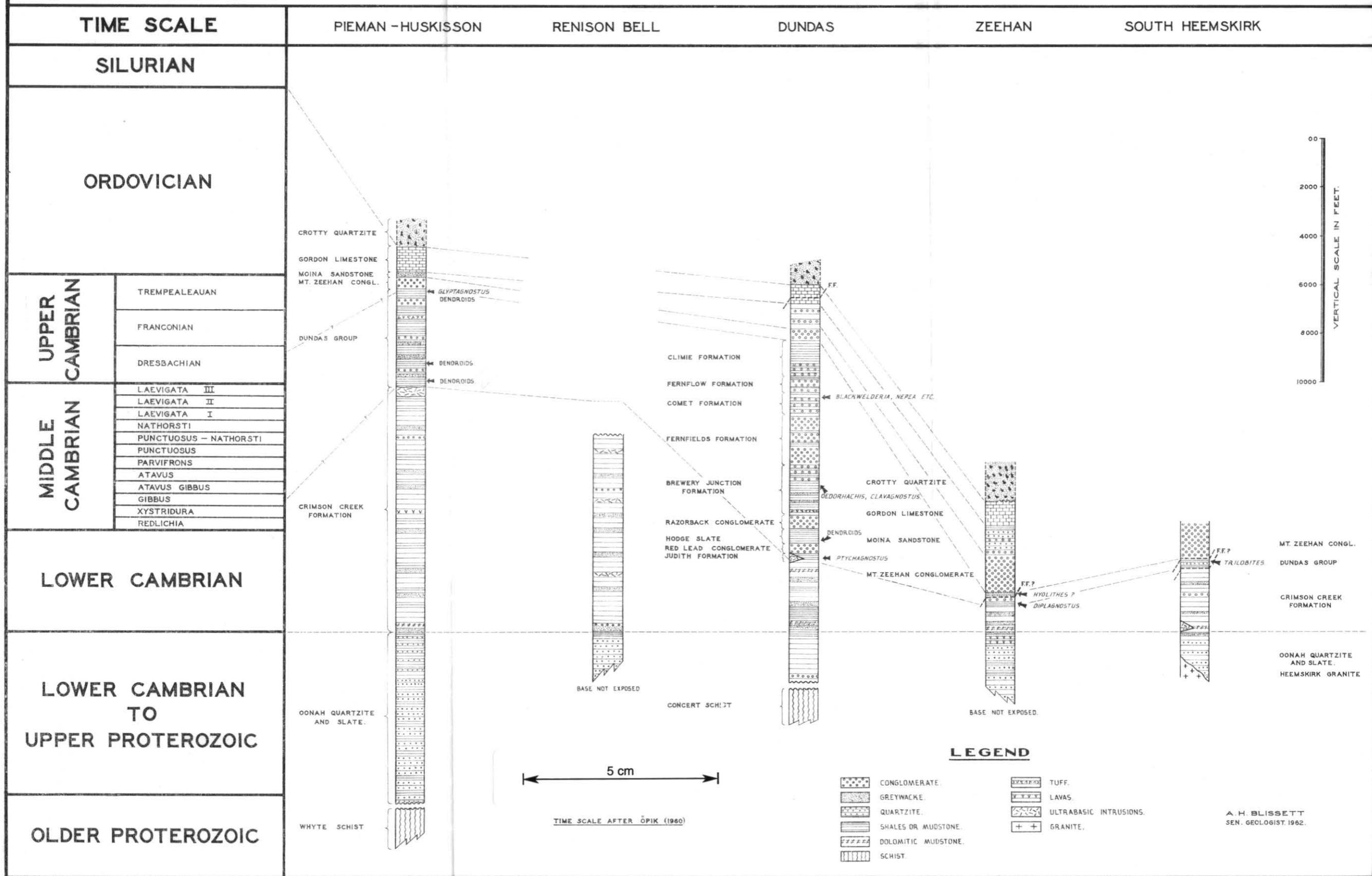


PLATE 11.—Site of the old town of Ringville.

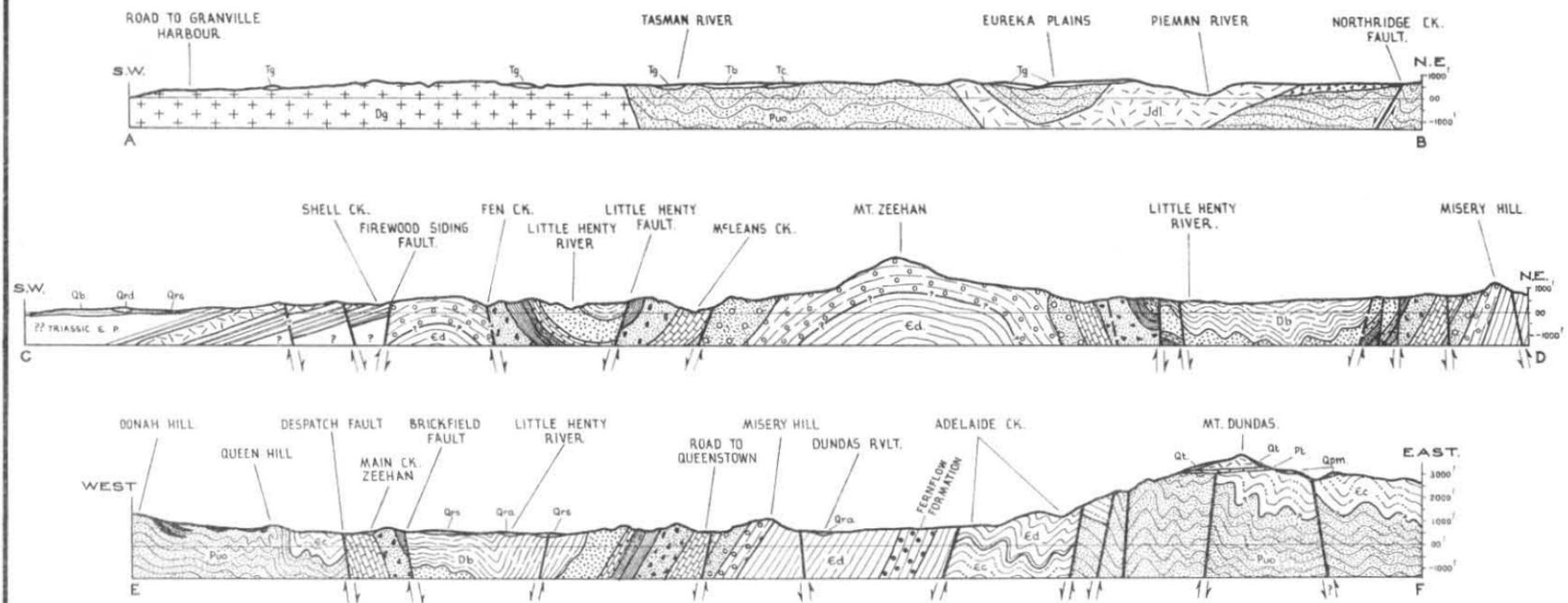
FIGURE 14—PROTEROZOIC TO UPPER CAMBRIAN — ZEEHAN QUADRANGLE



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A. H. BLISSETT
SEN. GEOLOGIST, 1962.

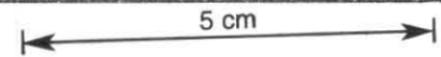
GEOLOGICAL SECTIONS- ZEEHAN QUADRANGLE



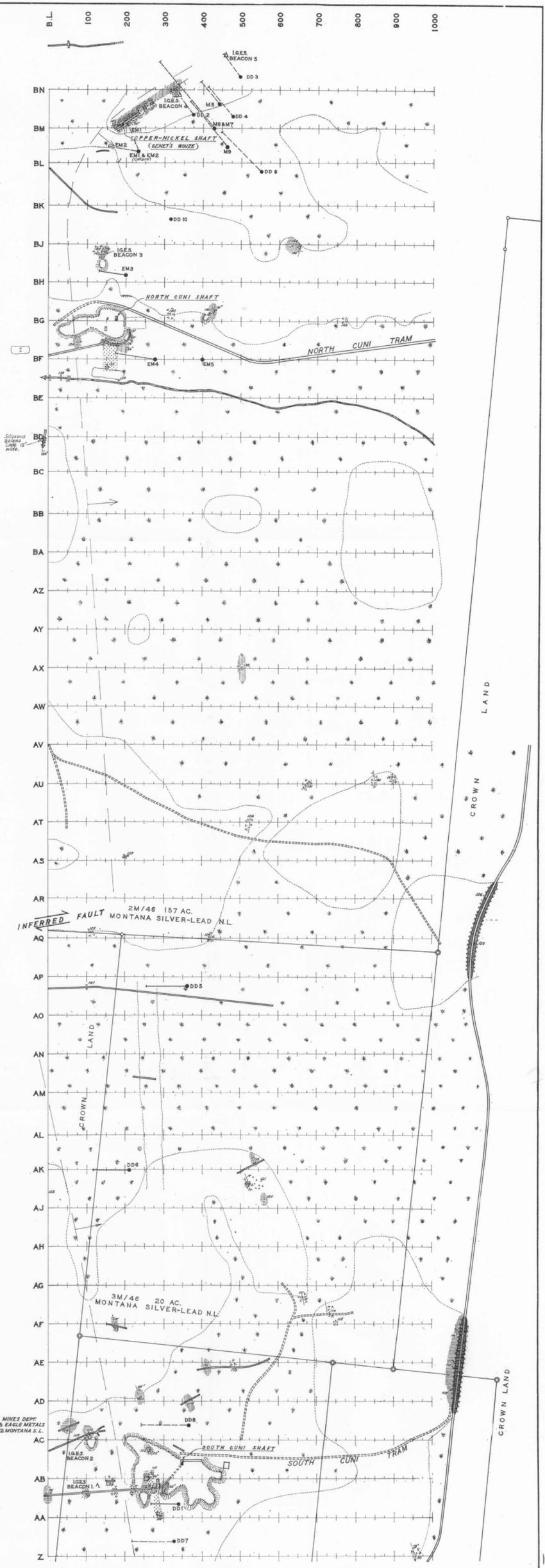
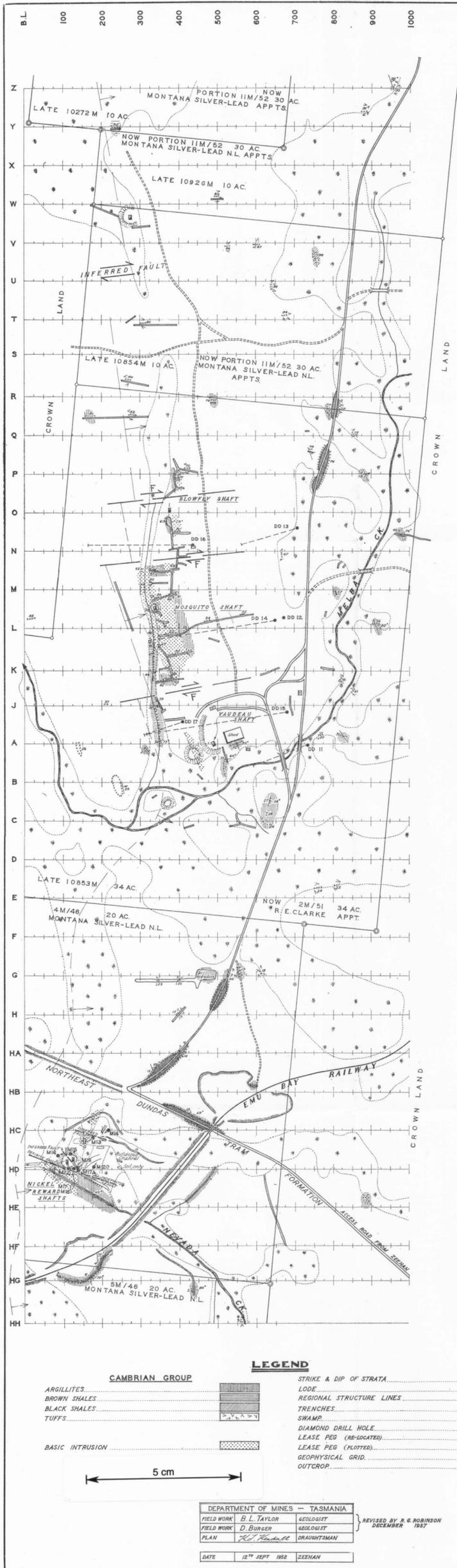
LEGEND

QUATERNARY	Qra	ALLUVIUM.
	Qrb	BEACH DEPOSITS.
	Qrd	SAND DUNES.
	Qt	DOLERITE TALUS.
	Qrs	OLDER ALLUVIUM MARSH DEPOSITS ETC.
TERTIARY	Qpm	MORaine
	Tc	CONGLOMERATE & GRIT.
PERMIAN	Tg	GRAVELS.
	P	MUDSTONES ETC.
DEVONIAN	Pl	ZEEHAN GLACIAL FORMATION.
	Db	BELL SHALE
SILURIAN	Df	FLORENCE QUARTZITE
	Soc	AUSTRAL CK. SILTSTONE
ORDOVICIAN	Sk	KEEL QUARTZITE.
	Sa	AMBER SLATE.
CAMBRIAN	Cg	CROTTY QUARTZITE
	Gd	GORDON LIMESTONE.
PRECAMBRIAN	Om	MOINA SANDSTONE.
	Ed	MT. ZEEHAN CONGLOMERATE. MISERY CONGLOMERATE.
TERTIARY	Ec	DUNDAS GROUP.
	Ec	CRIMSON CK. FORMATION
JURASSIC	Puo	POULSON VOLCANICS.
	Puo	UPPER PROTEROZOIC.
DEVONIAN	Tb	BASALT
	Jdl	DOLERITE
DEVONIAN	Dg+	GRANITE.

Figure 16.



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THE FIVE-MILE COPPER-NICKEL DEPOSITS
 DETAILED GEOLOGICAL PLAN

SCALE: 0 100 200 FEET

PLAN N^o: 1266-50

ER 7914S

Figure 17.