

ER8114N

TASMANIA
DEPARTMENT OF MINES

GEOLOGICAL SURVEY
EXPLANATORY REPORT

ONE MILE GEOLOGICAL MAP SERIES

K/55-6-45

MIDDLESEX

by

I. B. JENNINGS

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

1963

Registered by the Postmaster-General for transmission through the Post
as a book

D. E. WILKINSON, Government Printer, Tasmania

Price, 10s.

TASMANIA
DEPARTMENT OF MINES

GEOLOGICAL SURVEY
EXPLANATORY REPORT

ONE MILE GEOLOGICAL MAP SERIES

K/55-6-45

MIDDLESEX

by

I. B. JENNINGS

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

1963

Registered by the Postmaster-General for transmission through the Post
as a book

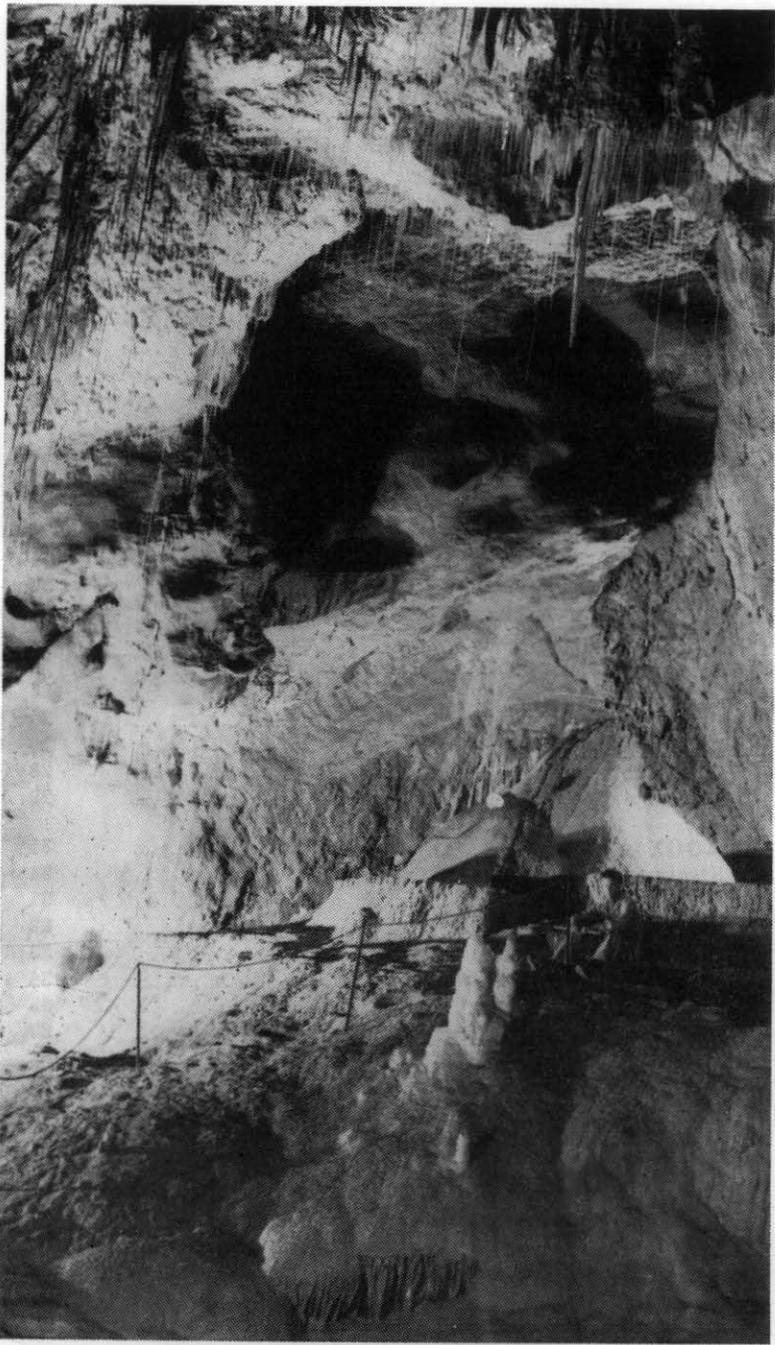
D. E. WILKINSON, Government Printer, Tasmania.

PREFACE

This report, the third in the series, was compiled to accompany the Geological Map of the Middlesex Quadrangle, issued in 1957. In preparing the Report, Mr. Jennings has been able to incorporate much knowledge gained since the issue of the map, both in this quadrangle and adjoining areas, by himself and his colleagues in the Geological Survey, and by others.

Geological interest in the Middlesex Quadrangle lies mainly in the complex structure, its history and its surface expression. The limestone in the Mole Creek district has produced important agricultural and pastoral country and at the same time provided interesting tourist attractions and problems for the hydrologist, as well as being a large potential source of commercial lime. Although mineralization has not proved of great economic interest in the past, it is varied in character and its possibilities are by no means exhausted. Those portions of the drainage systems of the Forth and Mersey Rivers which are incorporated in this Quadrangle are of importance from the point of view of water supply, whether for electricity, irrigation or other uses. Finally, the area contains a large amount of country of great interest to the bush walker.

J. G. SYMONS, Director of Mines.



Various types of limestone decoration in King's Hall, Marakoopa Caves, near Mole Creek.

Photo: F. R. Brown.

CONTENTS

	Page
INTRODUCTION	9
General	9
Previous Literature	9
Access and Facilities	10
Rainfall and Vegetation	11
Survey and Reliability	13
PHYSIOGRAPHY	14
Plateau Areas	14
Dolerite Escarpment	15
Fold Mountain System	17
Mole Creek Lowlands	19
Influence of Rock Type on Physiography	23
Tertiary Sands and Clays	24
Permo-Triassic Sediments	24
Gordon Limestone	24
Moina Sandstone and Roland Conglomerate	24
Cambrian Rocks	24
Precambrian Rocks	24
Tertiary Basalt	24
Jurassic Dolerite	24
Granitic Rocks	25
Erosion Surfaces	25
Glacial Features	28
Drainage Systems	29
GEOLOGY	31
Stratigraphy	31
General	31
Precambrian Rocks	32
Howell Group	33
Fisher Group	34
Dove Group	35
Summary of Precambrian Stratigraphy	37
Cambrian System	38
Lorinna Greywacke	39
Gog Range Greywacke	41
Bull Creek Formation	41
Cambrian Keratophyre	51
Unassigned Cambrian Rocks	52
Ordovician System	53
Magog Group	55
Gordon Limestone	59
Silurian System	60
Eldon Group (?)	60

CONTENTS—*contd.*

GEOLOGY—*contd.*

Stratigraphy—*contd.*

	Page
Permian System	60
Kansas Creek Beds	62
Liffey Group	65
Woodbridge "Glacials"	67
Ferntree Mudstone and Cygnet Coal Measures	68
Triassic System	72
Ross Sandstone	72
Unassigned Triassic Rocks	73
Tertiary Deposits	73
Quaternary Deposits	74
Glacial Deposits	74
Other Pleistocene Deposits	76
Scree and Talus Deposits	76
River Alluvium	77
Igneous Rocks	77
Cambrian Keratophyre	77
Devonian	77
Lone Pine Granite	77
Dove Granite	78
Dolcoath Granite	81
Jurassic Dolerite	82
Tertiary Basalt	83
Tectonics	85
Precambrian Nucleus	85
Lower Palaeozoic Fold Belt	85
Granite Intrusions	87
Block-Faulted Permo-Triassic Sediments	89
Dolerite Intrusions	90
Basalt Extrusions	92
Structural Geology	93
Introduction	93
Precambrian Rocks	95
Cambrian Rocks	96
Jukesian Movements	96
Ordovician and Silurian Rocks	97
Mole Creek Syncline	98
Lorinna Syncline	98
Claude Creek Synclinorium	99
Standard Hill Anticlinorium	100
Vandyke Syncline	100

CONTENTS—*contd.*

GEOLOGY—*contd.*

	Page
Structural Geology—<i>contd.</i>	
Structure of the Gog Range	101
Tabberabberan Orogeny	103
Age Relations of the Fold Systems	105
Post Permian Faulting	107
Economic Geology	
History of Mining Exploration	110
Relation of the Granites to Mineralization	111
The Five Mile Rise Goldfield	112
The Mineral Deposits	113
Detrital Deposits	113
Lode Deposits	113
THE MINING PROPERTIES	
(a) Gold Mines	115
O'Rourke's Hydraulic	115
Thistle Mine	115
Union Mine	119
Golden Cliff Mine	121
Golden Hill Mine	123
Campbells Reward Mine, Lorinna	130
Glynn Mine	130
Great Caledonian Mine	131
Devonian Mine	132
(b) Iron Prospects	133
Powerful Mine, Lorinna	133
(c) Silver-Lead Mines	134
Devon Mine	134
Other Prospects in the Dove Valley	137
(d) Ferro-Manganese Deposits	138
Olivers Hill	138
(e) Tin and Wolfram Deposits	142
Lone Pine Prospect	142
McCoy's Prospect	142
APPENDIX	
Report on Samples from Jackey Shale, Western Bluff: by B. E. Balme	143
BIBLIOGRAPHY	
	145

FIGURES

	Page
1. Locality Map	8
2. Solid Geology, Middlesex Quadrangle	12
3. Deep Leads, Middlesex Quadrangle	16
4. High Level Erosional Surfaces	18
5. Mole Creek, Geology	20
6. Hydrology, Mole Creek Area	21
7. Tectonic History	84
8. Surface Geology, Western Tiers	88
9. Preservation of Talus by Collapse	91
10. Structural Trends	94
11. Rock Distribution and Faulting	102
12. Geological Section across Dolcoath Anticline	104
13. Geological Section, Walters Marsh to Mount Roland	106
14. Geological Section across Western Tiers and Gog Range	108
15. Thistle Mine	116
16. Golden Hill Mine, Locality Map	124
17. Golden Hill Mine, Plan	126
18. Golden Hill Mine, Section	127
19. Ferromanganese Prospect, Olivers Hill	139

PLATES

Marakoopa Cave near Mole Creek	Frontispiece
1. Roche Moutonné with Perched Block	} At back of book.
2. Glacial Striae in Howell Group Rocks	
3. Resurgence in Gordon Limestone	
4. Stylolitic Limestone	
5. Glacial and Periglacial Deposits	
6. Pleistocene Till overlying Precambrian Metasediments	
7. Pleistocene Till and Alluvium	
8. Bedded River Gravels	
9. Double Folding in Quartzite	
10. Minor Folding in Fisher Group Rocks	
11. Internal Structure of Minor Fold	
12. Steeply Plunging Minor Folds	
13. Lineation in Garnetiferous Schist of the Dove Group	
14. Upper Mersey Valley from Walters Marsh	

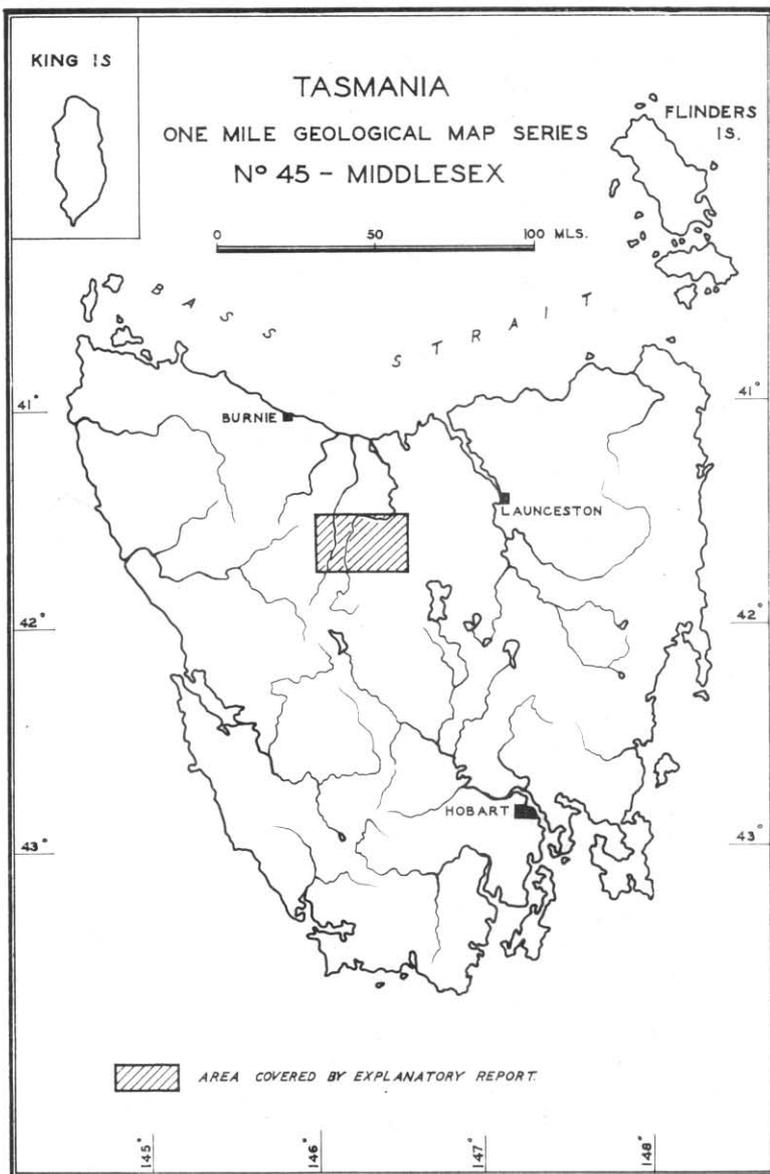


FIG 1.—Locality Map.

5 cm

Explanatory Report of the Middlesex Quadrangle

INTRODUCTION

GENERAL

The Middlesex Quadrangle covers the area between latitude $41^{\circ}30'S$ and $41^{\circ}45'S$ and longitude $146^{\circ}E$ and $146^{\circ}30'E$. The base map for the geological map was prepared by the Mapping Branch of the Lands and Surveys Department, Hobart, on a scale of 1:63,360. Other relevant survey information is indicated on the geological map. The sheet covers about 450 square miles in the central north of the State and includes part of the central plateau together with the north facing escarpment of these highlands.

Regional geological mapping commenced here in 1952 when a regional establishment under the control of J. Elliston was set up at Lorinna. From this time until late in 1954, Elliston and his co-workers, chiefly L. G. Nixon, carried out regional geological and topographic mapping of a wide area surrounding Lorinna. During this period, due to the lack of base maps, much work was directed toward purely topographic mapping, but in addition to this most of the major streams and access routes were examined in some detail. From this work Elliston compiled a set of 20 chain geological maps, part of which formed the basis of the later mapping. This early work covered only part of the Middlesex map sheet and was not restricted to the present map boundaries.

With the advent of the present base map, regional geological mapping was extended to cover the whole of the Middlesex quadrangle in more detail. From late 1954 the mapping was under the control of the author assisted for some of the time by K. L. Burns and for a short period by S. J. Mayne. Acknowledgment is tendered to Elliston and Nixon for the early mapping in the area and to Burns for mapping in the eastern part of the Mole Creek district, along part of the Western Tiers, the Gog Range, in the Forth River north of Lorinna and in the vicinity of Stormont. The geological map and text figures were produced by the Drawing Office of the Mines Department under the control of K. Kendall. Petrographic descriptions incorporated in the text were prepared by G. Everard, and analyses and assays were carried out at the Department of Mines Laboratory, Launceston.

PREVIOUS LITERATURE

Prior to the systematic mapping outlined above, several early general reports and surveys of individual mines or mining districts had been made, the most important being those by Twelvetrees (1913) and Reid (1919a) which covered the mining areas around Moina and Lorinna. During the course of this survey, smaller areas within the Quadrangle were mapped independently by Spry (1958) and Ford (1960). Although their work was independent of this survey their results have been available for some time. Full acknowledgment is accorded these workers for information relative to their respective areas. The most important reports dealing with the Quadrangle are listed in the bibliography at the end.

ACCESS AND FACILITIES

Apart from the farming district around Mole Creek and Chudleigh the Middlesex Quadrangle is only sparsely populated, though west of Mole Creek there are small settlements at Liena on the Mersey River and at Lorinna on the Forth River. Sawmilling is an important local industry and there are several temporary settlements in the vicinity of the major saw mills. At present the main mill encampments are at the "Dove" mill some 6 miles south of Lorinna on the west bank of the Forth River and another situated in the Mersey Valley about 3 miles south of Liena.

Over the past few years there has been considerable activity in the Mersey Valley in connection with the development of a major road system to exploit the timber resources and temporary camps have been erected at various places. It is anticipated that this developmental work will be pursued for some years yet.

A branch line from the Tasmanian railway system extends as far west as Mole Creek township.

The general road system is indicated on the geological map together with such cultural features as schools, post offices, houses, &c., complete up to the time of publication of the topographic base map in 1956. Since that time the road system in the Mersey valley has been extended considerably and now gives access to Maggs Mountain, part of the upper Arm valley, and the eastern portion of the Mersey valley towards Dublin Plains and the Fish River.

The vehicular tracks leading up the Forth valley to the Arm valley via the Borradaile Plains are only suitable for four-wheel drive vehicles during dry weather. These tracks are usually impassable during the winter and may be blocked by fallen timber at any time of the year. At the time of writing the Forth track is impassable beyond Sardine Creek. Many of the bridges are in poor condition and the track is only cleared of fallen timber at infrequent intervals. It is expected that the track will soon be impassable beyond Gisborne's hut unless some steps are taken to improve it.

Electric power supplies are confined to the farming districts around Mole Creek and Chudleigh and no power is available in any part of the Forth valley, the upper Mersey valley or on the plateau.

Apart from the roads and tracks indicated on the plan, access varies considerably depending upon vegetation, rainfall and topography. The plateau country in the SE is relatively clear and easy to traverse during the summer months. Access to this plateau may be gained from the walking track under Western Bluff, by the South Mole Creek track, and by the track up Western Creek. February Plains are accessible by E. G. Innes's track from Borradaile Plains (cut in 1896-97) but some care is necessary on the portion between the southern hut and February Plains. February Plains, like the central plateau, are relatively subdued and not heavily forested. The western portion of the Quadrangle bounded by the Dove and Forth rivers is difficult to penetrate. The Forth track gives access along the east bank of the river but progress to the west is impeded by rugged topography and dense vegetation. Normally, access is gained from the overland track through the Cradle Mountain Reserve but a route is available from the Dove mill through Cox's clearing on to the plateau. The Dove valley

is precipitous and thickly wooded, and the river is subject to rapid and violent fluctuations in level. The Forth River may be crossed by bridge at Lorinna and near the Dove mill about 6 miles south of Lorinna, and its upper reaches may be forded without undue difficulty during periods of low flow. The Mersey River is bridged at Liena, at the Union Bridge NW of Mole Creek, at the Mersey-Fisher junction and in the vicinity of Walters Marsh. South of Walters Marsh it may be crossed by logs at most points.

RAINFALL AND VEGETATION

Average annual rainfall for areas where records have been kept for longer than 10 years is shown on the Regional Planning Atlas, Economic Resources of Tasmania, 1945, and figures are listed below:—

Moina	70.74 inches per year
Lorinna	55.13 inches per year
Mole Creek	45.65 inches per year
Caveside	40.54 inches per year

Short-term rain gauges established recently indicate an average rainfall of about 70 inches at Lake McKenzie and about 50 inches in the Mersey valley near the Arm River.

Vegetation shows noticeable control by rainfall as well as altitude and the following associations are present:—

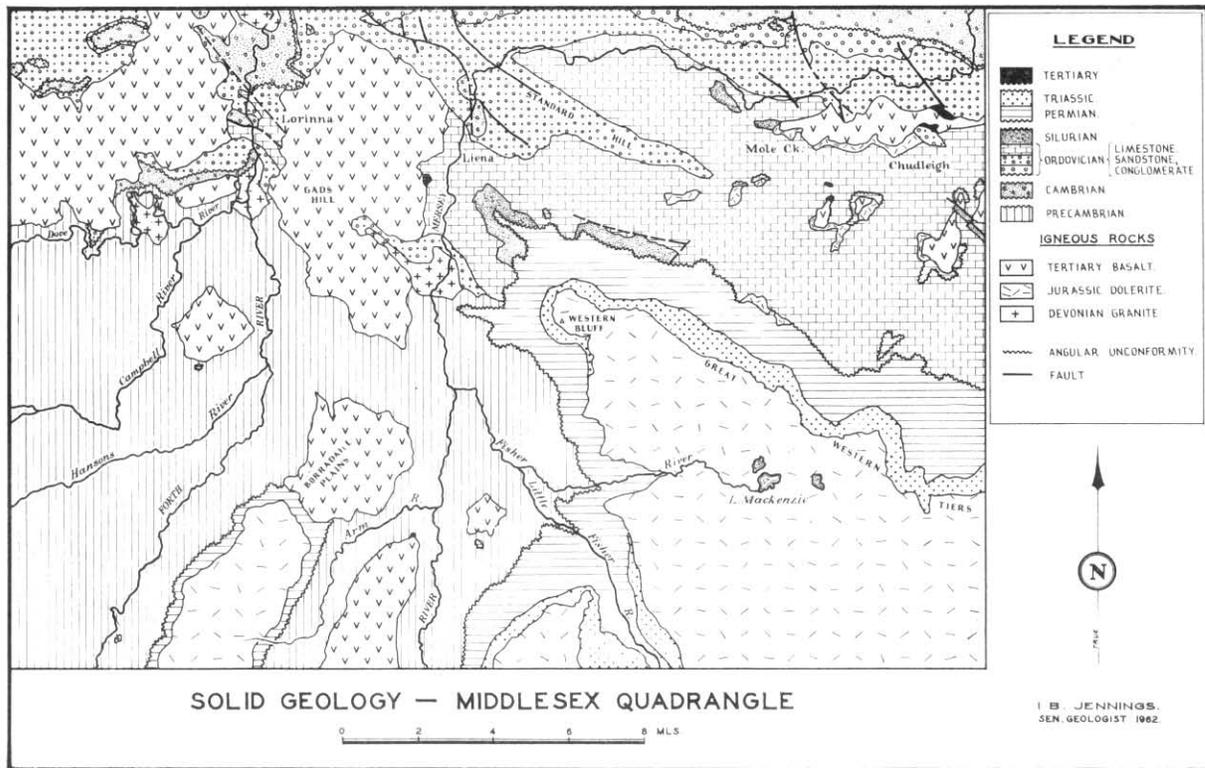
<i>Association</i>	<i>Access</i>
(1) Open farmlands	good
(2) Open eucalypt forest with sparse undergrowth	good
(3) Thick eucalypt forest with dense undergrowth	poor to fair
(4) Myrtle-sassafras rain forest	very poor to good
(5) Highland moors with button grass plains and stunted eucalypts characteristic of high altitudes	good
(6) Native grass plain with patches of thick ti tree	fair to good

These various associations are controlled also by aspect and the transition from one association to another may be extremely abrupt. The rock types present affect the resulting vegetation only through their influence on the physiography and the resulting aspect.

The influence of aspect and rainfall on vegetation is illustrated well in the Forth and Dove valleys. The east bank of the Forth is occupied by open eucalypt forest accompanied by sparse undergrowth and skeletal soils. The west bank, however, receives a higher rainfall and somewhat more shade and is covered by dense eucalypt forest, very thick undergrowth and peaty soils.

In the Dove Valley the south bank is relatively unshaded and the vegetation is open whilst the northern bank is well shaded and choked by thick forest and dense undergrowth. On the higher slopes of the Dove Valley the influence of rainfall becomes dominant and similar thick vegetation is developed.

The open eucalypt forest (2, above) is characteristic of the less shaded and/or lower rainfall areas whilst the dense eucalypt vegetation (3) is restricted to the shaded and/or high rainfall areas.



Myrtle-sassafras rainforest (4) is more characteristic of higher rainfall areas than (3), such as the upper Forth River and its tributaries and certain shaded tributaries of the Mersey River. Local rain forest associations occur in shaded valleys of areas otherwise occupied by eucalypt forests.

The highland moors associated with alpine floras, button grass plains and stunted eucalypts occupy the tops of the plateaus in the south and west of the district and local areas along the tops of the Fossey Mountains. Native grass plains with dense thickets of ti tree occur at Borradaile Plains, Emu Plains and in the vicinity of Daisy Dell.

The numerous sawmills in the district and the abundance of good eucalypt forests on much of the area assure a ready supply of mine timber within reasonable distance of any likely mining venture. The only exception to this is on the extensive dolerite plateau, which cannot be considered for mining purposes and the plateau in Precambrian rocks in the extreme SW of the sheet.

SURVEY AND RELIABILITY

The whole of the Middlesex Quadrangle is covered by good quality air photos at a scale of about 45 chains to 1 inch, flown in 1953. Earlier photographs on scales of 20 to 30 chains to 1 inch are also available for various parts of the sheet but the quality is variable and portions are obscured by cloud.

Field methods were varied according to the complexity of rock type, structure and access. Thus, the superficial deposits on the dolerite sill capping the Western Tiers could be mapped rapidly and accurately from air photographs, whilst some of the Cambrian rocks had to be mapped in detail by plane table and alidade. Generally, most mapping was performed by detailed traverses of all water-courses and access routes and by traverses of geological boundaries where possible. Points of interest were pricked on the air photographs and then transferred on to the base map. The wealth of topographic detail on the base map made it possible to transfer directly from photographs to map without using any special photogrammetrical equipment. The Permian sections along the Western Tiers were measured by repeated aneroid traverses checked where possible against topographic detail. Even after taking all reasonable precautions the conditions along the face of the Tiers are such that errors in altitude, totalling 100 feet over a whole traverse, could remain undetected.

A geological map of this kind is essentially a compromise between showing all the superficial deposits and drawing a solid geology map. In this case the superficial deposits are shown fairly fully because they are widespread and important and because the frequency of outcrops is too low to enable boundaries to be extrapolated reliably between them. The general policy has been to show solid geology when it is well exposed or can be reasonably predicted. Elsewhere, superficial deposits are shown in full. On the dolerite plateau, bedrock has been indicated only when clear jointing could be observed on the air photographs. A solid geology map of the Middlesex Quadrangle (Fig. 2) has been incorporated in this report. This is adapted from the 1 mile: 1 inch Map Sheet issued previously.

PHYSIOGRAPHY

The Middlesex Quadrangle may be divided conveniently into four physiographic units:—

- (1) The plateau areas.
- (2) The dolerite escarpment.
- (3) The fold-mountain system.
- (4) The Mole Creek lowlands.

This somewhat idealized subdivision is complicated by the distribution of Tertiary basalt, by the influence of rock types on erosion, by glaciation and perhaps by the superposition of some uplifted erosion surfaces.

THE PLATEAU AREAS

The southern portion of the Quadrangle consists of plateau area with an average elevation of about 4000 feet and a maximum height of 4733 feet on Ironstone Mountain. Most of this area is capped by a thick resistant dolerite sill underlain by relatively soft Permo-Triassic sediments and dense Precambrian metasediments. The northern edge of the plateau is dissected by the Forth and Mersey Rivers and in the SW the Permo-Triassic sediments and dolerite have been stripped off, re-exposing the pre-Permian surface. The dolerite sill has a regional tilt toward the SE and the plateau surface also slopes, at a lower angle, in this direction.

The plateau margins in the dolerite areas present bold, nearly vertical escarpments underlain by benched slopes reaching down to the pediment. The benched nature of the escarpment is due to differential erosion of the various members of the Permo-Triassic sequence and no doubt led to the escarpment being named the Western Tiers by the early settlers in the lowlands to the east.

The plateau tends to be slightly dish-shaped with a raised rim and sharp borders except for the areas where ice spillovers abraded and rounded the margins. A few peaks, such as Ironstone Mountain, stood out as nunataks during the Pleistocene glaciation, but apart from these the surface is relatively smooth with a partial cover of till, talus and residual soils. Numerous glacial moraine-dammed elongated lakes are present.

The SW corner of the Quadrangle is occupied by a dissected plateau developed in Precambrian metasediments. The surface here is nearly coincident with the pre-Permian surface. A single outlier of Permian sediments has been discovered SW of the Dove Mill and further extensive outliers occur immediately south and west of the map boundary. The elevation is generally lower, about 3250 feet a.s.l., than the dolerite plateau and it corresponds roughly to Davies's (1959) St Clair Surface. In contrast to the dolerite plateau which as a whole lacks dominant marginal drainage, the Precambrian plateau is being actively attacked by a number of youthful tributaries of the Forth River resulting in vigorous dissection.

THE DOLERITE ESCARPMENT

The main dolerite plateau is bounded to the north and west by precipitous concave escarpments. The upper, dolerite, part of the scarp stands subvertically as a line of bold cliffs up to 500 feet high beneath which the talus strewn pediment falls with decreasing grade to the plains of the Mole Creek Valley. Heavy dolerite scree accumulations fringe the upper cliffs and choke the ephemeral streams draining the escarpment. Huge dolerite boulders are found down on the frontal plain, either singly or in the "streams" shown on the map. The scarp is breached by only one major stream, the Fisher River; elsewhere, the streams along the scarp drain only limited areas of the plateau margins and the escarpment itself. They have small steep-sided valleys heavily loaded with talus in their upper reaches. The origin of the scarp is not clear. In the vicinity of Drys Bluff, some 20 miles east of Middlesex, McKellar (1957) attributed the scarp to parallel retreat from faults. However, he stated that west of Drys Bluff, although the scarp was similar, no boundary faults could be found. The same situation exists in the Mole Creek and Mersey valley districts. Despite diligent search, no evidence has been found for a fault from which the present scarp could have retreated.

Whatever the origin of the scarp, the process of retreat is fairly clear. It is being effected by means of major landslips, ice and rock wedging and frost action which eat back into the resistant dolerite mass, the rate of retreat of which controls the rate of retreat of the whole scarp.

Dolerite, when solid, is resistant to physical abrasion, although susceptible to chemical weathering. The abundant fresh dolerite faces here indicate that chemical weathering has not had sufficient time to make any serious contribution to the scarp retreat. The sill is, however, intensely shattered by closely spaced contraction joints and by several sets of tectonic joints. Among the latter is a relatively widely spaced set of major joints, or small faults, shown as linears on the geological map, which cut right through the dolerite sill and divide it primarily into a number of huge blocks, each block itself being thoroughly broken by smaller joints. Around the margins of the plateau the sill breaks off in blocks bounded by the major joints, in the form of large, more or less coherent landslip masses. These masses are then quickly broken up by rock and ice wedging.

Within the major joint blocks there is another strong set of vertical joints which divide the dolerite into rough columns several feet across. The columns are terminated above and below by horizontal joints forming columns 50 feet or so high. Along the scarp face these columns are being continually wedged out, first by ice wedging and later, as the joints open, by rock wedging. Columns subjected to this process are gradually levered out at the top until they topple over onto the scree slope below the free face. Around the foot of the dolerite cliffs some columns slide outward from the base, probably moving on water lubricated Triassic shale. Blocks of this kind are exposed in all stages of disintegration under Western Bluff.

Finally, the most closely spaced joints, which sometimes delimit fine sheeting only 5 mm or so thick, enable frost action continually to wear back the dolerite cliffs. On Western Bluff where the close spaced sheeting is well developed, the scree slope at the foot of

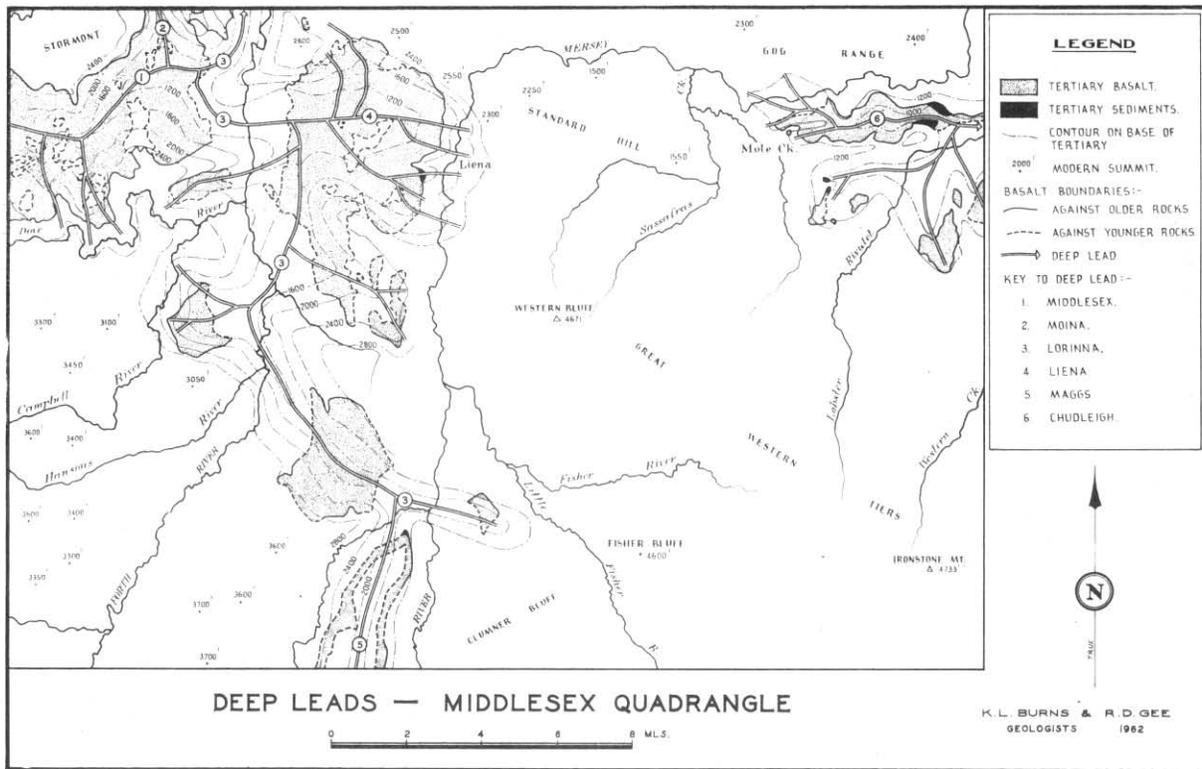
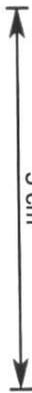


FIGURE 3.

5 CM



the cliffs is littered some feet deep with fresh dolerite chips spalled off the cliffs above. The dolerite presents abundant evidence of this action, showing small fresh patches on almost every exposed face, where chips have been flaked off.

Of the three processes described, it is difficult to estimate which is dominant. The first occurs infrequently but it moves hundreds of tons of material in a single slide. The column wedging is common everywhere but each column contributes a smaller mass than the landslips. The frost action removes only small fragments a few inches across but its action is continuous and the abundant deposits on the scree slope testify to its effectiveness.

Some idea of the rate of retreat of the Western Tiers escarpment may be gained from a consideration of the distribution of the basalt in front of the scarp. The base of the nearest basalt flow lies about 2 miles north of the corresponding contour along the face of the Tiers.

The age of the basalt is not known precisely, but it is most probably Pliocene. Assuming this to be correct, the scarp has retreated about 10,000 feet in 10,000,000 years or 1 foot per 1,000 years. This figure is subject to correction as more information regarding the age of the basalt becomes available.

THE FOLD MOUNTAIN SYSTEM

The northern part of the Middlesex Quadrangle is occupied by a belt of strongly folded Lower Palaeozoic rocks. The Ordovician quartzite and conglomerate are more resistant to erosion than the underlying Cambrian greywacke and conglomerate. Thus, when the Cambrian rocks are exposed to erosion, a scarp morphologically similar to the Western Tiers is formed.

The range of mountains which run roughly eastwards from Mt Magog to Black Bluff have recently been named the Fossey Mountains. Only part of the chain is present in the Middlesex Quadrangle. The Fossey Mountains are the northern equivalent of the West Coast Range. Structurally and lithologically the two mountain chains are similar. They both consist of Lower Palaeozoic rocks folded parallel to their length and crossed by NW trending cross-folds and they both lie athwart the main drainage channels. The Fossey Mountains lie at right angles to the Forth and Mersey Rivers which drain the country to the south of them. It is noticeable that whilst the Forth River cuts directly through the mountain range without deviation, the Mersey River is deflected at right angles some 12 miles east before it breaks through in the steep gorge between the Gog Range and Mt Magog. The origin of the Forth and Mersey Rivers as twin streams established on either side of basalt flows which filled the ancestral stream, the "Lorinna Lead," has been discussed by Spry (1958) and Rundle (1958). Both these authors presented a reconstruction of the Lorinna Lead and showed that it flowed roughly along the inter-fluve between the present rivers as far north as Lorinna before turning to the west. Beyond this point its course is doubtful but Rundle presented some evidence to show that it then turned north again along the present course of the Forth. The present study supports this view. (See Fig. 3). This may explain the different behaviour of the two streams where they impinge on the southern slope of the Fossey Mountains. The Forth has merely exhumed the valley of the old Lorinna Lead whilst the Mersey, having no

HIGH LEVEL EROSIONAL SURFACES

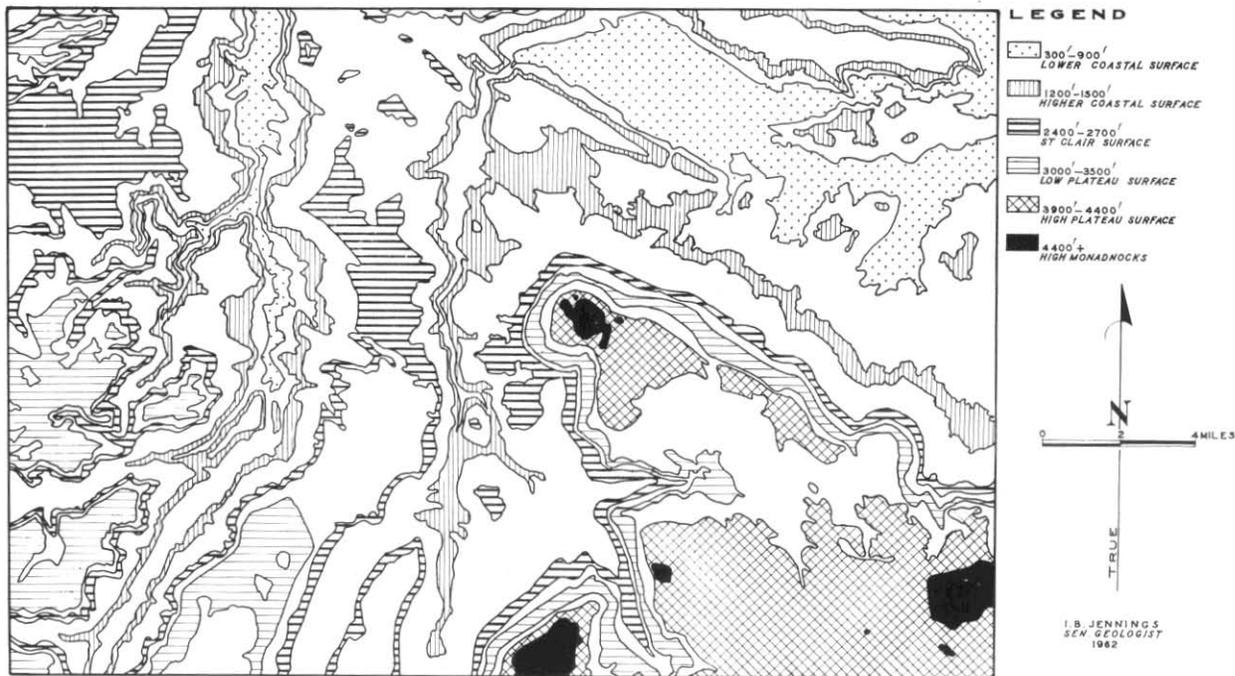


FIGURE 4.

5 cm

such gap in the range through which to flow, has been diverted down pitch to the east. The levels of the top of the basalt indicate that at the time that the Mersey was established Standard Hill would have been covered by basalt. The Mersey River has therefore cut down through the basalt over Standard Hill and become superimposed on the underlying quartzite. The map indicates that the superposition is modified locally by fault and shatter zones in the Palaeozoic rocks. North of Standard Hill the Mersey would have encountered the Palaeozoic rocks at a much higher altitude (2500 feet a.s.l.) and therefore somewhat further north than its present course. It became entrenched along the boundary of the Palaeozoic rocks and the Tertiary basalt and has migrated south, down dip, to its present course.

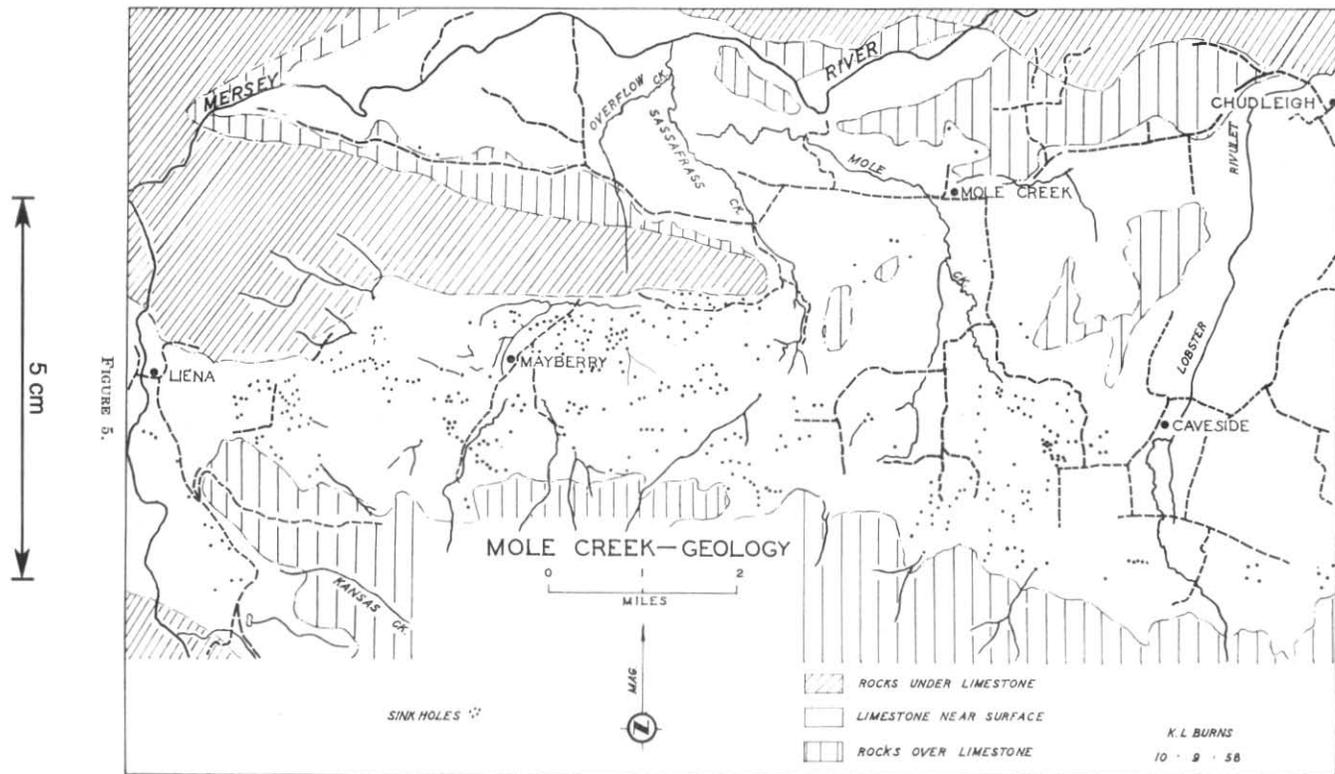
THE MOLE CREEK LOWLANDS

This is the broad flat floored valley lying between the foot of the Western Tiers and the Gog Range. Westward, the valley forks, the two parts being separated by Standard Hill. In the southern branch, from near Mayberry to Mole Creek township, the valley floor falls relatively rapidly (40 feet per mile). In this stretch the valley is largely carved out of Gordon Limestone and outcrops are frequent. East of Mole Creek the gradient flattens appreciably (10 feet per mile) and the valley becomes very broad and alluvium covered. Outcrop in this area is poor, being virtually absent in the extreme eastern portion. NW of Mole Creek township in the direction of the Union Bridge and the north side of Standard Hill the flatter profile is maintained. Within this lowland scattered outliers of Permian sediments, Gordon Limestone, Tertiary basalt and Jurassic dolerite stand out as monadnocks above the general level of the plains.

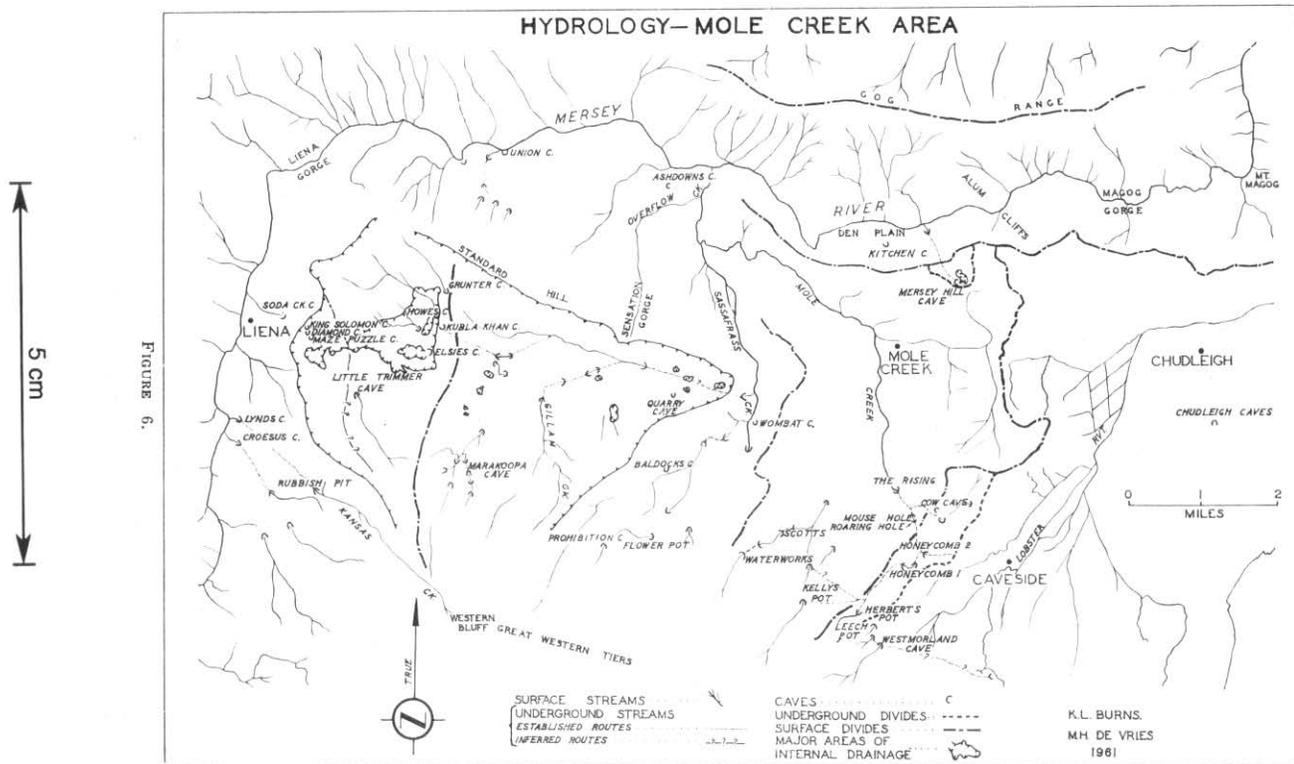
As indicated in Fig. 4 the lowlands fall within the contour limits proposed by Davies (1959) for the Upper and Lower Coastal Surfaces. A comparison of Fig 4 with the geological map (Fig. 2) reveals that most of the Quaternary superficial deposits have been deposited on the Lower Coastal Surface. In addition to this, if we compare Figs. 5 and 6 with the distribution of the erosion surfaces (Fig. 4) a correlation between underground drainage and erosion surfaces becomes apparent. Of the 600 or so underground drainage features shown on Figs. 5 and 6 all but a few fall in the Higher Coastal Surface or the interface between the Higher and Lower Coastal Surfaces. The remaining few are generally scattered around the margins of the Lower Coastal Surface. These facts indicate that the Lower Coastal Surface is pre-Pleistocene.

The limestone areas in the Mole Creek valley present wonderful examples of limestone topography. As early as 1845 Strzelecki noted limestone caves in the Mersey River area and he also commented on the presence of caverns and sinkholes in the vicinity of Circular Pond Marshes (near Mayberry). Later, Johnston (1888) noted the "numerous and extensive" caves near Chudleigh and described graphically the "New Caves" near Mole Creek. He also referred to the "crateriform cavities caused by underground drainage" at Circular Ponds.

At the present time King Solomon's Cave near Liena and the Marakoopa Caves, south of Mayberry, are exploited as tourist attractions, while numerous other caverns in the district have been explored by the Tasmanian Caverneering Club. Fig. 6, prepared by Burns and De Vries, shows all the known caves and indicates the known underground drainage features.



HYDROLOGY—MOLE CREEK AREA



It should be noted that the present surface drainage is not always related to the underground drainage. Surface divides have been breached underground near the Mersey Hill Cave, Cow Cave and Kubla Khan Caves. The relative surface and underground divides are indicated on the map (Fig. 6).

The district exhibits all stages of the Karst cycle from senility in the Chudleigh district to maturity in the Mole Creek-Caveside area and youth south of Mayberry. At Chudleigh the limestone has been eroded to base level leaving a flat plain covered with superficial deposits and having surface drainage. The plains around Caveside and Mole Creek are typical of a mature stage of the karst cycle having dominantly underground drainage, numerous caverns and sinkholes and abandoned surface drainage channels.

South of Mayberry there are limited areas of limestone around the foot of the Tiers where the limestone has not yet been exposed long enough for underground drainage to become established; this represents the youthful stage of the cycle. These areas were discussed in more detail by Burns and Rundle (1958) and details of some of the caves were given by Elliott (1958).

Major areas of internal drainage are shown on Fig 6. It will be seen from this that the large area around Mayberry is drained by an underground tributary of Sassafras Creek. Originally Gillam Creek must have drained most of this area to the Mersey via Sensation Gorge and Overflow Creek. However, at the present time Sensation Gorge is dry except for periods of high flood. The normal drainage channel is apparently underground around the east end of the Standard Hill anticline into Sassafras Creek. Although the direction of underground drainage in some part of the Mole Creek Valley has been established by means of fluorescein tests the drainage from Mayberry to Sassafras Creek has not yet been established. Brown and De Vries (1958) discussed the subterranean hydrology of the area generally and supported this theory by quoting "a prevalent but unconfirmed rumour" that sawdust from a timber mill at Mayberry has been observed in Sassafras Creek. They established that water from as far west as Howes Cave drains eastwards toward Mayberry. They also pointed out that this area receives considerable drainage from the vicinity of Marakooa Caves. Thus the Mayberry district is receiving a very considerable amount of water from various sources and the only visible outlet for this is the dry bed of Sensation Gorge.

The drainage from this area cannot go underground to the north because it is barred by the Standard Hill anticline. It has been established that at least part of the area west of Mayberry drains eastwards so it appears likely that the main drainage is also in that direction. All these features together with the hydrological characteristics of Sassafras Creek point toward underground drainage to the east, which has captured the headwaters of Overflow Creek above Sensation Gorge. A fuller account of the underground drainage of this and neighbouring areas is given by Brown and De Vries (1958).

Structural control of the cave system has been described by Brown and De Vries (1958, Figs. 2 and 3) who pointed out that the caves are controlled by the regional strike of the limestone areas and that they have a typically "dog-leg" course. The long stretches trend about 320° parallel to the strike and the shorter stretches are at right angles to this along prominent joint systems.

Burns and Rundle (1958) and Brown and De Vries (1958) both presented evidence for rejuvenation of the underground drainage since the Pleistocene. New channels have been cut across earlier, now abandoned, channels; Pleistocene till or periglacial deposits reach down from the Tiers into the present caves, and varve-like deposits (Burns, pers. comm.) within the caves are being dissected by the present drainage.

This suggests that the earlier caves were pre-Pleistocene and that cave development was arrested during the glaciation. Indeed, it seems that during the glaciation the caves were choked with material from the debris laden periglacial streams and much of the drainage diverted back onto the surface. With the resumption of less rigorous climatic conditions after the glaciation some of the caverns have been re-excavated and a new cycle of erosion has been initiated.

INFLUENCE OF ROCK TYPE ON PHYSIOGRAPHY

The recent interest in erosional surfaces (discussed below p. 25) in Tasmania (Davies, 1959; Scott, 1960) brings into prominence the question of the amount of influence which the various rock types may have upon a topography resulting from various erosional agencies. It is considered here that differential erosion is an important factor in the evolution of the present Tasmanian landscape.

It has been shown that there is good evidence for the existence of the Lower Coastal Surface, cut into Ordovician limestone, in the Mole Creek Valley. Davies's (1959) map does not indicate this, probably due to the small scale of the base map upon which his surfaces are reproduced. If we compare the erosional surfaces on Fig. 4 with the geological map (Fig. 2) we find some correlation between the Lower Coastal Surface and the distribution of the Gordon Limestone. Only in the NE corner of the Quadrangle, along the valley cut by the Mersey River, does this surface encroach on the underlying and more resistant Moina Sandstone. Similarly we find no noticeable bench along the Western Tiers, in the Gog Range or in the Forth or Mersey Valleys where the Higher Coastal Surface might be expected. Instead we find fairly extensive flat areas developed at intermediate levels along the Tiers, on the Gog Range and Standard Hill, which appear to be related to the distribution of rock types rather than to erosion levels.

The minor development of levels coincident with the Lower Coastal Surface in the Forth River is probably due in part to the existence of a former valley there, but it is noticeable that the restriction of this surface south of Lorinna is closely related to the distribution of the Gordon Limestone again. Other points of interest on Fig. 4 are that the Higher Plateau Surface is restricted exclusively to dolerite, and the St Clair Surface to basalt.

These facts suggest that the relative resistance of certain rocks to erosion and the effects of differential erosion are important influences on landscape development. Nevertheless, the author does not deny the existence of erosion surfaces, and in fact evidence is presented in favour of some of the lower surfaces. A summary of the physiographic characteristics of the main rock types present follows.

Tertiary sands and clays occupy only a very small part of the area but they have profound effects on the topography. They underlie and are interbedded with the Tertiary basalt flows and form gliding planes which initiate widespread landslips leading to rapid disruption of the basalt masses.

Permo-Triassic sediments.—In the Middlesex Quadrangle these rocks almost exclusively underlie thick, resistant dolerite sills. Thus, whilst not forming any significant landforms in themselves, they are in part responsible for the production of dolerite scarps such as the Western Tiers. Within the Permo-Triassic sequence differential erosion of the various formations produces the characteristic stepped appearance of the escarpment.

Gordon Limestone.—Elsewhere in Tasmania the Gordon Limestone almost exclusively occurs in areas of high rainfall and occupies broad, swampy button grass valleys. In the Mole Creek Valley there are some of the few notable positive topographic features developed in the formation. Such features include the hills around Mayberry and the hill which stands some 800 feet above the general level of the plains NE of Standard Hill.

Moina Sandstone and Roland Conglomerate.—These rocks are characterized by the rugged topography of the Fossey Mountains. They reflect the geological structure faithfully in their outcrop pattern and are important mountain-forming units everywhere in the State. Their bold outcrop is amplified by the relative weakness of the overlying thick Gordon Limestone. The quartzite and conglomerate formations are more resistant to erosion than dolerite so that the Western Tiers escarpment has retreated at about twice the rate of the escarpment in front of Mt Roland since the Tertiary basalt extrusions.

Cambrian rocks occupy only a small part of the Quadrangle and contribute no important landforms. The keratophyre exposed on the northern slopes of the Gog Range is hard, dense and resistant to erosion, forming steep slopes littered with scree. The greywacke in the extreme NE corner is much less resistant and occupies flat lying country along the Mersey River north of the Gog Range.

Precambrian rocks are mostly dense siliceous metasediments generally resistant to erosion. However, they are thoroughly broken by close spaced jointing and therefore are susceptible to ice and frost wedging. They occupy the highlands in the south and west of the Quadrangle and form steep slopes along the Forth and Mersey Rivers.

Tertiary basalt, when fresh and dense, is hard and resistant, and can withstand considerable physical abrasion. However, the basalt flows are well broken by contraction joints, contain less resistant beds of volcanic breccia and ejectamenta and are underlain by plastic clays. All these factors lead to severe slipping and general instability around the margins of the basalt areas.

Jurassic dolerite is a hard, dense rock, resistant to physical erosion, but thoroughly shattered by jointing. Its erosional properties are discussed elsewhere. (See page 15).

The granitic rocks form relatively small occurrences and play no important role in the physiography of the area. Fresh granite is extremely durable but the rock is liable to deep chemical weathering and it is difficult to obtain a fresh sample anywhere in the Middlesex area. Fine examples of deep weathering up to 60 feet below the natural surface are exposed where the Mersey Valley forestry road traverses the Dove Granite.

EROSION SURFACES

(See Fig. 4).

The existence of a number of land surfaces in the Middlesex area has been postulated by a number of workers. The most recent publications are those of Davies (1959); Scott (1960); and Spry (1958).

Davies (1959) gave the most complete and authoritative account. He postulated that the following surfaces exist and presented evidence to suggest that they are uplifted sub-aerial erosion surfaces, except for the lowest one which he considered might be partly or entirely of marine origin.

These surfaces are:—

<i>Elevation Range</i>	<i>Surface</i>
4400'-5300'	High Monadnocks
3700'-4400'	Higher Plateau Surface (H.P.S.)
3000'-3500'	Lower Plateau Surface (L.P.S.)
2400'-2700'	St Clair Surface (S.C.S.)
1200'-1500'	Higher Coastal Surface (H.C.S.)
300'- 900'	Lower Coastal Surface (L.C.S.)

Davies (1959, p. 195) further suggested that it might be "possible or even necessary to distinguish places within each major surface" and that there is some evidence for a seventh surface at about 1800 feet to 2000 feet. In presenting his views Davies used the Middlesex Quadrangle as part of his "type" area on account of the availability of topographic maps.

Scott's (1960) paper closely paralleled Davies's work, but it is mainly concerned with part of the West Coast. He suggested that the Higher and Lower Coastal Surfaces may be part of the same surface. Both papers presented an account of the previous work in this field but neither discussed Spry's views.

Spry (1958) worked on a much smaller area, within the Middlesex Quadrangle, and concluded that the following units were present there:—

- (1) Pre-Permian Surface.
- (2) Pre-Basalt (Maggs) Surface.
- (3) Post Basalt (Berriedale) Surface.
- (4) Central Plateau.
- (5) Fold Mountain Surface.
- (6) Karst Surface.

Only (1), (3) and (4) are pertinent to this discussion.

The various ideas which have been put forward as to the origin of various surfaces throughout the State are summarized below:—

- (A) The surfaces were formed by the disruption of a single early Tertiary peneplain.
- (B) They arose from one or more earlier surfaces together with (A).
- (C) They are due to a combination of normal erosion, glaciation, differential erosion, exhumation of the pre-Permian surface and pediplanation.
- (D) They are uplifted sub-aerial erosion surfaces.

In the last case differential movement of any magnitude between neighbouring fault blocks would present serious problems.

The general thesis that there are several surfaces present within the Middlesex Quadrangle and that they are not the same surface disrupted by faulting must be accepted. The extensive plains extending from Mole Creek toward Golden Valley are quite unrelated to the Central Plateau to the south of the Western Tiers. As mentioned earlier, a careful search has failed to disclose any significant faults which may have initiated the Western Tiers.

Accepting this, it is still necessary to relate the surfaces to one another and to the physiography of the area. To facilitate this the contour intervals proposed by Davies have been shaded in and are presented on Fig. 4. Obviously the portions of the surfaces indicated within the major valleys and along the face of the Tiers have little significance, but they were plotted to see if any significant benches occurred at the levels postulated. In the steeper country no such benches appear on the map.

If we compare Fig. 4 with Davies's (1959, Fig. 4) map of the surfaces in the Middlesex Quadrangle the following discrepancies emerge:—

- (1) A significant development of Lower Coastal Surface in the Mole Creek Valley;
- (2) The Higher Coastal Surface is much restricted;
- (3) The St Clair Surface north of the February Plains is much restricted and perhaps tilted;
- (4) Much of the February Plains lie above this Lower Plateau Surface;
- (5) The pre-Permian surface may form significant "surfaces" at intermediate levels, e.g., NW of Western Bluff, Standard Hill and the Gog Range.

Many of these discrepancies disappear when we allow for Davies's policy of extending the boundaries of the surfaces out to "the furthest accordant monadnock" and also allow for the small scale upon which his map is presented.

In spite of this, it is considered that the development of the Lower Coastal Surface around Mole Creek is real. As discussed earlier (p. 19), the drainage systems on the L.C.S. and H.C.S. are different. The H.C.S. and the escarpment between it and the L.C.S. represent a later stage of the karst cycle and the escarpment between the two surfaces in the Mayberry area is quite distinct.

The basalt which extends northwards from Maggs Mountain and the February Plains to just east of Lorinna does not coincide completely with Davies's surfaces and appears to be more in accord with Spry's (1958) Berriedale Surface. Davies appears to have noted this and said that "its height reflects the height of the original interflues and consequently the general height of the upland surface surviving at the time of the extrusion."

However, Spry (1958) pointed out that the basalt probably flowed upstream from the vicinity of Gisborne's hut. In a later study of the area, Rundle accepted this view and the present survey has found no contradictory evidence. This leaves a problem regarding the St Clair Surface in this area. If we extend it to the limits indicated by Davies, then it becomes virtually coincident with the surfaces above and below it. Fig. 4 indicates that the Lower Plateau Surface on the February Plains slopes gently to the north and at the south end of the plain it becomes almost continuous with the next surface above. In view of this, one wonders if these really are separate surfaces, or if they are tilted surfaces, or, perhaps more likely, if some of them are simply the resistant tops of tilted dolerite sills.

The only convincing scarps between the various surfaces, apart from those which may be structural, are those between the Lower and Higher Coastal Surfaces.

In support of his view that the central plateau is an erosional surface in its own right and not just a surface developed on top of a dolerite sill, Davies contended that the "surfaces under discussion are continued off the dolerite across a variety of softer rocks at similar altitude". In this area in the case of the Higher Plateau Surface, he cited "Mt Roland and the small plateau on which stand Cradle Mountain and Barn Bluff". These are certainly not on a "variety of softer rocks" and the argument is hardly convincing when one considers that the plateau around Cradle Mountain is the exhumed pre-Permian surface and that the plateau on top of Mt Roland, except for the extreme peak, lies below his limits for the H.P.S. This plateau also probably represents the pre-Permian surface.

The pre-Permian surface also introduces complications. Davies suggested that this only forms extensive surfaces where it is coincident with the levels of other postulated erosion surfaces. The regional distribution of the Permian rocks indicates that the surface is tilted to the east or SE. It falls gently from above 3300 feet in the SW of the sheet to below 1100 feet in the vicinity of Chudleigh. It is accordant with the Lower Plateau Surface west of the Forth River, below it north of the Borradalle Plains, accordant with the St Clair Surface SW of Western Bluff and below it NW of Western Bluff, on the Gog Range, and probably on Standard Hill. This surface is subdued but contains local topographic irregularities up to 400 feet high along the face of the Tiers and in the vicinity of Cradle Mountain (Jennings 1959, p. 74).

The surface is best developed in the SW of the area at the Lower Plateau level but it certainly seems to form quite significant plains at levels which do not accord with the suggested erosion surfaces. Differential erosion between the resistant Precambrian metasediments under the surface and the relatively soft sediments above it, appears to be the most important factor leading to the formation of extensive erosion surfaces coincident with the base of the Permian System.

The almost complete correlation between the Lower Coastal Surface and Gordon Limestone, St Clair Surface and basalt and higher Plateau Surface and dolerite, suggests that differential erosion may be fundamental in producing the present topography.

The main difficulty with Davies's thesis seems to be in the mechanism invoked. It implies uplift, since the Cretaceous, of some thousands of feet, without significant differential movement between adjoining fault blocks. The geological history of Tasmania suggests that this is extremely unlikely to have occurred. In the past, uplifts have been confined to relatively emergent blocks bounded by strong fault systems where the total displacement may be measured in thousands of feet. With such fault systems in existence the uplift of the whole State as a unit without adjusting movements between blocks seems to be unrealistic.

The alternative to uplift of the kind described above would be a fall in sea level of some 2000 feet. This also is difficult to envisage.

GLACIAL FEATURES

The dolerite plateau south of the Western Tiers exhibits many glacial features such as roches moutonnées, ice scoured platforms, moraines and rock basin lakes. The glacial characteristics have long been recognized, but the most recent, complete and authoritative account was given by Jennings and Ahmad (1957). Accounts of smaller areas have been given by Spry (1958), Ford (1960), and Mather (1956).

Jennings considered that the dominant ice movements were to the SE and NW away from a major ice divide trending roughly SW from Lake Meander, as shown on his map.

Most of that portion of the plateau in the Middlesex Quadrangle seems to have been occupied by an independent ice cap centred about Balmoral Moor with movements radially outwards spilling over the plateau edges and extending away to the SE. At the spillovers, the plateau margins are ice scoured and somewhat rounded in contrast to the sharp frost shattered scarps with raised rims which are found elsewhere. The glacial spillovers may be directly correlated with the "tongues" of superficial material shown on the geological map along the Western Tiers.

Jennings discussed the glacial conditions on top of the plateau but did not study glaciation in the Forth and Mersey Valleys, both of which show signs of having been occupied by glaciers.

The Mersey River south of its junction with the Fisher River occupies a broad flat floored valley notable for the presence of truncated spurs. Roches moutonnées occur on the east bank of the Mersey just north of Walters Marsh (Plate 1), and glacial till occurs along the floor of the valley as far north as the Fisher River. Ice scouring of the valley walls may be observed at several places; the scour marks are almost at right angles to the regional strike of the sediments (Plate 2). These and the roches moutonnées all indicate movement along the valley in a northerly direction.

Rundle (1958) described similar gouge and chatter marks in smoothed Precambrian quartzite about a mile north of Howells Plains, indicating movement down the valley at 355°T.

The floor of the Arm Valley is largely covered by till and/or outwash material overlying varved clays (Spry 1958; Plate II, Nos. 1 and 2).

In the Forth Valley varved sediments are exposed at several points in road cuttings south of Lorinna. The maximum thickness exposed is about 100 feet and a count of varves in two localities gave an average of 20 cycles per foot (R. G. Robinson, pers. comm.). The Hydro-Electric Commission drilled a number of holes in the vicinity of Lemonthyme Creek and the results of this drilling are recorded in a report of the geophysical studies carried out in that area (Polak and Duggin, 1961; Plate 8). The drilling revealed up to about 100 feet of till with varves above and below the till. Maximum thickness of varves encountered was 32 feet in drill hole No. 5802. Precise correlation between the various varve exposures and those located by drilling is not possible but they all lie within the altitude range of 850 to 950 feet.

The glaciation in the Mersey Valley appears to have reached only as far north as its junction with the Fisher, which corresponds in altitude to about Gisborne's hut in the Forth Valley. Rundle (1958) suggested that this was the northern limit of valley glaciation there. However, all the varve exposures are north of this and they appear to be related to a terminal moraine damming the Forth River at Lorinna. Remnants of till on the hillside at Lorinna may be found up to an altitude of about 950 feet which agrees with the upper limit of the varves in the Forth Valley further south.

Other indications of glaciation in the Forth Valley are roches moutonnées on the valley floor just south of the Dove Mill turn-off, the almost classical form of the valley south of that point and the presence of truncated spurs as far north as Gisborne's hut. The morphology of the valley suggests that Gisborne's hut is probably the northern limit of active valley glaciation, but at times of severe glaciation short-lived extensions of the glaciers may have reached as far as Lorinna without leaving a lasting imprint on the valley.

It would seem that the Precambrian plateau in the SW of the Quadrangle must have suffered erosion during the glaciation. None of the youthful streams which drain this plateau into the Forth River display the slightest sign of having been occupied by glaciers. The Dove River in particular is notable for its youthful profile and the abundance of overlapping spurs in its valley. In a similar manner the upper reaches of the Fisher River show no glacial features, yet this part has certainly been occupied by a spillover glacier from the central plateau (Jennings and Ahmad, 1957). Mather (1956) suggested that the amount of downcutting since the Pleistocene is not sufficient to account for the present valley and that the valley may have been filled with static ice over which the glaciers moved. This explanation would satisfy the conditions along the west bank of the Forth River south of Gisborne's hut, although it must also be conceded that such steep sided valleys could have been formed in glaciated areas by active subglacial melt-water streams.

THE DRAINAGE SYSTEMS

The present drainage pattern has been developed since the extrusion of the Tertiary basalts. The major drainage channels are the Forth and Mersey Rivers, most of the area being drained to the north by these rivers and their tributaries. Part of the dolerite plateau in the extreme SE of the sheet is drained by the headwaters of the Pine and Little Pine Rivers which flow toward the SE.

The most noticeable feature of both the Forth and Mersey Rivers is the relatively straight, roughly N-S courses in their upper reaches. This is in direct contrast to the persistent E-W trend of the rocks over which the rivers run, and it is only partly due to the glaciation of the river valleys. The upper Forth Valley south of Borradaile Plains swings roughly NE parallel to the western edge of February Plains. Perhaps its original course was determined by post Jurassic faulting or by a discordance in the dolerite sill forming February Plains.

The main tributaries of the Forth are the Dove, Campbell and Hansons Rivers which drain the Precambrian plateau to the west. All of these are extremely youthful and occupy steep-sided V-shaped valleys incised into the Precambrian rocks. Campbell and Hansons Rivers are notably strike-controlled and have developed a rectangular drainage pattern characteristic of folded rocks.

The Dove River appears to occupy an incised course determined at a much higher altitude by the edge of the basalt on Middlesex Plains, and by the outcrops of the Dove Granite. The deflection of the river by the granite in the vicinity of the Devon Mine is particularly noticeable: it has clearly been determined at a higher level and is now incised in the margins of the granite mass.

Glaciation in the Forth Valley is discussed elsewhere. It may be noted that despite the severe modification by glaciation a few rock bars have survived; one occurs about $1\frac{1}{2}$ miles SW of Gisborne's hut. Just north of Gisborne's hut the river now runs through a relatively narrow V-shaped gorge which is out of character with the general valley form in that vicinity. The glacier occupying the valley was diverted to the east at this point and flowed around the eastern side of the hill along the low divide where the vehicular track now passes. Rock bars also occur in glaciated stretches of the Mersey Valley near Walters Marsh and on the upper Arm River.

Major tributaries of the Mersey River are the Arm, Fisher and Little Fisher Rivers. The Arm River occupies a broad glacial valley in its upper reaches, but close to its junction with the Mersey the valley becomes steep-sided and the gradient increases rapidly. Probably the snow fields feeding this glacier were not large enough to provide sufficient material for sustained glaciation of the lower reaches of the valley. The Fisher and Little Fisher Rivers are controlled only locally by the underlying rocks and their general courses have been determined by glaciation although the valley forms have been only slightly modified by ice action.

Drainage in the limestone areas is discussed elsewhere (see page 22). It is mainly underground.

GEOLOGY

STRATIGRAPHY

General

The basement rocks of the Middlesex area are a thick sequence of complexly deformed Precambrian quartzite and schist. Intricacies of structure, lack of fossils and similarity of lithological type render the detailed stratigraphy of these rocks uncertain. They are overlain unconformably by an unknown thickness of greywacke and volcanic rocks of probable Cambrian age. The Cambrian system is in turn overlain unconformably by more than 5000 feet of folded Ordovician and Silurian quartzite conglomerate and limestone. All rocks up to this level are folded and have been affected by granite intrusions of probable Devonian age.

STRATIGRAPHIC TABLE

<i>Period</i>	<i>Rock Type</i>	<i>Thickness (feet)</i>
Recent	River alluvium, scree and talus
Pleistocene	Glacial, fluvioglacial and periglacial deposits. Varved clay and silt
Tertiary	Basalt, tuff and agglomerate.	800+
	Terrestrial sand and clay	50 approx.
Jurassic	Dolerite intrusions	1000 approx.
Triassic	Cluan Formation?	300+
	Ross Sandstone	600
Permian	Cygnnet Coal Measures	100 approx.
	Ferntree Group	700
	Woodbridge Glacials	250
	Liffey Sandstone and Shale	70
	Kansas Creek Beds	0-400+
- - - - -	<i>Unconformity</i>	- - - - -
Devonian	Dolcoath, Dove and Lone Pine Granites	
Silurian	(Crotty?) Sandstone	700+
Ordovician	Gordon Limestone	3000+
	Moina Sandstone	800
	Roland Conglomerate	800
- - - - -	<i>Unconformity</i>	- - - - -
Cambrian	Keratophyre	2000 approx.
	Gog Range Greywacke	3000 approx.
	Bull Creek Formation	1500+
	Lorinna Greywacke	1000 approx.
- - - - -	<i>Unconformity</i>	- - - - -
Precambrian	Dove Group	3000?
	Fisher Group	3000+
	Howell Group	3000+

All of the above rocks are followed unconformably by about 2000 feet of flat lying Permian and Triassic sediments which have been intruded by Jurassic dolerite in the form of thick sills. There is no record of any deposition between the Triassic and Tertiary when widespread extrusions of basaltic lavas occurred. Locally,

these lavas are underlain by, and interbedded with, terrestrial clay and sand. The lava fields are widely distributed but can be related generally to a pre-basalt drainage system.

Superficial Pleistocene deposits of glacial and periglacial origin occur widely on and around the Central Plateau and in the valleys of the Forth and Mersey Rivers and their tributaries. Recent scree and talus deposits obscure much of the geology around the Central Plateau and the lower slopes of the Fossey Mountains.

The Precambrian Rocks

Extensive outcrops of quartzite and schist assigned to the Precambrian outcrop along the upper Forth and Mersey Valleys. As the boundary between these rocks and the overlying Lower Palaeozoic rocks is either concealed beneath superficial deposits or intruded by granite it is not possible to give any instance of an observed unconformity between the Precambrian and younger rocks.

Despite a general concordance in strike between the Precambrian and younger rocks, an angular unconformity is postulated at this level on the following grounds:—

- (1) There is a great difference in tectonic grade between the Precambrian and the Cambrian rocks.
- (2) The Ordovician and Cambrian rocks contain fragments of rocks characteristic of the Precambrian System.
- (3) A widespread unconformity at this boundary has been described from many places (Carey and Banks, 1954) and has been widely accepted by most workers.

The precise age of the rocks which are considered here to be Precambrian is open to some doubt as they are overlain by Lower Palaeozoic rocks correlated with the Cambrian System only on lithological grounds and relationships to overlying rocks. Even so, there seems little doubt that the correlation is essentially correct. The Lower Palaeozoic rocks may reasonably be correlated with the Dundas Group of Elliston (1954a), and therefore it is considered that the Precambrian rocks here underlie correlates of the Dundas Group unconformably.

The Precambrian rocks consist of groups of similar lithologies, all severely deformed, and no fossils have been found in them. In this area they have been subdivided into 3 units based upon lithological characteristics. This is at variance with subdivisions proposed by Spry (1958) and the two sets of subdivisions are tabulated below:—

<i>This paper</i> Cambrian System	<i>Rock Types</i>	<i>Spry (1958)</i> Cambrian System
<i>Unconformity</i>		
Dove Group	Quartz-mica and garnet-mica schists. Little or no quartzite.	Dove Schist
Fisher Group	Thinly bedded, massive and laminated quartzite with inter-bedded quartz-mica schists.	Fisher Group Maggs Quartzite
Howell Group	Interbedded quartzite, quartz-mica and garnet-mica schists.	Howell Group Arm Schist

Spry's Arm Schist and Maggs Quartzite have been eliminated because no significant lithological difference could be established between them and the Dove Schist and Fisher Group rocks respectively. An overall structure can be postulated which fits the known rock distribution without the necessity of introducing more rock names.

It must be pointed out that the interpretation of the structure and stratigraphy of the Precambrian rocks in this area is not regarded as established definitely. Other interpretations are possible and even likely. The interpretation offered here is considered to be most in accord with the facts known at this time.

HOWELL GROUP

The quartzite and schist comprising this Group are regarded as being the oldest rocks present in the area. They outcrop along the Mersey Valley around Walters Marsh and in the vicinity of the Mersey-Arm confluence. Rocks assigned to this Group also occur in the upper Arm Valley but they are not well exposed and have not been examined in detail. From the known strikes in the Group one would expect Howell Group rocks to appear in the upper Forth Valley in the vicinity of the Lone Pine Granite. However, the rocks there are dominantly quartzite and do not appear to have any strong affinities with the Howell Group. Subsequent work to the south of the Middlesex Quadrangle has shown that the validity of the group outside the areas indicated here is open to doubt.

The group consists of thick (200 feet) alternating units of dominant quartzite with minor schist bands and dominant schist with minor quartzite bands. Types of schist are quartz-muscovite and quartz-garnet-muscovite, often with albite. The garnets are feruginous and usually weather out on exposed surfaces producing a pitted limonite stained appearance in weathered outcrops. They are usually small, seldom exceeding 5 mm in diameter.

The quartzite members of the Group tend to be thinly bedded or platy and often carry muscovite along the bedding planes. Just north of Howells Plains on the western side of the vehicular track there is an outcrop of laminated black and white quartzite now assigned to the Howell Group but hitherto regarded as characteristic of the Fisher Group.

Further mapping outside the Middlesex Quadrangle has shown a possibility that the Howell Group may be a facies variation of the Fisher Group which may pass downwards from a dominantly quartzite facies into a series of alternating quartzite and schist bands. The lack of good continuous outcrops in the critical areas prevents study of the problem at this stage.

The Howell Group rocks have been strongly deformed: they show structural ribbing, boudinage, rod and mullien structure as well as small and large scale shear folds. The overall structure within the Group is difficult to assess but numerous examples of the smaller folds and minor structures are exposed at many places along the road cuttings in the Mersey Valley.

The Group is overlain, apparently conformably, by the Fisher Group. Because of the complicated structure, the thickness of the group is unknown but it is estimated to exceed 3000 feet.

FISHER GROUP

Rocks assigned to this group outcrop widely over the SW portion of the Sheet. The unit as indicated on the geological map differs slightly from that defined by Spry. His definition was not published at the time this survey was made.

The boundary between the Dove and Fisher Groups is exposed on the Forestry Commission's Mersey Valley Road at 8732N 4204E. The boundary is formed by a short sequence of passage beds consisting of interbedded Fisher-type quartzite and Dove-stype schist. The boundary chosen here is the upper limit of this sequence whilst Spry's boundary is taken at the bottom of it. As indicated above, the Maggs Quartzite of Spry (1958) is considered here to be part of the Fisher Group.

The Fisher Group rocks are dominantly siliceous and consist of thinly bedded quartzite with micaceous schistose partings between beds and interbedded bands of quartz-muscovite schist. A characteristic feature of the Group is the occurrence of finely laminated black and white quartzite and of fine black partings along bedding planes. Usually the quartzite is white but pink quartzite is not uncommon. In the Forth Valley near 8747N 4128E the pink quartzite contains small nodules of hematite. Much of the quartzite is dense, white or glassy and completely recrystallized but in some of the less deformed zones individual grains may be distinguished clearly in hand specimens.

The rocks are shattered by closely spaced jointing and veins of milky quartz up to 5 feet wide are fairly common. The most common rocks encountered are thinly bedded to flaggy or blocky, but some massive bands have been noted, usually severely crushed and brecciated. The relatively thin bedding combined with the close jointing provides easy entrance for water and frost and the Group produces abundant scree slopes. The scree is composed of joint-blocks about the size of a house brick, and is well exposed along the west facing slopes of Parangana Sugarloaf. Minor structures resembling ripple marks have been observed at many parts in both the Forth and Mersey Valleys. On the northern slopes of the hill at 8736N 4128E these structures may be found plunging in opposite directions in adjoining beds. However, the minor tectonic folds, resembling ripple marks, are also doubly plunging and not too much reliance can be placed on these observations. The preservation of ripple marks in rocks as deformed as the Fisher Group seems to be unlikely. In the Mersey Valley in the cliffs SW of the Hydro-Electric Commission's hydrometric station hut, and at other places, structures which resemble current bedding may be found. Again, the resemblance to sedimentary structures may be misleading and the structures could be interpreted as minor folds with one limb sheared off.

The following extract from field notes refers to the transition rocks between the Dove and Fisher Groups:—

<i>Thickness</i> (ft.)	<i>Unit</i>	<i>Lithology</i>
?	1	Garnetiferous quartz muscovite schist (Dove Group).
....	Dove-Fisher Boundary - - - - -
35	2	Dense white quartzite with schist partings parallel to bedding. Ripple-like folds along contact.

<i>Thickness</i> (<i>ft.</i>)	<i>Unit.</i>	<i>Lithology</i>
100	3	Banded quartz-mica schist.
?	Scree and creek crossing.
?	4	Blocky white quartzite with thin micaceous partings, some minor folds, black partings along bedding planes.
120	5	Slaty quartzite, thinly bedded and laminated, black and white with occasional schistose bands grading into (6).
60	6	Blocky, then thinly bedded and flaggy white quartzite with black partings along bedding planes.
120	7	Thinly bedded, black, sometimes laminated quartzite, brecciated and closely folded.
-----	-----	Gap in section, (probable fault)-----
100	8	Thinly bedded, slaty black and white quartzite passing into blocky quartzite.
30	9	Massive quartzite.
?	10	Thinly bedded and flaggy quartzite with much minor folding.
?	11	Flaggy white quartzite with some thin grey schist bands.

The fine lamination which is so characteristic a feature of the Dove Group seems to occur also in the quartzite of at least the upper part of the Fisher Group.

The thickness of the Group cannot be assessed from field exposures but a minimum estimate is 3000 feet. Faults occur in all sections and the folding on all observable scales is severe.

DOVE GROUP.

The Dove Group is defined here as that group of rocks, dominantly quartz-sericite schist and garnetiferous quartz-sericite schist, which outcrop along the Forth Valley between the southern boundary of the granite at the Dove River and the boundary of the Fisher Group half a mile south of the Dove sawmill.

The rocks were referred to by Twelvetrees (1913) who spoke of the "schists . . . south of the Dove River belt of granite porphyry", by Reid (1919a) who referred to the laminated schists in the same area, and by Elliston (1954b) who described the "Dove River Schists" as "dark grey micaceous irregularly laminated schist".

In the type area the northern boundary of the schist is intruded by granite, elsewhere it is overlapped by Cambrian rocks or Tertiary basalt. It is therefore recognized that the upper part of the group may be missing in the type area. However, no more satisfactory type area is known in the Middlesex district and the group has not so far been recognized elsewhere.

Typical Dove Group rocks are glossy, grey, finely laminated, quartz-sericite schists. They are frequently garnetiferous and such varieties weather to an olive green or brown colour. The weathered surfaces of such rocks are studded with minute limonite-filled holes from which the garnets have been shed.

The fine laminations are due to alternating siliceous and micaceous layers which give the appearance of bedding. Both microscopically and in hand specimen the siliceous layers are seen

to be lens shaped. Quartz augen are frequently present and have been observed in all sizes up to 5 feet long, grading upward from the microscopic lenticular siliceous masses.

As a whole the group contains very few bands of pure quartzite but some have been noted in the Dove and Mersey Valleys. The schists are contorted on all scales from microscopic up to folds as large as may be seen in the available outcrops. They often have at least two cleavages at a low angle to one another and many exposures are faulted. The dominant cleavage is parallel to the compositional banding.

Petrographic descriptions of rocks typical of the group in the type area are as follows:—

- (1) *Dark grey, fine grained, spotted, laminated rock with iron oxide stains.* In thin section it is seen to consist of orientated sericite with lenses of quartz grains. Spots of iron oxide indicate the erstwhile presence of small garnets. Chloritoid is also present in pleochroic greenish brown confused masses. A quartz vein crosses the section at a low angle to the bedding. The rock is a garnetiferous quartz-sericite schist.
- (2) *Grey quartzitic schist, irregularly laminated.* In thin section the rock shows intense folding on a microscopic scale. It consists of about equal amounts of quartz and sericite with occasional garnets. Much of the quartz is microcrystalline. There is a small amount of magnetite, the octahedra having been distorted and sometimes shattered to give fine bands and strings.
- (3) *Greenish grey, banded, schistose rock.* There are two planes of schistosity and both cut the banding or bedding. Thin sections show the laminae of sericite enfolding lenses of quartz, quartz grains and microcrystalline quartz. There is some chloritoid, a little chlorite and a small amount of iron ore. The rock is a quartz sericite schist.
- (4) *Silky grey, finely spotted, laminated rock.* Thin sections show orientated biotite and sericite interlaminated with fine granular quartz. The laminae of quartz are really attenuated lenses. Most of the spots are merely holes, but a few are filled with minute books of biotite in random arrangement, the whole mass giving a hexagonal section indicating that the biotite has replaced garnet.

At the contact of the Dove Group and the Dove Granite on the Mersey Valley forestry road the schist has been affected considerably by thermal alteration which extends for about a hundred feet into the schist. This alteration, together with a general shattering and extensive surface weathering, makes it difficult to fix the boundary of the granite precisely. Macroscopically, the main effects of the thermal alteration are the widespread development of biotite and a general induration of the schist.

A typical specimen of the thermally altered schist is a medium to fine grained mesocratic rock with irregular banding. Biotite flakes and granular quartz about 1 mm across are set in a white opaque matrix.

In thin section directional texture may be seen. The minerals present include anhedral quartz and microcrystalline aggregates of yellowish sericitic mica resulting from the alteration of feldspar. Books of biotite are common and there is much iron ore present in small disseminated crystals and aggregates. Occasional anhedral and imperfect crystals of cordierite are also present.

In the valley of the Dove River quartzitic bands are found interbedded with the schist. Near the Dove Granite the quartzite is dense and recrystallized and often shows a strong development of biotite. In the lower reaches of the Dove Valley the top surface of the granite is just exposed and the overlying Dove Group rocks have been considerably altered. Porphyroblasts of quartz are developed together with biotite in a groundmass of quartz and sericite. No feldspar is evident in hand specimens; pyrite mineralization together with some galena and chalcopyrite occurs at various localities. Injection veins and stringers of quartz together with the development of quartz augen is characteristic of this zone. In the vicinity of the Dove-Forth junction it becomes difficult to distinguish between marginal phases of the granite, altered Cambrian, and Precambrian rocks in the field. The zone of alteration is quite narrow, usually less than 100 feet, and no consistent regional schistosity is developed in the granite or in the Cambrian rocks.

In areas of lower rainfall or exposed aspect the Dove Group weathers to produce meagre, ironstained skeletal soils with an abundance of flaky schist particles. Where the rainfall is higher and vegetation thicker, the soil produced is considerably thicker, also iron stained, and contains much organic material.

Structurally the group is very complex; at least three generations of folding can be observed and two sets of cleavage are commonly found. Although the thickness of the group is estimated at 3000 feet, this figure must be accepted with reserve.

SUMMARY OF PRECAMBRIAN STRATIGRAPHY

The Precambrian sequence consists of the following three associations:—

- (1) An upper, quartz-sericite schist facies.
- (2) A middle, dominantly quartzite facies.
- (3) A lower sequence of interbedded quartzite and schist.

In these three groups the quartzite and schist from any one group are lithologically similar to the rocks in the other groups.

Generally speaking the schist is finely laminated and the quartzite thinly bedded, though exceptions do occur. No coarse grained sediments of any kind have been observed.

Reid (1919b) indicated Cambrian dykes cutting the Precambrian rocks in the vicinity of the Lone Pine Granite. The area is now overgrown and exposures are poor but a careful search revealed a fine grained greenish rock near where the porphyry was shown by Reid.

In thin section this rock is a structureless granoblastic aggregate of diopside and sericite. A small amount of yellowish-green tremolite-actinolite is associated with the diopside. Irregular small patches of feldspar with wavy extinction occur with the sericite. This is probably orthoclase, but it is difficult to determine owing

to the irregular shape and undefined optical properties. There are also occasional incomplete crystals of carbonate, probably calcite. The rock is a hornfels and would appear to be the result of metamorphism of a dolomitic rock followed by alteration of the feldspar. The dyke-like forms of this rock as shown by Reid cannot be established or disproved from the existing known outcrops.

The linear form of these bodies may be due to alteration proceeding along lines of structural weakness. The strike of the 'dykes' here and in the vicinity of Commonwealth Creek, SW of the Middlesex Quadrangle, is about NW, parallel to one of the Tabberabberan structural trends.

As outcrop is poor, no solution to these problems can be offered at this stage. It seems though, that Reid's interpretation of these rocks as Cambrian intrusions must be regarded with considerable doubt.

The Cambrian System

Rocks assigned to the Cambrian system occur unconformably overlying Precambrian sediments along the south facing slopes of the Five Mile Rise. They underlie the Roland Conglomerate unconformably in the Liena Gorge, along the northern slopes of the Gog Range and to the north of Lorinna. The basal beds of the Roland Conglomerate frequently contain fragments of Cambrian volcanic material. As no Cambrian fossils have been found in situ in this area, the age of the rocks cannot be taken as precisely established. However, a boulder of Gog Range Greywacke just north of the boundary of the Quadrangle yielded trilobites generally associated with the Dundas Group (Banks, pers. comm.). This fact, taken in conjunction with the stratigraphic position of the rocks, their facies and tectonic fabric, points toward a Cambrian age. They are regarded as being correlates of the Dundas Group of Elliston (1954a).

No continuous section through the Cambrian System is exposed anywhere in the district, so some uncertainty exists as to the succession which cannot be resolved satisfactorily in the absence of fossils. The stratigraphic sequence most in accord with the field evidence has been adopted for the purpose of this map in order to present a coherent picture, and different formation names have been assigned to the various units. It is realized that correction will be necessary as further evidence is brought forward. For example, the Lorinna Greywacke could be interpreted as lying either above or below the Bull Creek Pyroclastics and it may even be coeval with the Gog Range Greywacke.

The Cambrian system consists of a thick and variable sequence of sediments and lavas which were deposited in a rapidly developing trough trending roughly E-W along the northern edge of the Middlesex Quadrangle.

Within the trough sediments and volcanic material accumulated rapidly, accompanied by widespread volcanic activity. The sediments are mostly greywacke with minor chert bands and they are interbedded with a wide assortment of generally acid volcanic material.

The generally unstable conditions prevailing during sedimentation and the rapidity of deposition resulted in frequent debris slides and turbidity currents sweeping the material away from the trough

margins into the deeper portions. North of the Quadrangle graded bedding and other features characteristic of turbidity current deposits have been noted in the Cambrian rocks.

The rapid facies changes, lensing out of beds and the subsequent alteration of the rocks make a complex picture in terms of local stratigraphy. There is also a possibility that many of the porphyritic members may be intrusive bodies penecontemporaneous with the volcanic extrusions. Nevertheless, the general picture of a rapidly forming basin being filled quickly by an assortment of material, both volcanic and sedimentary in origin, is well founded.

In his systematic account of the geology of this area, Twelves (1913) referred to "slates and schistose conglomerates" and "interbedded crushed porphyritic igneous rocks" which he assigned to the "porphyroids". He regarded them as pre-Silurian in age and as unconformably underlying the "West Coast Range" (Roland) conglomerate. Likewise Reid (1919a) referred in similar terms to these rocks, correlated them with the Dundas Slate Group and stated that they belonged to the "porphyroid series". He considered that they were older than the "Mt. Claude" (Roland) conglomerate and the "tubular" (Moina) sandstone.

Following this early work there was much controversy regarding the age and origin of the so-called "porphyroid series".

Later workers, notably Finucane (1932), held the opinion that many, or most, of the porphyritic members were of intrusive origin and of Devonian age. Finucane cited as an example of Devonian intrusions a quartz porphyry which outcrops along the Cockatoo (Thomas's) road just north of the mapped area. The writer has examined this occurrence carefully (Jennings, 1958) and concluded that there is no conclusive evidence for the Devonian age of the porphyritic rocks.

In his early mapping in this district Elliston (1954b) affirmed the Cambrian age of most of these rocks. However, he regarded the porphyries as being recrystallized basic volcanic rocks and Devonian granite as the end product of the recrystallization. Later work has shown that some of the porphyries have suffered post depositional alteration but no evidence has been found to indicate that the granite is related genetically to the porphyries.

LORINNA GREYWACKE

This name has been assigned to an assemblage of greywacke, chert, quartzite and volcanic rocks which underlies the Moina Sandstone on the Five Mile Rise and also outcrops in the Forth River about $\frac{1}{2}$ mile north of the Lorinna Bridge.

In the valley of the Dove River it forms the base of the Cambrian System by overlap onto the Precambrian rocks there. However, the paucity of regional outcrop and the lack of fossils makes it impossible to assign it to a definite position within the Cambrian sequence elsewhere. As the greywacke members of the formation contain fragments of chert and volcanic rocks, it is clear that other Cambrian rocks had been deposited elsewhere before the deposition of this formation. The unit has not been recognized outside the limited areas indicated on the map but similar rocks were noted by Burns in the Liena Gorge. (See p. 52).

The formation is tightly folded and has suffered considerable dynamic and hydrothermal alteration so that it is difficult to establish the detailed stratigraphy and the precise thickness of the

unit. In the Dove Valley the Lorinna Greywacke is considered to exceed 1,000 feet in thickness whilst in the Forth Valley Paterson (1960) reported the thickness as "some 600 feet".

South of the Five Mile Rise the formation is represented by a sequence of altered greywacke, greywacke conglomerate and porphyritic rocks. Although the exposures are poor the formation appears to contain a higher proportion of volcanic rocks than it does elsewhere.

Around the margins of the Dove Granite considerable hydrothermal alteration has taken place so that the exact boundary between altered porphyries and marginal phases of the Dove Granite is difficult to establish.

On the Five Mile Rise Robinson (pers. comm.) and others recorded the presence of greywacke and porphyry in the lower workings of the Golden Cliff and Union Mines and in the vicinity of the Great Caledonian workings. All these occurrences may be assigned to this formation.

On the western slope of the Forth Valley north of the Lorinna bridge occasional outcrops of weathered porphyritic rocks may be found although much of the ground is covered by basalt talus. An outcrop occurs on the side of the road leading to A. C. Hall's property. In hand specimen this rock is light coloured, stained with iron oxide and contains visible quartz grains. Superficially it resembles a porphyry but microscopically it is a greywacke. In thin section it consists of a very fine groundmass of quartz and sericite in which are set angular fragments of quartzite, quartz and sericitized feldspar. The original biotite has been altered to muscovite and ilmenite to leucoxene.

In the Forth River at the H.E.C. dam site the Lorinna Formation outcrops as a sequence of greywacke, chert, tuff, and conglomerate. The greywacke is generally thinly bedded whilst the quartzite and conglomerate tend to be more massive. At the southern end of the dam site the formation has been cut off by a powerful thrust fault which has resulted in shearing. A specimen of greywacke from this sheared zone is a fine grained grey sheared rock containing numerous quartz grains, up to 1 mm across in a fine grained matrix; a few crystals of pyrite are present. In thin section the fine grained matrix appears as a felted mass of wisps of sericite, darkened by carbonaceous material containing angular grains of quartz from 1 mm down to the limits of visibility. Other fragments consist of sericitized feldspar, chert, quartzite, quartz porphyry, volcanic glass and magnetite.

Elsewhere at the dam site the rocks are less sheared, hard and dense. The quartzite is a very fine to medium grained grey, bluish and purple rock containing angular fragments of quartz up to about 1 mm in a fine grained, sometimes ferruginous cement. In thin section the rock is a mosaic of quartz and quartzite fragments. Interstitial sericite is common and some of the quartzite fragments contain sericite parallel to bedding or lineation planes in the parent rock. Some of the sericite patches may be remains of original feldspar fragments. A good deal of interstitial limonite and a little hematite also occur.

Spry (in Paterson, 1960) described banded quartzite, sheared greywacke or tuff, conglomerate, quartzite and cherty quartzite from the same locality belonging to the Lorinna Formation.

GOG RANGE GREYWACKE

This is a thick sequence of greywacke siltstone and slate occurring along the northern slope of the Gog Range. It weathers back rapidly to form sparse soils characterized by the presence of abundant fragments of milky reef quartz shed from gash veins in the greywacke. Natural outcrops of the formation are rare and in this Quadrangle they are confined to the banks of the Mersey River north of the gorge through the Gog Range. The best exposures may be seen in the underground workings of the Star of the West Mine near Lower Beulah in the Sheffield Quadrangle. At this locality the Gog Range Greywacke passes upwards conformably into keratophyre and the upper part of the sequence contains interbedded keratophyre bands. The base is nowhere well exposed but regional mapping indicates that the formation passes downwards into a sequence of basic lavas, breccia and conglomerate.

The rocks of the Gog Range Greywacke are generally soft, fine grained, pale yellow, brown, grey or pink greywacke. The most common rocks are of siltstone grade but shale and sandstone also occur frequently. Some of the rocks north of this Quadrangle are tuffaceous and, as mentioned, lavas also occur at the Star of the West gold mine. No conglomerate has been observed in this area although a few bands have been noted elsewhere. A boulder of greywacke siltstone from this formation yielded Dundas Group fossils but so far no fossils have been found *in situ*. The fine beds usually have a well developed axial plane cleavage and the abundant fragments of reef quartz generally associated with the soils developed on this formation would suggest that quartz veining was widespread throughout the rocks. However, in underground exposures these veins are not nearly as common as might be expected.

The structure of the Gog Range Greywacke exposed in the Quadrangle cannot be determined precisely from the available outcrops and the section measured contains at least two faults. The overall thickness of the unit is therefore unknown but it would appear to be in excess of 2000 feet.

BULL CREEK FORMATION

This name is applied to the complex assemblage of quartz feldspar porphyry and sediments which outcrops along the Forth River between 8859N and 8888N and is also well exposed in road cuttings from 2 miles north of Lorinna to the northern boundary of the Quadrangle. Smaller outcrops of similar rocks also occur in the upper reaches of the Iris River and in the vicinity of Stormont.

For the most part, the formation is composed of dynamically hydrothermally altered porphyry containing minor bands of sedimentary material. The problems of age, stratigraphic position and genesis of these rocks have been argued at considerable length in the literature dealing with this part of the Tasmanian geological sequence. Here and on the West Coast these and similar rocks were referred to formerly as the "porphyroids", following Waller (1904). They were reviewed by Carey (1947), and although the term "porphyroid" has been discarded in recent years, it might well be retained in a descriptive sense for many of these rocks. The literature concerning the "porphyroids" is voluminous and even a summary would be out of place here. The reader is referred to the accounts cited by Smith (1957) as well as Spry (1962), Blissett (1962) and Campana *et al.* (1968).

The problem of the Bull Creek Formation and related rocks has been to decide whether the sheared porphyries are extrusive or intrusive, igneous or sedimentary or part of some or all these things. In the field they outcrop as sheared structureless bodies which lack the characteristic features of lavas and which are not obviously intrusive. Occasional bands (or pockets) of sedimentary material may be found but they are difficult to trace for any distance. Petrologically the rocks consist of sometimes euhedral but often cracked and corroded quartz and altered feldspar phenocrysts set in a fine grained quartz-feldspar groundmass containing hornblende, epidote and chlorite. So far petrological examination has failed to yield any positive evidence on the genesis of these rocks and it appears unlikely that it will do so except in local areas.

Chemical analysis of six typical quartz-feldspar porphyries from cuttings along the Lorinna road are given below.

	<i>Specimen Number</i>						<i>Average (Six analyses)</i>
	58/24	58/25	58/26	58/27	58/28	58/29	
SiO ₂	64.14	64.08	65.16	63.20	66.36	63.24	64.36
Al ₂ O ₃	14.53	15.37	14.67	14.36	12.57	15.59	14.51
Fe ₂ O ₃	1.79	1.07	1.86	3.07	1.47	1.32	1.76
FeO	4.11	3.99	3.99	4.50	5.11	4.28	4.33
MnO	0.12	0.13	0.08	0.12	0.18	0.08	0.12
TiO ₂	0.60	0.75	0.65	0.73	0.57	0.55	0.64
P ₂ O ₅	0.16	0.19	0.19	0.20	0.16	0.16	0.18
CaO	4.07	4.49	4.74	4.64	6.20	5.60	4.96
MgO	2.75	2.75	2.52	2.42	2.85	2.90	2.70
Na ₂ O	2.30	0.53	0.48	0.53	0.80	0.39	0.84
K ₂ O	3.84	5.45	4.54	3.89	2.72	4.44	4.15
H ₂ O-	0.16	0.21	0.22	0.38	0.16	0.15	0.21
H ₂ O+	1.39	1.44	1.58	1.87	1.14	1.10	1.42
TOTAL ..	99.96	100.45	100.68	99.91	100.29	99.8	

A feature of these analyses is the high potash/soda ratio. Petrographic descriptions of the above rocks are given below:—

58-24 Quartz-feldspar porphyry

Medium to fine grained dark green rock. The colour is not quite uniform as there is an occasional patch of paler feldspathic material. Visible crystals consist of irregular glassy quartz and white rectangular feldspar about 1 mm across.

In thin section the texture is porphyritic with euhedral, rounded or irregular and corroded quartz crystals, cloudy crystals of feldspar, and confused masses of uraltic hornblende in a quartzo-feldspathic groundmass, with chlorite and epidote.

The feldspars show alteration and may have sericitic inclusions, but simple twinning along 001 and extinction parallel to the twin plane indicate orthoclase. Occasional crystals show fine multiple twinning with low extinction angles. Accessory minerals are ilmenite and magnetite.

58-25 *Quartz-feldspar porphyry*

Fine grained greenish-black rock with glassy phenocrysts of quartz.

In thin section it shows rounded and euhedral crystals of quartz, all slightly corroded, and lath-like and irregular remains of hornblende crystals, partly chloritic, and partly altered to iron ore minerals. In between the size of the phenocrysts and the very fine groundmass is much quartz in angular and irregular grains. The groundmass is greenish and seems to consist of chlorite, quartz, epidote and feldspar. There are patches of iron ore and euhedral crystals of zircon. Original feldspar crystals are absent or exist only as very shadowy and irregular patches.

58-26 *Quartz-feldspar porphyry*

Greenish black rock with phenocrysts of glassy quartz. The groundmass is very fine grained but the rock is not uniform as there are xenoliths of lighter coloured siliceous material which seem to be associated with epidote, and some xenoliths consist almost entirely of epidote.

In thin section the rock shows plastic flow structure. There are lenticular inclusions of quartzo-feldspathic material containing corroded quartz grains, multiple twinned feldspar crystals and aggregates of uraltic hornblende. The very fine grained groundmass seems to consist of chlorite and epidote.

58-27 *Quartz-feldspar porphyry with pyrite nodules*

Dark greenish rock with phenocrysts of quartz, and large single crystals and coarse grained aggregates of pyrite.

In thin section the rock is seen to consist of a quartzo-feldspathic groundmass, not entirely uniform, some parts being of coarser grain than others, containing patches of epidote and iron ores. The quartz phenocrysts are rounded and peripherally corroded.

58-28 *Quartz-porphyry*

Medium to fine grained dark greenish rock with glassy phenocrysts of quartz and a trace of sulphides.

In thin section the quartz crystals appear corroded and have inclusions of other minerals. The groundmass is quartzo-feldspathic and contains in addition innumerable small granules of epidote. Uralitic hornblende also occurs in confused aggregates. Flow structure is prominent.

58-29 *Porphyry*

Dark greenish rock with glassy phenocrysts of quartz and fewer cloudy phenocrysts of feldspar.

In thin section the texture is porphyritic and glomeroporphyritic, with single crystals of feldspar and quartz somewhat corroded, and groups of crystals comprising quartz, feldspar, uraltic hornblende, epidote and iron ores. The matrix is very fine grained; it consists of quartz, feldspar and epidote, and shows plastic flow structure.

From the evidence of the above sections it is apparent that these rocks have a complex origin and a complicated history. Metamorphic textures and structures are plainly shown. However, the minerals present indicate an igneous origin. Such an origin would be indicated by a high ratio of potash relative to soda. A high silica content in such melanocratic rocks is anomalous; but under the microscope there is evidence for a high silica percentage in the groundmass.

The Cambrian section in the Forth River north of Lorinna was studied by Burns who summarized his views on these rocks in a recent publication (Burns, 1961). The following notes have been supplied by him:—

“The rocks of the Dolcoath Anticlinorium are of Cambrian age, and are designated the Bull Creek Formation. The dominant lithology is a quartz-feldspar porphyry, which is probably a pyroclastic rock. The Geales Bridge Member occurs in the middle of the formation, consists of greywacke, chert and porphyry and is about 850 feet thick. The rocks were sheared in Devonian times, with contemporaneous low grade metamorphism producing metamorphic segregations and secretion veins, in that order.

Bull Creek Formation

This is defined as those rocks outcropping in the Forth River between 8859N and the Dolcoath Granite at 8888N. For the most part the lithology is quartz-feldspar ‘porphyry’, but bands of chert and greywacke (lutite to conglomerate) occur. The approximate distribution of the greywacke is shown on the map (Burns, 1961, p. 36). The outcrops are thought to represent a single band in the middle of the Bull Creek Formation, which is named the Geales Bridge Greywacke and Chert Member, and defined as those rocks outcropping in the vicinity of Geales Bridge (88752N/41148E).

Evidence for Age:—The formation underlies Ordovician conglomerate or sandstone, and where the contact is clearly exposed, as in the Iris River near Hinman Creek (8892N/4058E) and on Stormont (8877N/4007E), it is unquestionably an unconformity. The contacts on the Lorinna Road at the gravel quarry (8862N) and Tin Spur are not clear, but are probably unconformities.

The rocks unconformably underlie the Ordovician, and are distinct lithologically from the Precambrian, so are presumably Cambrian.

Stratigraphic Relations:—At the moment these are obscure. On general grounds it seems likely that the Bull Creek Formation underlies the Cethana Group of Elliston (1954b).

The Lorinna Formation probably underlies the Bull Creek Formation but may be equivalent to the Geales Bridge Member.

Quartz-Feldspar Porphyry:—The rocks are medium to fine grained; blue, black or green in colour, with fragments of glassy quartz and cloudy feldspar. The quartz is rounded to euhedral, corroded, and almost invariably cracked. The feldspar is euhedral, corroded, with cloudy alteration, identified in one specimen as orthoclase. The fragments range from 1 to 3 mm in diameter. The matrix consists of chlorite, quartz and feldspar, with hornblende, epidote and iron ore often present. Euhedral zircon occurs in some specimens.

The rocks are not homogeneous, some portions being mainly quartzo-feldspathic. This variation is visible megascopically and a feldspathic phase is prominent at 8873N/4122E. The content of quartz fragments visible in the field varies from 10 to 90 per cent.

Agglomerate:—This occurs on the Lorinna Road at 88762N 4124E; it consists of large angular blocks, up to 6 inches in diameter, of purple and green porphyritic lava in a matrix of porphyry. A similar phase occurs in the Forth River at 88690N.

A rock from the Lorinna Road consists of pink pebbles of quartz-feldspar porphyry up to 3 inches in diameter and small pink shreds, in a matrix of porphyry. This is probably an agglomerate. The porphyry matrix is in places almost entirely amphibole, with occasional 5 mm bands of material with fibres orientated perpendicular to the walls of the band.

Chert Pebbles in Porphyry:—Chert pebbles and boulders occur sporadically throughout the porphyry—on the Lorinna Road at 88810N, on the old road at 88780N, in the Forth River at 88700N and at Geales Bridge. The size varies usually from 1 inch to 3 inches in diameter, although a greywacke 50 yards north of Geales Bridge contains boulders up to 3 feet in diameter.

Geales Bridge Member:—The contact with the Dolcoath Granite is not well exposed in the river, although it can be located within several feet. The rocks within 100 feet south of the contact contain occasional dykes of granitic material, the porphyry being altered to biotite hornfels. At the first bend to the south the rocks are undoubtedly sediments, consisting of bands of greywacke siltstone (volcanic ash?) and bands containing large quartz crystals about 3 mm in diameter. The sediments continue to 88816N/41213E, the southern-most (highest) beds being greywacke siltstone with laminations of slightly coarser material, and a hard blue rock that may be chert.

Beds of chert occur near 88980N/41220E, with chert pebbles in the neighbouring quartz porphyry. A banded chert is exposed on the old road at 88760N/41190E.

Just north of Geales Bridge there is a greywacke conglomerate consisting of boulders of chert varying from 1 inch to 3 feet in diameter in a matrix of greywacke arenite which contains abundant chert fragments.

At Geales Bridge the rock is quartz porphyry containing numerous pebbles of chert ranging in size from 2 inches down to 3 mm. Just south of Geales Bridge at 88751N/41150E chert bands occur in the porphyry, showing reaction against intrusive veins of hornblende and epidote. Chert of probably the same horizon is exposed on the old road at 88730N/41170E, and on the new road at 41230N/88630E.

If all these sediments are the same horizon, the probable sequence is as follows:—

- (1) Porphyry (Upper porphyry member of Bull Creek Formation).
- (2) Geales Bridge Member:
 - (a) Greywacke sandstone and conglomerate, interbanded with porphyry in places—about 500 feet thick.
 - (b) Porphyry, containing chert pebbles and fragments in places—about 100 feet thick.
 - (c) Chert, interbanded with porphyry at the top and greywacke siltstone at the base—about 250 feet thick.
- (3) Porphyry (Lower porphyry member of Bull Creek Formation).

Origin of the Bull Creek Formation:—The high potash-soda ratio and petrology of the porphyry indicate an igneous origin. The porphyry contains agglomeratic phases, and chert pebbles in numerous localities. Although the pebbles of lava and chert could perhaps be construed as xenoliths, the Geales Bridge Member is possibly an interbedded continuous band. This suggests an extrusive rather than an intrusive origin.

Despite very careful search no evidence of lava flows has been found—no vesicles or pillow structure—while at the same time there is no field evidence, such as discontinuities, against a common origin for all the porphyry of this district. At Geales Bridge the porphyry contains chert pebbles and grades upward into greywacke, and at 88855N/41180E there are thin bands of quartz-rich porphyry interbedded with laminated greywacke siltstone. These considerations imply that the porphyritic lithology in this formation has a common origin which is sedimentary.

Metamorphic Segregations in the Bull Creek Formation:—Numerous patches of quartz-porphyry, of high hornblende content and surrounded by white reaction rims, occur in the porphyry, notably at Geales Bridge on the Lorinna Road near 88762N, in the Forth River near 88690N, and in greywacke about 50 yards north of Geales Bridge.

The segregations average 2-3 inches long, and are ellipsoidal in shape with the long and intermediate axes in the plane of schistosity. At Geales Bridge the segregations are green, with a white border, in brown porphyry country rock.

The enclosing porphyry is quartz-feldspar porphyry, with quartz and feldspar crystals in a fine grained quartzo-feldspathic matrix, with a little epidote and iron ore. The white border is similar, but contains much more epidote, some hornblende, and the matrix is fresher. The segregation is similar, but with abundant hornblende. The boundaries are transitional. In the field the country rock of this occurrence (Geales Bridge) is seen to contain chert pebbles. The schistosity runs through the segregations, which are therefore earlier or the same age as the deformation. The number of quartz crystals visible in the field (10%) is not markedly different between the segregation and country rock. In one locality near Geales Bridge

there occurs a joint oblique to schistosity. Where this intersects the segregation, the segregation is locally elongated in the direction of the joint. This is not due to deformation, and appears to be due to the joint-fracture acting as a locus of alteration. Another joint in the same locality has narrow elongated segregations along its length.

Hornblende and Epidote Knots:—These are prominent on weathered surfaces and are abundant in various localities, notably Bull Creek (88773N/40960E), the new Lorinna Road near 88772N, and in the Forth River near 88700N. They are sometimes associated with the metamorphic segregations mentioned above, and would seem to have a common origin.

The hornblende occurs as large rounded knots up to 12 inches long, rarely less than 6 inches. Smaller knots, 1-2 inches in diameter, are usually epidote. Both hornblende and epidote occur in some knots. The country rock is usually porphyry, but knotted greywacke occurs as boulders in the river near Geales Bridge, so that knots must occur in greywacke somewhere upstream, probably in Bull Creek. The knots appear to be the same age as, or slightly earlier than, the schistosity.

Veins:—Veins of hornblende and epidote occur in places, notably in Bull Creek at 88773N/40960E, on the Lorinna Road between 88726N and 88772N, and in the Forth River at 88751N at the boundary of sediments and porphyry. One vein specimen examined consists of a central portion of hornblende and magnetite, with an outer portion of anhedral feldspar, anhedral to euhedral quartz, and epidote.

The veins cut across the schistosity, and appear to be structurally controlled by shear joints symmetrically related to schistosity. This would date the veins towards the end of the tectonic movement.

The material is resistant, forming crosses on weathered surfaces. On Bull Creek some veins are banded with epidote and hornblende, while some poorly exposed epidote veins may be infilled tension gashes.

The veins often contain a central portion of chalcopyrite, as between 8872N and 8882N on the new road.

Mineral veins of calcite, quartz and chalcopyrite occur at 8872N on the new road, while disseminated pyrite is abundant at 8858N to 8865N in the Forth River, and just north of Geales Bridge.

Structural Considerations:—The dominant feature is a very strong schistosity, which reaches maximum development near the mouth of Oliver Creek and decreases in intensity northwards. Between Oliver Creek and 8867N the deformation is very intense, the rock in places being sericite schist with the schistosity lensing around the quartz crystals. Near 8860N in the Forth River incipient boudinage is developed.

The schistosity is Tabberabberan in age, as the limestone in the Forth River at 8859N shows strong shear folding with the shear planes parallel to those in the Cambrian rocks to the north. In the Iris River at Hinman Creek the schistosity is difficult to locate in the Roland Conglomerate due to the weathered outcrop but it is developed in some of the overlying beds. Generally, however, the schistosity is poorly developed in the Ordovician quartzite where accommodation could be made by bedding plane slip.

Drag folds have been seen in three places, where their axial planes are in the plane of schistosity. Plunge appears to be variable.

There is an indication that the schistosity ranges within the Dolcoath Anticline from dipping 30° north on the south limb to vertical or overturned in the axial portion.

There appear to be several second order folds developed in the Cambrian rocks contained within the Dolcoath Anticline, trending obliquely to the major structure. The divergence is somewhat less than 45°. The schistosity appears to be related to the axial plane of the first order folds. The increased intensity southwards is considered to be due to increasing deformation in the vicinity of the fault or shear zone which crosses the Forth near Oliver Creek. Petrographic descriptions of some of these rocks are given below.

59/275. *Hornblende vein in porphyry*

This is a fine grained, dark grey rock with glassy phenocrysts about 1 mm across. The specimen is cut by a complex vein about $\frac{1}{2}$ inch wide, consisting principally of quartz with an irregular centre up to 6 mm wide, consisting principally of hornblende needles.

In thin section the rock consists of a fine grained groundmass of quartzo-feldspathic mosaic with disseminated, minute books of yellowish mica. The groundmass in general has a rather mottled appearance due to palimpsest structure. In this matrix are crystals of quartz and feldspar. The quartz is somewhat cracked and distorted and the feldspar is corroded. Opaque rounded iron ore minerals are fairly common and there are patches of yellow mica.

The vein boundary is in most places quite sharp, but there are places where minerals from the vein have penetrated into the rock. As stated, the middle of the vein consists of hornblende. The mineral is strongly coloured, intensely pleochroic, and arranged in radial and sheaf-like masses of prismatic crystals. Euhedral crystals of magnetite arranged in strings and irregular patches tend to be associated with the hornblende. The outer parts of the vein contain anhedral crystals of feldspar up to 0.5 mm across. Most of the crystals show no twinning, but irregular coarse lamellar twinning is sometimes seen. Granulation that may be due to recrystallization is also common. Quartz is present in equal or greater quantity. The quartz is mainly in irregular grains, but some euhedral crystals are present. The anhedral quartz contains much included material, including minute drops of liquid with mobile bubbles. Yellowish epidote is common, as small irregular grains and masses.

59/257. *A lava pebble in porphyry*

The specimen is a dark greenish fine grained rock with subrounded quartz phenocrysts and irregular patches of pink feldspathic material. A large pebble-like inclusion of pinkish feldspathic material containing quartz grains also occurs.

The rock has a fine granular quartzo-feldspathic matrix, containing larger grains (up to 1 mm) of quartz, altered feldspar, irregular granular masses of epidote, and masses of fine acicular hornblende, sometimes altered to chlorite.

The pink area has a matrix of quartzo-feldspathic material of even finer grain, and it shows flow texture. Phenocrysts of corroded quartz grains and semi-opaque feldspar crystals are common. Quartz, and quartz and epidote, occur as groups of fine granular crystals in the finer-grained matrix.

59/259. *Hornfels from within 1000 feet of the Dolcoath Granite*

This is a fine grained dark greyish or brownish rock with indefinite porphyroblastic patches. One part of the specimen is thickly studded with somewhat rounded quartz crystals about 3 mm across.

The rock is a very fine, even grained aggregate of quartz, feldspar, sericite and biotite. Irregular areas consisting mainly of sericite become visible under crossed nicols and may be the ghosts of feldspar crystals. The large quartz crystals show rounding and embayment.

59/261. *Segregation in porphyritic rock containing chert pebbles*

A dark brownish-grey rock with numerous white phenocrysts contains a rounded flattened inclusion, greenish in colour and surrounded by a white border.

In thin section the rock appears as a sheared quartz-feldspar porphyry with subrounded crystals of clear quartz and rounded rhomboidal crystals of altered feldspar showing simple or no twinning, in a very fine grained quartzo-feldspathic matrix. A little epidote, magnetite, and pyrite is present.

The green inclusion consists largely of hornblende and epidote in confused masses of fine crystals, together with phenocrysts of quartz and feldspar and irregular masses of quartzo-feldspathic matrix.

The white band is similar to the sheared porphyry but the matrix is fresher and whiter and there is more epidote present. The three different types merge gradually into one another.

Sheared and altered quartz-feldspar porphyry also occurs in the upper reaches of the Iris River. It underlies the Roland Conglomerate unconformably. Petrographic descriptions of rocks from this area are given below:—

61/59. *Iris River 8860N/4012E*

The specimen is a leucocratic rock, consisting of glassy irregular grains of quartz, euhedral and subhedral crystals of feldspar and dark greenish crystals of ferromagnesian minerals in a pale coloured aphanitic matrix.

In thin section the matrix is resolved into a mosaic of quartz and feldspar crystals, averaging 0.05 mm across, which is rendered a little cloudy with extremely fine grained opaque material. The phenocrysts average 1 or 2 mm across

and are sharply demarcated in size from the matrix. The quartz grains are somewhat rounded and corroded. Feldspar is but slightly sericitized and lies within the albite-oligoclase range.

The ferromagnesian phenocrysts are of various kinds. Some are rectangular masses with somewhat ragged ends, consisting of chlorite and epidote, with opaque inclusions of ilmenite almost completely altered to leucoxene; others are made up of minute interlacing plates of chlorite; others again are groups of epidote crystals.

61/61. *Iris River 8887N./4059E*

In hand specimen this rock is medium to fine grained; its dark grey colour is probably due to staining by surface solutions. Many grains of quartz and feldspar are visible.

In thin section the porphyritic character of the rock becomes apparent. It contains corroded grains of quartz, altered feldspar crystals and ragged crenulated micaceous flakes, in a very fine grained groundmass of quartz, feldspar and sericite.

Some of the feldspar crystals show compound twinning, but in general there has been too much alteration for determination of the species, and some crystals are difficult to distinguish from the matrix. The main alteration product is epidote.

Hornblende is present as broken, ragged crystals. Biotite, largely altered to epidote, is present in bent and twisted masses. Minute crystals of pyrite are very numerous and lie scattered through the matrix of the rock.

A lack of homogeneity in the matrix of the rock has been brought about by shearing which has left the phenocrysts relatively undisturbed.

61/67. *Iris River 8863N/4037E*

The specimen is a porphyritic rock, consisting of phenocrysts up to 5 mm long of translucent white, or colourless transparent, rounded grains of quartz, opaque white feldspar crystals, and dark ferromagnesian minerals in a very fine pale-coloured groundmass.

Thin section shows a fine grained quartzo-feldspathic groundmass, with much opaque white clay material due to weathering, the average grain size being 0.05 mm.

Quartz phenocrysts are rounded grains up to 5 mm across, with inclusions. They are somewhat corroded and cracked. Feldspars are weathered and largely opaque. The darker crystals include lath-like chlorite with inclusions of magnetite (an alteration from hornblende) and epidote.

The rock is a quartz-feldspar porphyry.

61/70. *Iris River 8865N/4035E*

The specimen is a strongly sheared porphyritic grey rock with phenocrysts of quartz up to 5 mm across.

In thin section it is composed of a matrix of quartz grains about 0.05 mm across, and sericite. In the matrix are crystals of feldspar, completely sericitized, and irregularly shaped quartz, corroded and embayed. There are also patches of chlorite and magnetite."

SUMMARY

The information presented here indicates that the porphyritic rocks in the Bull Creek Formation are of igneous origin. The lack of discordant contacts within the Formation and the rarity of extrusive features suggest that the majority of these rocks are of pyroclastic origin. Although Burns (1961) named the Geales Bridge Member within the Formation the field exposures are not clear enough to demonstrate conclusively that this unit is continuous throughout the area mapped by him. It may well be a series of discontinuous lenses of sedimentary material within a thick pile of pyroclastic rocks and lavas.

Until comparatively recently the Cambrian volcanic rocks in Tasmania were regarded as being generally soda-rich, but the Bull Creek Formation and some rocks cited by Solomon (1960, p. 49) indicate that important sequences of potash-rich lavas and pyroclastics are also present. As more analyses become available it seems likely that the Cambrian volcanic suite will be found to contain a very wide range of rock compositions.

Spry (1962) indicated the compositional range of Cambrian volcanic rocks. He suggested that many of the porphyritic rocks may be welded tuffs and this suggestion seems to be in accord with the facts presented here.

CAMBRIAN KERATOPHYRE

Small areas of quartz and quartz feldspar porphyry have been mapped along the northern boundary of the Quadrangle. The relationship of these rocks to the Roland Conglomerate is discussed on page 56. Further north they are underlain by the Gog Range Greywacke.

The upper limit of this formation is difficult to ascertain due to shearing and hydrothermal alteration in the critical areas. They appear to pass upwards into more basic hybridized rocks and then into sheared quartz feldspar porphyry similar to the Bull Creek Formation, but the sequence is far from clear.

Although the rocks have been indicated as keratophyre on the map, later analyses of similar rocks from the suite collected near Beulah indicate that they resemble more closely the soda-potassic rhyolite described by Solomon (1960) from the Queenstown area.

Details of analyses of 2 specimens from near Beulah are given below.

	(1)	(2)	(Average)
SiO ₂	77.26	77.16	77.21
Al ₂ O ₃	11.84	12.78	12.31
Fe ₂ O ₃	0.50	1.10	0.80
FeO	1.60	0.93	1.26
MnO	0.01	0.04	0.03
TiO ₂	0.16	0.18	0.17
P ₂ O ₅	0.05	0.03	0.04
CaO	0.76	0.68	0.72
MgO	0.46	0.25	0.35
Na ₂ O	3.22	2.38	2.80
K ₂ O	3.52	3.58	3.55
H ₂ O—	0.02	0.42	0.22
H ₂ O+	1.12	1.04	1.08
TOTAL	100.52	100.57	

In thin section the rocks consist of a fine grained groundmass of quartz and feldspar with some chlorite and sericite. The phenocrysts of quartz are usually but not always cracked and corroded and the feldspars are almost always sericitized, usually orthoclase and albite-oligoclase being present where identification is possible.

In the field the rocks are grey, green or purple, sometimes sheared, and contain phenocrysts of quartz and feldspar up to 3 mm in diameter in a fine grained matrix. No flow structures, pillows or vesicles have been observed although closely spaced and well developed hexagonal jointing is present in some exposures of similar rocks from near Beulah.

UNASSIGNED CAMBRIAN ROCKS.

In the Mersey Gorge about a mile north of Liena there is a sequence of unfossiliferous greywacke and volcanic rocks assigned to the Cambrian System. The area exposed is relatively small and isolated from the remainder of the Cambrian rocks in this Quadrangle. The rocks have not been assigned to any particular formation and their position within the Cambrian sequence is unknown.

The section was examined by Burns and the following description is based on notes prepared by him.

The rocks are exposed in the bed of the Mersey River between 8835N and 8868N, the easiest access to the outcrops being along a fishermen's track down the east bank of the river from behind

the Liena post office. The southern boundary is faulted against Moina Sandstone and at the contact the rocks consist of about 5 feet of highly jointed greywacke siltstone. This is succeeded northwards by an outcrop about 200 yards wide of massive quartz-feldspar porphyry which varies in colour from green to brown depending upon whether the feldspar is colourless or pink. The feldspar crystals average about 1 mm in diameter. The quartz phenocrysts average 2 mm and are sometimes black and lustrous.

The porphyry is overlain by a laminated greywacke siltstone dipping north at 60° and striking at 130°. This rock is highly indurated, with bands and lenses of white siltstone up to 2.5 mm thick intercalated with bands less than 1 mm thick of black, fine siltstone. The bedding planes of the rock carry tiny muscovite flakes. The formation dips north at between 30° to 60° and the strike is between 130° and 140° true.

North of this unit is a thick bedded purple greywacke sandstone containing rare quartz fragments and flakes of talc schist up to 3 mm in diameter. The greywacke is interbedded with pyroclastic rocks but these are best exposed on the west bank of the river. This unit is less than 50 feet thick and is succeeded to the north by a flaggy bedded chlorite rock which is isoclinally folded about an axis trending at 130° T. This rock is pale green, fissile, very soft, with a white streak and occurs in beds about 8 inches thick over a distance of several hundred feet.

The northern boundary of the exposure is faulted against Moina Sandstone. The probable sequence in the Liena Gorge is:—

	<i>Thickness.</i> (feet)
Top—	
Chlorite rock	100
Greywacke sandstone and tuff	50
Laminated greywacke siltstone	500
Quartz-feldspar porphyry	500

Ordovician System

The Ordovician System is represented by more than 4500 feet of limestone, sandstone, shale and conglomerate. It has been subdivided into 3 formations as indicated below:—

<i>Unit.</i>	<i>Thickness.</i> (feet)	<i>Lithology.</i>
Gordon Limestone	3000+	Pure limestone with some calcareous sandstone.
Magog Group—		
Moina Sandstone	800	Sandstone, quartzite and shale.
Roland Conglomerate	800—	Quartz conglomerate and quartzite.

Rocks of this age have been recorded from this Quadrangle since the earliest days of geological exploration but the first reports were chiefly concerned with the Mole Creek district.

In 1845 Strzelecki reported the presence of limestone near Circular Ponds (Mayberry). In 1860, Gould paid a brief visit to Chudleigh and noted limestone in the vicinity of the town. His opinion of its age is discussed under Gordon Limestone. Johnston (1888) gave a fuller account of the rocks and their stratigraphic position. Johnston's stratigraphy together with the existing nomenclature is tabled below:—

<i>Johnston 1888</i>	<i>Lithology</i>	<i>Present Paper</i>
(1) Primordial Califerous Group ..	Limestone	Gordon Limestone
(2) Magog Group	Quartzose grits sandstone and aluminous slates	Magog Group— Moina Sandstone Roland Conglomerate
unconformity		
(3) Metamorphic schist and slate		Cambrian System

Thus it will be seen that Johnston's stratigraphic succession has survived over 70 years of geological investigation without any important changes.

Following Johnston, numerous other workers examined various parts of the area. The most important accounts are those of Twelvetrees (1913), Reid (1919a) and Elliston (1954b).

All these workers followed the same general pattern of stratigraphy although several formation names have been coined for the various units. The stratigraphic nomenclature for the Ordovician system has been discussed elsewhere (Jennings, 1958).

Although the existing nomenclature is not ideal, it avoids introducing any new formation names at this stage and also avoids direct correlation with similar, but perhaps not identical, units on the West Coast and elsewhere.

The Ordovician rocks overlie the Cambrian System with angular unconformity and the basal beds often contain phenoclasts of the Cambrian rocks. In the vicinity of Liena and near the Den the Gordon Limestone is succeeded, apparently conformably, by Silurian (?) sandstone correlated with the Eldon Group. Although no useful fossils have yet been recovered from the Moina Sandstone, correlates of this formation elsewhere contain a Tremadocian fauna. As this formation is underlain by up to 800 feet of Roland Conglomerate it seems likely that deposition commenced in very early Ordovician times. Banks (1957) reported that at Liena the Gordon Limestone contains corals "which may be upper Ordovician or Silurian, but no definitely Silurian forms have yet been found". Thus it is clear that the rocks assigned to this System represent all or most of the Period.

The Ordovician rocks are restricted to the northern half of the Quadrangle and occupy much the same sedimentary basin as the Cambrian rocks. However, the regional distribution indicates that these rocks transgress southwards onto the Precambrian basement. The thickest part of the Roland Conglomerate is restricted to the Cambrian basin but it persists to the south for some distance as a thin (100 feet) basal conglomerate to the Moina Sandstone. South of Lorinna and Liena, the Roland Conglomerate is overlapped by the Moina Sandstone which there rests directly on the Precambrian basement.

A notable feature of the System is the general decrease in grain-size of the sediments from the bottom upwards. The system commences with coarse quartz conglomerate and passes upwards into interbedded sandstone and shale and finally into limestone. However, the detailed descriptions of the lower formations show that the change in sedimentation is not gradual but occurs in three major stages upon which many smaller cycles are impressed. The major stages are due to changes from terrestrial to shallow water marine deposition and from this to conditions suitable for limestone deposition. The smaller cycles are probably due to intermittent uplifts and subsidences in the source and basin areas.

MAGOG GROUP.

ROLAND CONGLOMERATE.

The lithology of this formation and its correlate, the Owen Conglomerate (previously called the West Coast Range Conglomerate), has been described elsewhere many times. The typical rock is a dense recrystallized quartz conglomerate, generally but not invariably coloured pink, composed of sub-rounded fragments of quartz, quartzite, and quartz schist in a fine grained siliceous matrix. The pink colouration is due to finely divided hematite disseminated through the rock and also to a predominance of pink pebbles among the phenoclasts.

The formation is composed of thick beds of conglomerate which are readily discernable from a distance or on air photos but not always obvious on closer inspection. Crossbedding is sometimes noticeable, the phenoclasts are in contact with one another, grading and fossils are absent, and the matrix is subordinate. The material comprising the formation was derived from the Precambrian quartzite to the south. These features together with the regional distribution suggest a terrestrial origin for the formation.

The formation attains a maximum thickness of about 800 feet along the Fossey Mountains. South of Mt Claude it thins out rapidly to 100 feet or less and persists as a thin unit as far south as Lorinna. Along the Gog Range it is also about 800 feet thick but in the Standard Hill Anticline it is very much thinner than this and just north of Liena it is absent. The formation is also either thin or missing in the vicinity of Stormont and in the gorge of the Mersey River between the Gog Range and Mt Magog.

Whilst the Roland Conglomerate is predominantly coarse grained, some quartzite beds are present. The basal beds are commonly coarser than average and there is a general reduction in grain size from the bottom upwards. However, the reduction in grain size is not uniform and is interrupted by numerous changes in sedimentation which are probably related to uplifts in the source areas. Likewise the characteristic pink colouration is not uniform and many of the beds are white in colour.

The basal beds usually contain fragments of the underlying Cambrian rocks but it may be noted that the unconformity between the Roland Conglomerate and the Cambrian System is seldom well exposed. Where exposures have been found there is almost always evidence of some movement and the boundary is very frequently faulted. This is regarded as evidence for decollement action between the two systems due to the contrast in fold styles and to the difference in competence.

The best exposure of the unconformity is along the north facing slopes of the Gog Range where the conglomerate overlies purple Cambrian keratophyre. Here the basal beds are composed of boulders of keratophyre set in a matrix of keratophyric material. Passing upward, the beds contain fewer boulders of keratophyre until a normal quartz conglomerate without keratophyre is reached. This occurs relatively abruptly some 30 feet above the base but as the keratophyre conglomerate is so similar to its parent rock, the precise base of the conglomerate is difficult to ascertain within a few feet. The exposure is regarded as illustrating the inclusion of Cambrian soil horizons in the conglomerate and strengthens the suggestion of a terrestrial origin for the formation. However, this exposure is somewhat atypical for the area and elsewhere the transition from Cambrian rocks into the Roland Conglomerate is abrupt, although the lowest bed of the conglomerate is usually more argillaceous than the rest of the formation.

In the vicinity of the Dolcoath Granite the Roland Conglomerate underwent wholesale recrystallization which resulted in the formation of a dense white quartzite. On close inspection shadowy outlines of the original phenocrasts may still be observed. This rock has locally been termed the "Ghost" conglomerate" and some workers have regarded it as a separate formation (Elliston 1954b).

MOINA SANDSTONE.

About 800 feet of fine grained marine sediments occur conformably between the Roland Conglomerate and the Gordon Limestone. They are shown on the map as the Moina Sandstone Formation. The stratigraphic nomenclature concerning these rocks has been discussed elsewhere (Jennings, 1958) but some problems still remain. No type area for the formation has yet been defined and up to the present no satisfactory type section has been located.

For the purpose of this report the Moina Sandstone is here defined as: That formation of marine sandstone, quartzite, shale and conglomerate, about 800 feet thick, which occurs stratigraphically below the Gordon Limestone and above the Roland Conglomerate. The formation may be observed at many places within the Middlesex and Sheffield Quadrangles but it is best exposed along the Fossey Mountains in the vicinity of Round Hill and Moina.

As defined, the unit is therefore equivalent to the "Fucoid Sandstone", "'Tubicular' series", "Pipestem Series" and "'Worm-cast' sandstones" of early workers and is probably equivalent to the Caroline Creek Beds (Johnston, 1888) and the Upper Owen Conglomerate (Wade and Solomon, 1958). It would include the Florentine Valley Beds of Etheridge (1904).

The thickness given, 800 feet, is considered to be the maximum development of the formation but in the absence of a satisfactory type section and since it is complexly folded and faulted everywhere the figure must be regarded as provisional only.

Wherever the boundary is exposed, as on Mt Roland, the Gog Range and Olivers Hill, the Moina Sandstone follows the Roland Conglomerate conformably and the boundary between the two units is frequently transitional. The transition zone may be up to 50 feet thick and consists of interbedded quartzite, conglomerate and grit. Similarly, the upper limit of the formation may be difficult

to define in detail as transitional beds of varying thickness may be present. Banks (pers. comm.) considers that these beds are sufficiently distinctive to warrant their recognition as a separate unit, the Florentine Valley Mudstone (after Etheridge, 1904).

A section through the upper portion of the Moina Sandstone and the base of the Gordon Limestone is tabulated below. This illustrates the transitional nature of the boundary in the Mersey River south of Liena:—

<i>Thickness.</i>	<i>Lithology.</i>
<i>ft.</i>	
100+	Limestone
20	Laminated shaly limestone
6	Massive calcareous sandstone; dip 15° to 025°M
approx. 30	Shaly limestone with bands of calcareous sandstone
approx. 20	Calcareous sandstone; dip 30° to 110°M
approx. 12	Shaly limestone
2	Flaggy, slightly calcareous sandstone
	Nose of small anticline plunging 15° to 330°M; N limb dips 15° and S limb 60°
25	Black flaggy sandstone
6	Massive calcareous sandstone
	Syncline
	Small fault striking 330°M
6	Calcareous sandstone
4	Ripple-marked mudstone
4	Massive quartzite
4	Sandy mudstone; dip 15° to 020°M
?	Calcareous quartzite
6	Calcareous sandstone
?	Massive quartzite with tubicolar casts
10	Massive sandstone
10	Calcareous mudstone
	Massive quartzite containing brachiopods and tubicolar casts.

Elsewhere, the contact between the Moina Sandstone and the limestone seems to be somewhat more abrupt, although it is seldom well exposed. Calcareous beds in the upper part of the Moina Sandstone have been observed on the Five Mile Rise, Standard Hill and near the contact at 8838N/4258E.

Generally speaking, the formation is fine grained, dense and siliceous. It consists largely of quartzite and quartz sandstone with minor bands of shale, conglomerate and grit. The bedding planes are well developed and are accentuated by bedding plane slip during concentric folding. Individual beds are usually of the order of a foot or so thick and these, in conjunction with a strongly developed joint system, divide the rocks into a blocky form. Flaggy

bedding occurs, particularly where the lithology is more variable. Finely laminated bedding has not been observed and beds over 3 feet in thickness are rare.

The sandstone units consist of white, grey, pink and brown, fine to medium quartz grains set in a slightly argillaceous quartzose matrix. Prolonged surface weathering reduces the semi-indurated quartzite to the appearance of a somewhat porous clean white sandstone and it seems likely that in depth the bulk of the formation would be termed quartzite. The unweathered rock is seldom variable in colour, being a uniform pale grey.

The quartzite members are dense white saccharoidal or glassy rocks. The degree of recrystallization corresponds with the proximity of the granite intrusion and many of the contact rocks are exceedingly hard, dense and flinty. In outcrop the quartzite is frequently white but the pink colouration of the underlying Roland Conglomerate sometimes persists into this formation. Strong jointing with a spacing similar to that between bedding is often difficult to determine. Tension cracks, usually en echelon and filled with milky quartz, are common as are thin films of quartz along bedding planes which often display well preserved slickensides.

Shaly bands are more common and thicker toward the top of the formation but most of the lower beds are separated by thin shaly partings. As the shale beds rarely outcrop, the proportion of shale to arenaceous material is not known, but it seems to be low, probably less than 20%. The influence of the shaly beds on the fold style has been discussed elsewhere (Jennings, 1958).

Interbedded with the sandstone, quartzite and shale are occasional conglomerate beds, more common toward the base of the sequence where they resemble the beds of the Roland Conglomerate. Higher in the formation the conglomerate beds are thinner and finer, and there occur bands of intraformational breccia consisting of small (less than 1 inch) pellet-shaped sub-rounded fragments of fine grained sandstone in an argillaceous and fine grained sandy matrix. One such band is exposed just inside the main drive of the Round Hill Mine.

Within the formation numerous bands of grit have been noted. These consist of angular particles of quartz about 3 mm across set in a fine grained siliceous matrix. The beds are sufficiently common and similar to one another to be of no use as regional marker horizons.

Beds containing pyritic spherulites were noted previously in the vicinity of Round Hill (Jennings, 1958) and similar beds have been observed in the vicinity of the Devonian Mine on Olivers Hill.

The Moina Sandstone was recognized as a distinctive mapping unit by the early workers on account of the numerous "tubicular" casts which occur in many of the beds. These casts have been described by various authors, but they have no stratigraphic value. The formation is not universally fossiliferous and indeed most of the beds are barren, the tubicolar casts being restricted to certain beds within which they are exceedingly common. In addition to the tubicles or worm casts, brachiopods, gastropods and fragments of trilobites have been found on the Five Mile Rise, in the Forth River below Lorinna, in the Mersey south of Liena and at other localities. Unfortunately, none of the specimens so far found can be used as index fossils, but a correlate of the Moina Sandstone, the Caroline Creek Beds, contains a rich trilobite fauna of Tremadocian age.

The deposition of the Moina Sandstone marks a change in sedimentation from the well sorted, probably terrestrial, gravels of the Roland Conglomerate into finer grained marine sediments. The composition of the rocks and their regional distribution, thinning out as they do against the Precambrian craton, indicate that the material forming them was derived from the Precambrian rocks to the south. A shallow water environment is indicated by the faunal elements, oolites, cross bedding and well sorted sediments. The formation is strongly folded into a complex pattern of NW and easterly trending concentric folds accompanied by thrust faults.

The structure, together with the resistant nature of the rocks, exerts a strong influence on the drainage system of the areas occupied by the Moina Sandstone. All but the major streams are closely controlled by the distribution of folds, faults and major joint systems.

The formation is an important host for structurally controlled ore deposits on the Five Mile Rise and in the vicinity of Moina.

GORDON LIMESTONE.

The presence of enormous deposits of limestone in the vicinity of Mole Creek and Chudleigh has been noted since the middle of the last century. (Strzelecki, 1845, Gould, 1860, 1861; Johnston, 1888). Then, as now, the main interest in these high grade and freely accessible deposits was confined to the scenic beauty of the caves formed in them.

Gould (1866) considered that the limestone which "forms a prominent feature in the neighbourhood of Chudleigh" (i.e. Mole Creek District) should be included with the Gordon Limestones in the Lower Silurian (later known as Ordovician).

In Johnston's (1888) account of the limestone, he called it the Primordial Calciferous Group and considered it to be of Upper Cambrian age because of the apparent lack of fossils.

The Gordon Limestone occupies a large area of the flat country around Mole Creek and Chudleigh and extends westwards to Liena and Lorinna.

Around Chudleigh the limestone is very largely obscured by superficial deposits of Quaternary age, but west of Mole Creek the bedrock rises and there is stronger relief and considerable outcrop. (See Plate 3.)

The underground drainage system which has developed has resulted in the formation of cave systems which have been exploited as a tourist attraction. Apart from this and small amounts of limestone used for road dressing, this vast mass of limestone has not yet been developed economically.

Jennings (1957) discussed in detail the lithology, grade and distribution of the limestone in the Middlesex Quadrangle so that a brief discussion will suffice here.

It has been estimated that the formation exceeds 3000 feet in thickness in the Mole Creek area. The limestone is hard, compact, generally massive and frequently stylolitic. (See Plate 4.) Axial plane schistosity is well developed locally and gash veins of calcite are often present. The bedding is prominent and dips generally are low. Current bedding has been observed at 8830N/4252E. Solution weathering has etched the surface of the limestone, showing up the impure bands, sand grains, fossils and stylolites.

Although the great bulk of the limestone is high grade, some shaly and sandy bands are present towards the top of the formation at Marakoopa Caves, near Mayberry, at 8806N/4262E and in cuttings along the Forestry road leading up the Mersey Valley.

The Gordon Limestone is followed by at least 600 feet of marine sandstone, probably of Silurian age. The sedimentary basin continued to sink during Ordovician times to a total depth approaching a mile and during all this time comparatively shallow water conditions prevailed.

Although Johnston regarded the Gordon Limestone as unfossiliferous, later workers have shown that fossils are comparatively common in the Mole Creek and Chudleigh districts, and that the limestone there may be confidently correlated with the Gordon Limestone elsewhere in the State, as suggested by Gould (1866).

Banks (1957) discussed the age, palaeontology and stratigraphy of the Gordon Limestone in this and other areas.

Silurian System

ELDON GROUP (?)

At several localities in the vicinity of Mole Creek the Gordon Limestone is succeeded, apparently conformably, by a sequence of sandstone and quartzite. These rocks are considered to be of Silurian age and probably equivalent to the Crotty Sandstone of the Eldon Group.

As the rocks are lithologically similar to some members of the Moina Sandstone and contain tubicolar organisms characteristic of that formation they were assigned previously to the Moina Sandstone (Jennings, 1958). However, more recent mapping and the determination of fossils from the limestone immediately beneath these rocks showed that they are underlain by a unit high in the Gordon Limestone. Thus the possibility that the sandstone and quartzite sequence is uplifted Moina Sandstone is most unlikely. The contact of these rocks with the limestone has not been observed in the field, but the regional mapping has not disclosed any structural discordance between them.

The maximum thickness exposed is about 700 feet but the top of the sequence is missing. Along the face of the Western Tiers, in the upper reaches of Gillam Creek and along the lower part of Kansas Creek the unit outcrops boldly in thick beds of massive unfossiliferous quartz sandstone with some quartzite. In the vicinity of the Den the sandstone occupies the top of a low ridge but the outcrop is poor. The formation is also exposed in cuttings along the Forestry Road NW of Western Bluff. In this locality the rocks are brecciated fine grained sandstone and no useful information could be obtained from them.

Permian System

The main outcrops of Permian rocks occur along the face of the Western Tiers and in the Mersey Valley. Smaller isolated patches have been mapped in the vicinity of Mole Creek, Chudleigh, the Gog Range and on the Precambrian plateau SW of Lorinna.

Permian rocks were recorded in this area by Johnston (1888) but no systematic study of the sequence was made until 1954 when Wells studied the system in the vicinity of Golden Valley (Wells,

1954, 1957). Wells's work was extended and amplified by McKellar (1957) who established a similar sequence in the Poatinah area, helped by a number of diamond drill holes which penetrated most of the system. The original sequence worked out by Wells and extended by McKellar remains the basic stratigraphy for this part of the State and has been adopted for this map and report.

McKellar's sequence can be applied to this area and most of his units have been recognized in the field. However, the scale of the Middlesex Map Sheet prohibited the use of many of his formations as mapping units. The Permian System has been subdivided into four convenient units and the relationship of these units to those of McKellar is indicated below.

<i>Middlesex Map</i>	<i>McKellar (1957)</i>	<i>Approx. Thickness ft</i>
Cygnets Coal Measures and Ferntree Mudstone	Jackey Slates Ferntree Group	700
Woodbridge Glacials	Woodbridge Group	250
Liffey Standstone and Shale	Liffey Group	100
Kansas Creek Beds	Golden Valley Group Quamby Mudstone Stockers Formation	0-400

The maximum thickness of Permian rocks described is in excess of 1400 feet but it varies somewhat according to the thickness of the basal unit. However, the thickness of the sequence is fairly constant above the base of the Liffey Formation and averages close to 1100 feet. This thickness is compared below with sections measured in surrounding areas.

Thickness of Permian System in Middlesex and nearby districts

Section	Total thickness (approx.) (ft)	Thickness above Liffey Formation (ft)	Remarks
Middlesex Quadrangle (Tiers)	1400	1050	
Wells (Golden Valley)	1830	1095	Using Banks's (1958) figures for Liffey.
McKellar (Tiers near Poatinah)	2200	1182	Assuming 140 ft for Jackey Shales, which may be excessive.
Ford (Mersey Valley)	1344	1027	Probably excludes the Cygnets Coal Measures.
MacLeod <i>et al.</i> (Du Cane)	2000	1200	Includes up to 300 ft of Cygnets Coal Measures.

If the Cygnet Coal Measures, which are variable in thickness and difficult to define accurately, were excluded from these sections the combined thickness of the Liffey, Woodbridge and Ferntree Formations would be roughly constant over a wide area surrounding the Middlesex Quadrangle.

The Permian rocks dip gently to the SE and rest unconformably on a tightly folded basement of Lower Palaeozoic or Precambrian rock. Phenoclasts in the numerous conglomeratic horizons within the system can generally be related to formations in the Lower Palaeozoic units or the Precambrian basement.

No demonstrable tillite is present in the area and the formation name Woodbridge "Glacials" as used here is a correlative rather than a generic term. The basal beds generally consist of clean, well sorted, breccia conglomerate, although the unit becomes less well sorted toward the east in the direction of Wells's type area for the Stockers Tillitic Conglomerate. Toward the south the basal beds are still conglomerate as shown by MacLeod *et al.* (1961) but glacial sediments at the base of the system occur further south still in the vicinity of Mt Arrowsmith.

Similarly the Cygnet Coal Measures show broad regional facies changes which were not seen within the area mapped. MacLeod *et al.* (1961) indicated that south of the Middlesex Quadrangle this unit becomes thicker and includes thicker and more persistent coal seams though they are still sub-economic. East of the Quadrangle the unit persists with a similar thickness at least as far as Poatina but the coal seams are missing, although plant fragments and carbonaceous remains are still common. Further east still the Cygnet Coal Measures and its correlates appear to be missing altogether and the Triassic System disconformably succeeds the Permian rocks.

The abundance of pebbly and conglomeratic mudstone and siltstone in the Permian System provides a problem in sedimentation which has not been satisfactorily explained. If, as has been widely accepted, glacial conditions prevailed in nearby areas during the deposition of these sediments, this must have influenced the deposition considerably at certain times. Petrologically, many of the rocks have a greywacke matrix and a disrupted framework is common to many of the formations. The influence of turbidity currents on deposition has not been studied fully here but it must be considered as a probable factor.

The system is made up broadly of two thick marine sequences separated and overlain by two freshwater sequences.

KANSAS CREEK BEDS

The type section for this unit is exposed in the bed of Kansas Creek between elevations 2150 feet and 2500 feet above sea level. The heights quoted have been established by controlled aneroid readings but are subject to variations of up to 50 feet. The section as measured by Banks is given in detail by Ford (1960). It consists essentially of about 50 feet of basal conglomerate overlain by 60 feet of uniform pebbly siltstone and then by more than 200 feet of richly fossiliferous limestone, siltstone and sandstone containing abundant erratics.

The Kansas Creek Beds include several of McKellar's (1957) formations as tabulated below:—

<i>Middlesex Map</i>	<i>McKellar (1957)</i>	
Kansas Creek Beds	Golden Valley Group	{ <ul style="list-style-type: none"> McRae Mudstone Billop Sandstone Brumby Formation Quamby Mudstone Stockers Tillitic Conglomerate

Apart from the Stockers Tillitic Conglomerate which is here represented by a well sorted quartz conglomerate, all McKellar's formations may be recognized in the Kansas Creek section. For the most part the basal conglomerate is well sorted and contains fragments of Precambrian and Lower Palaeozoic rocks in a subordinate siliceous matrix. Towards the eastern edge of the Quadrangle the matrix becomes more abundant but no demonstrable tillite has been observed anywhere. The basal beds of the formation are always conglomeratic, but since the Permian System was laid down on a surface which locally had significant relief the various formations wedge out against topographic highs in the basement. The basement may transgress as high as the Liffey Formation but even at such places a thin basal conglomerate is always present.

BASAL CONGLOMERATE

At Gibsons Sugarloaf, Dairy Plains (87655N/44700E) the unconformity below the Permian is exposed. The conglomerate overlies limestone with a 60° discordance in dip and it consists of rounded boulders of Precambrian quartzite, Cambrian lavas and Ordovician limestone in an abundant siltstone matrix. The bottom 6 inches has a clay matrix derived from the underlying limestone. In the bed of an adjacent creek the formation contains plant fragments. The total thickness is about 30 feet.

The unconformity is also exposed on Kelly's Farm at South Mole Creek in the cliffs above a cave entrance. At the Waterworks, South Mole Creek, the unconformity is exposed above a cave entrance several hundred yards downstream from the intake and west of the pipeline. The basal conglomerate is 12 inches thick and is composed of sub-rounded quartzite pebbles averaging $\frac{3}{4}$ inch in size together with tabular black phyllite phenoclasts up to 3 inches long and a quarter of an inch thick, in a matrix of quartz and rock fragments of sand grade. This is overlain by 14 inches of sandstone composed of 90% clay with quartz and rock fragments (mostly phyllite) up to one tenth of an inch. The sandstone is unfossiliferous and green in colour; the larger fragments are sub-rounded and equant whilst the phyllite is in flakes. The rock is tough with incipient horizontal partings.

Boulders of basal conglomerate containing *Eurydesma* were found overlying Ordovician limestone at 8739N/4400E. On the Gog Range small outliers of basal conglomerate occur. The following description of these outcrops was supplied by Burns.

"The unconformity is of about 15°, and is particularly well exposed at 8888N/4361E, but it may prove difficult to locate. It was discovered by accident in reconnaissance of the Gog Range.

The small tarns on the summit are related to the unconformity. The constituent boulders of the conglomerate above the unconformity are recognizable as a distinctive quartzite which forms the immediate bedrock. There is no bedding, but the grain size varies from sandstone to coarse angular boulders. In common with similar rocks at the Little Horn and Mt Emmett, the rock is polymodal, the three modes being apparently: (a) highly angular boulders of low sphericity and pink colour, ranging from 1 inch to 2 feet in diameter, averaging 3 inches (this mode forms from 0-50% of the rock); (b) white, angular quartzite, equant, of medium sphericity, ranging from 1/10 inch to 1/2 inch in diameter, averaging 1/4 inch (this is about 30% of the rock); (c) fine grained siliceous matrix, no feldspar (this forms from 30% to 60% of the rock). The various lithologies are combinations of these modes in differing proportions. The rock is well indurated, unjointed, and without fossils."

The outcrop of basal conglomerate on the plateau to the west of the Forth River is about 20 feet thick and a chain or so long. It consists of fragments of Precambrian quartzite and tillite set in a sand-grade siliceous matrix and rests unconformably on the Precambrian rocks in that vicinity but lacks their tectonic fabric and abundant quartz veining.

TASMANITE HORIZON

Although no known outcrops of tasmanite oil shale are known in the Middlesex Quadrangle, farmers in the vicinity of Chudleigh have reported ploughing up boulders of shale in paddocks. The oil shale is exposed at Gibsons Sugarloaf (8766N/4469E) just east of the Quadrangle boundary and was at one time quarried there. It occurs about 30 feet above the basal unconformity. In other sections along the base of the Tiers west of that point the tasmanite is absent and Burns (pers. comm.) suggested that the approximate western limit of the shale is about grid line 440 East. Beyond this it laps onto the basement and is cut out.

QUAMBY MUDSTONE

At the Mole Creek Waterworks the basal conglomerate is overlain by a blue mudstone with shaly partings, spheroidally weathered, containing sub-rounded pebbles of quartz-mica schist averaging 1/2 inch but up to 3 inches in diameter. About 100 feet above the base another conglomerate occurs and about 10 feet above this again fossiliferous mudstone (Brumby Formation) occurs. The total thickness exceeds 180 feet. At 8775N/4299E the mudstone is poorly exposed and about 140 feet thick. It appears to interfinger with the basal conglomerate to the west (Burns, pers. comm.).

In Kansas Creek and in other localities in the vicinity of Western Bluff the formation is represented by grey siltstone, sometimes with shaly partings, which contains scattered erratics of Fisher and Howell Group rocks and occasionally boulders of Dove Granite. Uncontrolled aneroid readings indicate thicknesses of up to 180 feet.

BRUMBY FORMATION

In the vicinity of Gibsons Sugarloaf at 8759N/4466E there are exposures of highly fossiliferous blue micaceous shale in the road cuttings. They are probably Brumby Formation rocks and contain abundant stenoporids, spiriferids, productids, fenestellids and crinoid stems.

On the bank of Western Creek about 50 yards south of the quarry at 8723N/4460E, marl is exposed over a vertical thickness of about 100 feet. The rock is a blue shale containing abundant rounded quartzite pebbles averaging about one inch in diameter; one pebble of Gordon Limestone was observed. The micaceous shale contains lenticular bands of fossiliferous limestone up to 20 feet long and 12 inches thick which yields spiriferids and stenoporids (Burns, pers. comm.).

Pebbly fossiliferous mudstone with bands of conglomeratic feldspathic siltstone, correlated with the Brumby Formation, was mapped in the vicinity of Westmorland Falls at South Mole Creek and in the Marakooopa Creek. The formation is also well exposed in cuttings along a Forestry road near the crossing of Kansas Creek as well as in the creek itself. Banks's description, given by Ford (1960), details this section.

BILLOP SANDSTONE

Overlying the Brumby Formation in Kansas Creek is a small but unknown thickness of sparsely fossiliferous mudstone and conglomerate which is considered to be equivalent to the Billop Sandstone. The phenoclasts are large (up to 18 inches), angular to sub-rounded and locally derived.

In Western Creek the Billop Formation, whilst not well exposed, forms a bench at an elevation of about 1050 feet a.s.l. It is probably less than 20 feet thick.

MACRAE MUDSTONE

This formation is represented in Kansas Creek by more than 100 feet of grey pebbly siltstone. Toward the top the pebbles are small, quartzose and well rounded, but at the bottom of the unit large boulders of Dove Schist (up to 12 inches long) are present. Some brachiopods and bryozoa have been observed but they are not abundant. At Western Creek the formation is about 190 feet thick and occurs roughly between elevations 1070 and 1250 feet a.s.l. The lower part consists of cream to buff siltstone with a few rounded quartz pebbles whilst the top is a micaceous shaly siltstone which is transitional with the overlying Flat-top Sandstone. In the west branch of the creek at Westmorland Falls at about 1700 feet a.s.l. the formation is represented by feldspathic pebbly siltstone. In the east branch of this creek, mudstone at elevation 1550 feet and pebbly mudstone at 1680 feet a.s.l., immediately underlying the Liffey Group, are correlated with the McRae Mudstone.

LIFFEY GROUP.

This unit was called Liffey Sandstone by Wells (1954, 1957), and Liffey Group by McKellar (1957) who sub-divided it into four formations as tabulated below:—

Group	Formation	Lithology	Thickness (ft)
Liffey	Creektion	wormcast sandstone	10
	Woodside	sandstone	35
	Kopanica	shale and sandstone	15
	Flat-top	sandstone	30

The total thickness of 90 feet given by him is similar to the thicknesses recorded for this formation around the face of the Tiers in the Middlesex Quadrangle. The unit outcrops well and forms a prominent bench, and is an important marker horizon. The absence of marine fossils and the presence of carbonaceous material indicate a freshwater environment for its deposition in contrast to the marine sediments of the formations above and below. It is composed of clean well sorted quartz sandstone and carbonaceous siltstone and has been mapped over much of the northern face of the Tiers. Whilst the individual units within the formation have been recognized locally they are too thin to be indicated on a map of this scale. Descriptions of McKellar's units at various localities are given below.

FLAT-TOP SANDSTONE

On the timber track up the Western Tiers near Western Creek at an elevation of 1250 feet a.s.l., the McRae Mudstone is overlain by a medium grained sparkling quartz sandstone correlated with the Flat-top Sandstone. Similar sandstone occurs at about 1680 feet a.s.l. in the east branch of the creek at Westmorland Falls.

In Kansas Creek the Flat-top Sandstone is about 40 feet thick and consists of clean, massive, medium-grained quartz sandstone with cross-bedding.

KOPANICA SHALE

This is represented by the finely laminated grey micaceous siltstone about 20 feet thick which overlies the Flat-top Sandstone in Kansas Creek. The top of the formation is formed by 5 feet of massive grey siltstone. Cross bedding is common.

WOODSIDE SANDSTONE and CREEKTON SANDSTONE

Above the Kopanica Shale in Kansas Creek the following sequence, which probably includes both of the above formations of McKellar, is exposed.

<i>Aneroid Elevation (ft)</i>	<i>Lithology</i>	<i>Thickness (ft)</i>
2590	Grey and black silty shale (Meander Mudstone?)	...
2570	Thinly bedded, fine-grained sandstone	...
	Gap	5
	Thin bedded, fine yellow sandstone	4
	Gap	10
2550	Yellow, medium grained sandstone	10
	Yellow, micaceous, thin bedded, fine sandstone	15
	Massive yellow sandstone	5
	White pebbly grit	1
	Massive, medium-grained yellow sandstone	5
	Massive grey siltstone	5
2510	Finely laminated siltstone (Kopanica Shale?)	...

On the section up the timber track near Western Creek the uppermost beds in the Liffey Group consist of fine to coarse sandstone with flaggy bedding and conglomerate bands containing phenoclasts up to 6 inches in diameter. These rocks lie at an elevation of about 1310 feet. At about 1560 feet a.s.l. on the face of the Western Tiers below Lady Lake there is a small bench with a waterfall over carbonaceous sandstone. Boulders of quartz sandstone containing worm casts may be found nearby.

The top of the Liffey Group in the east branch of the creek at Westmorland Falls is located at an elevation of 1850 feet. It consists of fissile micaceous sandstone containing plant remains. At a similar elevation in the west branch of the creek there are outcrops of fissile micaceous siltstone with massive quartz sandstone and a band of conglomerate 2 feet thick.

In none of the exposures detailed above were any marine fossils observed, but carbonaceous material and plant remains are fairly common.

WOODBRIDGE "GLACIALS"

This unit corresponds with McKellar's Woodbridge Group which he sub-divided into three formations as tabulated below:—

<i>Group</i>	<i>Formation</i>	<i>Thickness (ft)</i>
Woodbridge	Weston Mudstone	30
	Dabool Sandstone	40
	Meander Mudstone	195

Some doubt exists concerning the validity of the name Woodbridge as it is not certain that the rocks referred to this unit here and by McKellar and Wells further east can be correlated with the rocks originally described at Woodbridge by Voisey (1938). Banks (1962) used the term Malbina Formation. As used here the name refers to the Woodbridge Group as defined by McKellar and does not necessarily imply correlation with Voisey's unit.

The presence of abundant erratics in the unit possibly indicates that glacial conditions prevailed in the surrounding areas during its deposition. Its average thickness along the north face of the Western Tiers is about 250 feet. The Weston and Dabool Formations often outcrop well and are useful mapping units but the underlying Meander Mudstone rarely outcrops and is lithologically similar to many of the other unfossiliferous mudstones in the Permian system.

The sequence indicates a return to marine conditions following the terrestrial sedimentation of the underlying Liffey Group. The Meander Mudstone is only sparsely fossiliferous but the upper formations are exceedingly rich in marine fossils, chiefly robust brachiopods and bryozoa. Although outcrops generally are fragmentary, all three of McKellar's formations have been recognized in various parts of the Middlesex Quadrangle. The main outcrops are noted below:—

MEANDER MUDSTONE

This formation is by far the thickest of the Group, but it has been seen only in isolated outcrops. In Western Creek between elevations 1310 and 1475 feet a.s.l. there are a few outcrops of a buff coloured spheroidally weathered mudstone which contains a few pebbles but no fossils. It is estimated to attain a total thickness of about 165 feet.

In the west branch of the creek near Westmorland Falls at an elevation of 1960 feet, a mudstone containing many pebbles of quartz, and one of Gordon Limestone, is referred to this unit. It contains abundant spiriferids. Talus blocks and small outcrops of spheroidally weathered, pebbly, unfossiliferous mudstone, grey when fresh but weathering to a buff colour, occur commonly on the steep slopes of the Tiers above the bench formed by the Liffey Group. These are correlated with the Meander Mudstone and indicate its presence in the vicinity.

DABOOL SANDSTONE

This consists of grey, sometimes green, silty sandstone which is richly fossiliferous with a predominantly brachiopod fauna. The base of the formation is not exposed clearly anywhere and the precise thickness is unknown but it appears to be about 20 feet.

In the Western Creek section the formation consists of green, feldspathic sandstone containing pebbles of quartz, carbonaceous material and shell fragments. It is richly fossiliferous, particularly in spiriferids. In Kansas Creek the boundary of the Dabool Sandstone and the overlying Weston Mudstone is exposed. The Dabool Sandstone consists of well bedded, blocky, grey, silty sandstone with numerous pebbly and marly bands. The marly bands are formed by the abundance of shell fragments and well preserved robust brachiopods together with some bryozoa. Some shaly bands are present.

WESTON MUDSTONE

In Kansas Creek at elevation 2660 feet a.s.l. the Dabool Sandstone passes upwards conformably into a pebbly bryozoal mudstone. The full thickness of this formation is not exposed but it appears to be at least 60 feet. A small fault striking at 060° and downthrowing to the north disrupts the section at 2720 feet.

The Weston Mudstone is distinguished from the Dabool Sandstone by a decrease in grain size from silty sandstone to mudstone and by a change from a fauna dominated by brachiopods to one dominated by bryozoa. Both formations contain abundant erratics.

At an elevation of 1485 feet in Western Creek this unit is 40 feet thick and consists of brown, finely laminated shale without erratics or brachiopods but containing abundant bryozoa, chiefly fenestellids (Burns, pers. comm.).

FERNTREE MUDSTONE AND CYGNET COAL MEASURES

The rocks united under this heading are well exposed at many places along the Tiers. Although the restrictions imposed by the map scale have made it necessary to combine these two units, it was possible to identify McKellar's formations in some of the sections measured. McKellar considered the freshwater sandstone and shale (Jackey Shale) which overlie the Ferntree Group, as belonging to the Triassic System. Samples of coal from beds tentatively correlated with the Jackey Shale were submitted to the C.S.I.R.O. Coal Research Section for analysis and the result (given as an appendix to this report) indicates that they are upper Permian in age.

On this evidence, McKellar's Jackey Shale is correlated with the Cygnet Coal Measures of Johnston (1888) and Voisey (1938). The stratigraphic sequence of the upper Permian beds in this region, as used here and by McKellar is set out below:—

<i>Period</i>	<i>McKellar (1957)</i>	<i>Middlesex Quadrangle</i>														
Triassic	Ross Sandstone Jackey Shale disconformity	Ross Sandstone Transition Cygnet Coal Measures (= Jackey Shale)														
Permian	<table border="0" style="margin-left: 20px;"> <tr> <td style="vertical-align: middle;">Ferntree</td> <td rowspan="2" style="font-size: 3em; vertical-align: middle;">}</td> <td style="padding-left: 10px;">Eden Mudstone</td> <td rowspan="6" style="vertical-align: middle;">} Ferntree Mudstone</td> </tr> <tr> <td></td> <td style="padding-left: 10px;">Blackwood Conglomerate</td> </tr> <tr> <td></td> <td style="padding-left: 10px;">Drys Mudstone</td> </tr> <tr> <td></td> <td style="padding-left: 10px;">Palmer Sandstone</td> </tr> <tr> <td style="vertical-align: middle;">Group</td> <td style="padding-left: 10px;">Springmount Mudstone</td> </tr> <tr> <td></td> <td style="padding-left: 10px;">Garcia Sandstone</td> </tr> </table>	Ferntree	}	Eden Mudstone	} Ferntree Mudstone		Blackwood Conglomerate		Drys Mudstone		Palmer Sandstone	Group	Springmount Mudstone		Garcia Sandstone	
Ferntree	}	Eden Mudstone		} Ferntree Mudstone												
		Blackwood Conglomerate														
	Drys Mudstone															
	Palmer Sandstone															
Group	Springmount Mudstone															
	Garcia Sandstone															

The best section through the upper part of the sequence is exposed in the top of Marakoopa Creek. Details of this section are set out below:—

<i>Formation</i>	<i>Lithology</i>	<i>Thickness</i>		<i>Aneroid Elevation</i>
		ft	ins	ft a.s.l.
Ross Sandstone	Massive yellow, medium grained sandstone	250	+	
	Micaceous sandstone with minor shale and siltstone bands			
Cygnet Coal Measures	Grey micaceous, banded claystone and shale	?		3610
	Yellow quartz sandstone	25		
	Impure coal		4	3585
	Grey micaceous siltstone with thin sandstone bands	5		
	Impure coal		4-6	3580
	Shale	10		
	Grey banded, and thinly bedded, micaceous, yellow sandstone	8		
	Grey micaceous siltstone with thin sandstone bands, upper portion frets readily, bottom massive	15		
Massive, grey, sandy siltstone grading into banded grey shale with sandstone	10			
Grey siltstone and shale	35			

Formation	Lithology	Thickness ft ins	Aneroid Eleva- tion ft a.s.l
Eden Mudstone	Interbedded grey mica- ceous siltstone and mudstone in beds 15 inches thick spheroid- ally weathered	?	
Blackwood Conglomerate	Coarse grit and quartz conglomerate	2	
	Grey micaceous siltstone and yellow current bedded sandstone in beds 12 inches thick	4	
	Talus	10	
	Mudstone	2	
	Shaly siltstone	2	
	Blocky, sandy mudstone	3	
	Sandy siltstone, frets easily	4	
	Spheroidally weathered mudstone	3	
Drys Mud- stone	Blocky mudstone, occa- sional erratics spheroid- ally weathered	3	
	Hard, grey mudstone and siltstone in beds 2 feet thick separated by 12- 18 inches shale bands, occasional erratics	70	
	Mudstone—Small fault bearing 135° dipping SW	50	3360
	Hard fine grained sand- stone interbedded with grey siltstone	45	
? Palmer Sand- stone	Massive, medium to fine grained quartz sand- stone	20	
	Hard, dense mudstone with thin shaly part- ings along bedding	90	
Springmount Mudstone	Talus	45	
	Top of high waterfalls in uniform blocky mudstone	?	3080

If the correlation with the Palmer Sandstone is correct, it appears that the Drys Mudstone here is somewhat thinner than given by McKellar. However, some of the thicknesses given are based on uncontrolled aneroid readings and at least one fault occurs in the section. The total thickness given must therefore be treated with reserve.

In the vicinity of Western Creek, Burns (pers. comm.) recorded the following sequence: —

<i>Aneroid Elevation (ft a.s.l.)</i>	<i>Lithology</i>
2630	Sandstone (probably Triassic). Gap with talus
1995	Possible top of Drys Mudstone, boulders of Blackwood Conglomerate on a small bench
1935	Possible fault striking NW
1820	Base of Drys Mudstone. Dense, tough, blue mudstone, spheroidally weathered, in 6 inch beds, no erratics or fossils, weathers to soft blue shale. Thickness exceeds 175 feet.
1815	Base of Palmer Sandstone. Massive, cream to buff feldspathic sandstone with occasional erratics and bands of quartz pebbles. Enclosing formations increase in grain size toward the boundaries. Erratics less than 1%, quartz and mica schist. Thickness 5 feet.
1565	Base of Springmount Sandstone. Dark blue micaceous mudstone with rare rounded quartz pebbles averaging $\frac{1}{2}$ inch. Tough, no fossils, no siliceous bands except near top. Thickness, about 250 feet.
1525	Base of Garcia Sandstone. Forms a small cleared bench. Cream feldspathic sandstone at base with occasional sub-rounded quartzite pebbles. A 10 foot shale band in the middle and a sparkling quartz sandstone at the top. Fossils rare. Thickness 40 feet.

In the top of Kansas Creek the Permian rocks are almost totally obscured by dolerite talus. An outcrop at 2835 feet a.s.l. of medium grained feldspathic sandstone containing numerous erratics and some brachiopods is probably the Garcia Sandstone. Above this the few scattered outcrops of mudstone with occasional erratics may be assigned to the Springmount Mudstone.

The following section measured by Burns in the upper part of the east branch of Westmorland Creek is of interest as it infers that the Cygnet Coal Measures are missing there and that the Triassic System follows the Permian disconformably. This is in direct contrast to the well exposed sequence of Marakoopa Creek which indicates conformity and transition, but it supports the view of shallowing conditions, during Cygnet time, toward the east.

<i>Aneroid Elevation ft a.s.l.</i>		<i>Thickness ft</i>	<i>Lithology</i>
	Triassic	20	Quartz sandstone, crossbedded in 2 feet sets, currents from the north.
		5	Coarse arenite with angular quartz (1/10 inch) less than 10% clay matrix.
		10	Soft yellow lutite with mud flakes, 10% sand, no bedding but fine horizontal partings.
		5	Green sandstone, massive, coherent, with mud flakes. Disconformity of 1 inch in 3 feet at base. Conglomeratic at base.
2480	Permian		Blue micaceous mudstone.
2400			Fine arenite, 50% feldspar.
2300			Fine lutite, blue, occasional mica flakes, hard, spheroidally weathered, 2 inch beds.
2210			Dry Mudstone. Jointing strikes 320° and 50°.

End of traverse

Triassic System

The Permian sequence is succeeded along the Western Tiers by up to 1100 feet of quartz sandstone and feldspathic sandstone and shale. No fossils have been found in these rocks but they are considered to be Triassic as they overlie known upper Permian rocks and exhibit typical Triassic lithologies.

The Triassic rocks pass downwards conformably and transitionally into upper Permian rocks under Western Bluff but in Westmorland Creek a disconformity may be present. They are terminated above everywhere by Jurassic dolerite intrusions. From the lithological assemblages present it is considered that correlates of the Ross Sandstone and Cluan Formation of McKellar (1957) are present.

Although the Triassic rocks generally are massive and resistant to weathering, the shale and siltstone beds and the more micaceous sandstone are easily eroded and are marked by landslip scars. The system forms a distinct bench, covered by dolerite talus, which may be followed readily on air photos.

The lack of fossils and marker beds within the system makes it difficult to fix the base of the Triassic accurately. For the purpose of this work the base has been taken arbitrarily at the base of the first massive sandstone unit above the upper coal seam in the section at the top of Marakoopa Creek (p. 69).

ROSS SANDSTONE

At Western Bluff the Cygnet Coal Measures are succeeded by at least 250 feet of massive quartz sandstone and feldspathic sandstone. Toward the base of the formation micaceous shaly sandstone and siltstone occur interbedded with the more massive units. The

presence of Triassic rocks along the Tiers has been deduced largely from the physiography and the presence of sandy soil, landslip scars and sandstone boulders.

In the first creek to the west of Mother Cummins Peak (just east of the map boundary) Burns (pers. comm.) reported that the top of the Ross Sandstone occurred at 3000 feet a.s.l. He described the formation as massive sandstone with torrential crossbedding and laminated siltstone, and estimated the thickness as between 420 feet and 600 feet. Shale bands were noted at 40 feet and 120 feet from the top of the unit and grit bands at 370 feet and 280 feet, also from the top. The formation also occurs in the Mersey Valley under Clummer Bluff and in the headwaters of the Fish and Little Fish Rivers (MacLeod, *et al.*, 1961). No beds lithologically similar to the Gould Formation of MacLeod *et al.* (1961) were noted anywhere in the Middlesex Quadrangle.

UNASSIGNED TRIASSIC ROCKS

Sandstone and shale overlying the Ross Sandstone north of Lake McKenzie and just west of Mother Cummins Peak appear to be sufficiently distinctive to warrant separation from the Ross Sandstone. They are considered to be correlates of the Cluan Formation of McKellar (1957). The best section is that west of Mother Cummins Peak. Burns's description of the section is given below.

<i>Aneroid Elevation (ft a.s.l.)</i>	<i>Thickness (ft)</i>	<i>Lithology</i>
3140	50	Flaggy bedded shale, buff, fissile, with micaceous partings; Dip E at 15°. Highest portion hard and perhaps metamorphosed.
	10	Banded green and white sandstone, highly feldspathic with micaceous bands and clay pellet conglomerate and a dense green quartzite. Dip E at 15°.
	18	Brown feldspathic shale, flaggy bedding.
	2	Sandstone.
	18	Brown feldspathic shale, flaggy bedding.
	30	Cross bedded, siliceous sandstone.
	10	Shale.
3000	?	Ross Sandstone.

Tertiary Deposits

Sub-basaltic Tertiary deposits consisting of small thicknesses of plastic clay, sand and gravel, have been mapped on the northern end of Maggs Mountain, on the hills SW of Liena and to the north of Chudleigh. The outcrops are small and the boundaries usually indefinite due to the prevalence of landslips caused by the mobility

of the clay beds. They probably occur much more widely underneath the basalt than the geological map indicates. The deposits are of two types:—

- (1) Gravel and breccia representing the gravel, soil and talus of pre-basaltic river valleys. The Tertiary beds described by Spry (1958) at the north end of Maggs Mountain seem to be of this kind.
- (2) Well sorted and stratified sands and clays deposited in ephemeral lakes caused by damming of drainage channels by basalt flows. They occur widely beneath the basalt and probably also between flows.

SW of Liena the basalt is underlain by waterlogged plastic white clays which are characteristic of the lake deposits.

Tertiary beds occur on the hills north of Chudleigh between the basalt and Moina Sandstone though paucity of exposure and confusion of the Tertiary deposits with material derived from weathering of the underlying sandstone prohibits any useful account of these rocks.

The Tertiary deposits seem to have undergone little diagenesis but as the outcrops are invariably situated in areas subject to landslips they have usually suffered some post-depositional deformation and cannot be considered as representative of the deposits in situ.

Quaternary Deposits

As a result of glaciation and prolonged sub-aerial erosion on an area of high relief, large areas of the Middlesex Quadrangle are covered with superficial deposits.

Where possible a distinction has been made between scree and talus accumulations. The term "scree" is used here for open accumulations of rock fragments shed by ice wedging and frost action from overlying cliffs. Such deposits contain little or no matrix. The term "talus" has been used to describe the more extensive deposits of rock fragments, weathered rock and soil occurring usually downslope of the scree fields. A distinction of this kind is difficult to maintain over an entire map sheet and in practice the distinction applies only on the steep slopes underlying the dolerite sill and on the south facing slopes of the Gog Range.

GLACIAL DEPOSITS

Varves occur at several points in the Forth Valley between the Dove sawmill and Lorinna and also in the upper Arm Valley, as described by Spry (1958). Varved sediments were recovered in drill cores by the Hydro-Electric Commission from the vicinity of Lemonthyme Creek.

The thickest exposures are in the Forth Valley at the road crossing of Addisons Creek south of Lorinna where they are about 100 feet thick. At the bottom of the cuttings near Addisons Creek several lenses of dense limestone several feet long and up to a foot thick were exposed. The fine banding in the enclosing varved silty clay passed through the limestone lenses without interruption. When freshly exposed in this locality the varves showed minor

folding which appeared to be more in keeping with compaction folding than ice ruckling. A few pebbles of fresh dolerite and basalt were extracted from the varves. Burns (pers. comm.) noted varve-like sediments in caves in the Gordon Limestone north of the Western Tiers.

The valley floors of the upper Arm, Forth and Mersey Rivers carry heavy accumulations of glacial drift. The best exposures of this material may be seen at various points along the Mersey River (Plates 5 and 6). The deposits consist of poorly sorted boulder clay containing angular and sub-rounded fragments almost exclusively of dolerite in a matrix of weathered rock flour.

Spry (1958) gave a mechanical analysis of a sample from the Mersey River north of the H.E.C. Hydrometric Station and showed that most of the finer material was the result of the disintegration of a dominantly dolerite terrain.

It may be inferred from the large number of sub-rounded cobbles and boulders that much of the material has been subjected to fluvial action and was probably deposited from meltwater streams under and in front of the glaciers. Plate 7 shows a pocket of well sorted alluvium in Pleistocene till from the Mersey River.

The varve deposits in the Arm River are overlain by drift containing fairly abundant sub-rounded boulders. This appears to be better sorted than most of the deposits in the Mersey Valley. In the Fish River the varved clays are overlain by and interbedded with 200 feet of boulder clay (MacLeod *et al.* 1961) in which the phenoclasts all show some degree of rounding (Threader, pers. comm.). Thus it must be accepted that these deposits often do not exhibit the features of true ground moraines. They are poorly sorted but contain abundant waterworn pebbles and wherever good sections are available they show bedding. It is suggested therefore that most of the valley glacial deposits have been reworked during and probably since the retreat of the glaciers. The deposits are best termed drift in the sense defined by Cotton (1945).

Despite the prevalence of waterworn pebbles in the drift it is clear that the glaciers at times carried heavy loads of ground moraine. Ice abraded sub-glacial pavements and roches moutonnées (Plate 1) in the Mersey and Forth Valleys present abundant evidence of sub-glacial erosion.

The following description of glacial deposits in the Lake McKenzie area is modified from Mather (1956).

On the plateau much of the lower country adjacent to and in the beds of lakes and rivers is covered by till. The material consists of ill-sorted boulder clay ranging from clay size particles up to blocks of dolerite 10 feet across. At the surface it is usually poorly consolidated, probably indicating surface weathering, whilst at shallow depths in test pits and in stream beds it is quite firmly cemented. Hills (1922) described the material from test pits near Lake McKenzie as "mudstone" to emphasize this point. In the 40 years which have elapsed since Hills inspected it, the "mudstone" on the dumps still retains its well cemented character.

Terminal moraines backed by bedded deposits of sand and clay were noted at 4365N/8682E and there is evidence for an extensive moraine-dammed lake over what is now flat country between Lake McKenzie and Lake Balmoral.

At various places on the plateau there are deposits of dolerite blocks ranging in size from 6 inches up to several feet in diameter and completely lacking matrix. These may be relict tills from which the matrix has been flushed out or perhaps periglacial deposits formed during the waning phases of glaciation (the conglifractates of Davies, 1958).

OTHER PLEISTOCENE DEPOSITS

On the northern slopes of the Tiers heavy dolerite talus accumulations generally do not extend much below the Ross Sandstone bench although they may extend down as far as the Liffey Group. For the most part the escarpment displays the characteristic stepped appearance from which its name was derived and which is due to differential weathering of the various Permian formations.

However, there are areas where the topography sweeps uniformly from the top of the escarpment to the frontal plain in huge, roughly fan-shaped "rock glaciers" composed almost exclusively of dolerite detritus. The most striking of these features falls 2000 feet from the scree fields just below the dolerite sill to the limestone plain between Western Creek and Dale Creek.

Burns (pers. comm.) prepared the following notes on superficial deposits on the plains around Mole Creek.

"Piedmont fans of Permian, dolerite and older rocks coalesce as flat sheets covering the valley floor. These fans are ancient, as at Mole Creek township and in the vicinity of Sassafras Creek (8855N/4305E) the present drainage has cut through them to expose limestone bedrock. At South Mole Creek (8790N/4365E) there are signs of post-Pleistocene (?) rejuvenation in the appearance of sinkholes in the plain sediments. This process is much more advanced at Lorinna (8843N/4124E; 8845N/4120E) in similar circumstances. This pattern with sinkholes developing in the headward region, and limestone pavement exposed near the mouth of modern streams such as Mole Creek, indicate that the profile of aggradation was steeper than the profile of the modern eroding streams, which there are frequently subterranean as is to be expected".

SCREE AND TALUS DEPOSITS

The dolerite scree-fields have been indicated separately on the geological map and their origin is discussed under the section dealing with physiography, and elsewhere. Talus accumulations consisting largely of quartzite and conglomerate occur extensively along the southern slopes of the Gog Range and around the flanks of Standard Hill. Part of the material may be glacial drift distributed from a small ice cap on Mt Roland (Jennings, 1958).

Extensive talus deposits and landslip masses occur around the edges of the basalt areas. Where possible the heels of the landslip blocks have been indicated. The presence of the slips and the widespread talus accumulation is due to the presence of the sub-basaltic clays providing a suitable slip plane and to the closely spaced joint system in the basalts which facilitates rapid disintegration of the slip masses. Unlike the dolerite scree fields the basalt talus is invariably accompanied by sufficient soil to make it sought after for farming purposes.

RIVER ALLUVIUM

The most extensive areas of alluvium occur along the lower reaches of the Mersey River downstream from Liena and along the flood plains of creeks in the Mole Creek district. At Liena the river gravels exhibit well marked imbricate texture (Plate 8) and are bedded. The river at this point is actively eroding these gravels and their age is therefore somewhat uncertain. It is quite possible that the material which is so well exposed on the west bank of the Mersey at the Liena bridge could be fluvio-glacial material of Pleistocene age.

A complicated set of river terraces occurs along the Mersey River and these have been described by Spry (1958) and Rundle (1958).

In the Forth Valley, alluvium is much less plentiful and no important accumulations are present north of the bridge leading to the Dove saw mill except for the minor development of a flood plain thinly covered by alluvium over the limestone area in the vicinity of the Lorinna bridge.

IGNEOUS ROCKS

Cambrian Keratophyre

As these lavas are intimately associated with the Cambrian sediments they have been discussed under the section dealing with the Cambrian sedimentary rocks (p. 51).

Devonian

LONE PINE GRANITE

This tiny intrusion was discussed by Reid (1919b) under his section dealing with muscovite-biotite granites. Since the time of Reid's visit the prospects in and around this granite have been neglected and the exposures which were available to Reid are now obscured. The only worthwhile outcrops of the granite occur along cuttings in the Forth track over a length of about a chain. In the vicinity of the granite, boulders of pegmatitic granite and greisen may be found on the surface. The porphyroid "dykes" noted by Reid are considered to be hornfelsed sediments as discussed earlier (p. 38). The pegmatitic granite consists of crystals of milky quartz up to 2 inches long intergrown with crystals of kaolinized feldspar. The greisen consists of a fine intergrowth of quartz and white mica together with large crystals of milky quartz. The specimens of greisen appear to have come from a narrow vein.

Reid noted that aplite and pegmatitic phases occur and that greisenization of the granitic wall rock is common. He stated that in general the granite is a light to dark grey rock consisting of quartz, orthoclase and muscovite.

The granite is associated with several small quartz veins which in the past were prospected for tin and wolfram.

DOVE GRANITE

This granite outcrops in three places along or near the Precambrian-Lower Palaeozoic unconformity. Features of the granite are its variation from place to place, the presence of roof pendants and its complicated outcrop pattern in fine detail. From the relationship of the granite outcrops to the topography it appears that only the top of the granite is exposed and that many of the exposures represent marginal phases.

Both the Mersey and Dove Rivers have been deflected by the granite masses along their courses and the present cycle of erosion has not yet advanced sufficiently to smooth out the effects of differential erosion between the granite and the enclosing meta-sediments.

In the Mersey Valley the Dove Granite has been opened up in cuttings along the Mersey Valley Forestry road. The granite here is mostly weathered to depths exceeding 60 feet and the numerous deep road cuttings have disclosed remarkably little fresh rock, but the parent rock seems to have been a grey biotite granite.

Near the contact with the Moina Sandstone along this road the Dove Granite is a medium to coarse grained pinkish weathered rock containing pink feldspar, glassy quartz and a green micaceous mineral. In thin section the rock shows typical granitic texture with quartz filling the interstices between the larger irregular crystals of orthoclase. The feldspar is generally only slightly turbid but occasional areas are completely sericitized. Other areas show a mosaic of fine grained feldspar with very little quartz. Greenish pleochroic chlorite is closely associated with muscovite and magnetite, and in places quartz may be seen between the laminae of muscovite. Muscovite and chlorite are often inter-laminated.

Aplite and basic dykes up to 2 feet wide occur in the road cuttings and usually stand out well as fresher material against the completely weathered enclosing granite. Analyses of some of these dyke rocks are given later.

Outcrops of Dove Granite are also found along the Tasmanian Board Mills road leading toward the Borradaile Plains. The fresher material from this locality is a coarser even-grained rock consisting of pink feldspar, colourless glassy quartz and dark green biotite. In thin section all the feldspar is a cloudy pink colour. Irregular crystals of orthoclase are fresh, but sub-hedral crystals of plagioclase are sericitized and twinning is difficult to observe. Shreds of pale green chlorite may be included in the quartz and feldspar. Hornblende, somewhat cracked and altered, occurs along with the biotite which seems to have been derived from it. Iron ore minerals are associated with the ferromagnesian. Small euhedral crystals of zircon are occasionally seen.

Weathered specimens from the same locality are pale coloured, coarse grained rocks with large crystals of quartz and white kaolinized feldspar. In thin section the large irregular and intergrown crystals of quartz show undulose extinction. The feldspar crystals are completely altered and semi-opaque with finely divided kaolin streaked with birefringent sericite. Micrographic intergrowth occurs between quartz and fresh feldspar.

Dove Granite outcrops fairly widely around the junction of the Dove and Forth Rivers but it is deeply weathered and variable. Hematite and sulphide mineralization within the granite at this locally is described elsewhere. (See pp. 133, 137).

In the road cuttings the granite is deeply weathered and consists of rounded quartz crystals with kaolinized feldspar and chloritized biotite. Marginal phases of the granite outcrop in the bed of the Forth River about a mile north of its junction with the Dove. The rocks there are mesocratic, medium grained and greenish coloured. The green colouration is due to plates of chlorite 1-2 mm across; quartz occurs as grains 2-3 mm across and the rock has a brownish mottling due to the development of limonite. In thin section the texture tends to be hypidiomorphic with euhedral and subhedral crystals of feldspar completely saussuritized, subhedral chlorite and irregular granular quartz and albite. Octahedra of magnetite, about 0.22 mm across are fairly common, there are occasional short prismatic crystals of topaz and some zircons. Limonite pseudomorphs after magnetite are common in association with chlorite. The larger feldspars are too much altered for further identification but many of them show zoning. The albite is cloudy with incipient alteration.

Granite porphyry and marginal phases of the granite also occur in the vicinity of the Devon Mine higher up on the Dove River. A specimen from near the contact of the granite in that locality consists of rounded crystals of quartz, feldspar and biotite in a quartzo-feldspathic groundmass. The feldspar is too much altered to show twinning in thin section and the quartz is somewhat shattered and shows reaction veins. There are occasional composite fragments of quartz and feldspar and fragments composed of interlocking biotite crystals indicating that some, perhaps all, of the coarser grained minerals belong to an earlier generation.

The following analyses of granite and dyke rocks are from specimens collected in road cuttings along the Mersey Valley Forestry roads.

Specimen No.	59/189	59/190	59/191	59/192	59/193	59/194
Reg. No.	807	808	809	810	811	813
SiO ₂	74.48	49.92	73.16	64.68	58.52	91.42
Al ₂ O ₃	13.26	9.24	14.18	13.37	14.74	2.79
Fe ₂ O ₃	0.68	30.36	0.57	1.53	2.24	0.71
FeO	0.67	1.34	0.45	3.77	5.50	0.86
MnO	Trace	Trace	Nil	0.06	0.06	Trace
TiO ₂	0.11	0.27	0.14	0.60	0.71	0.08
P ₂ O ₅	0.07	0.18	0.13	0.21	0.22	0.07
CaO	1.12	0.40	0.84	4.60	6.56	0.32
MgO	0.64	0.32	0.25	3.52	3.87	0.38
K ₂ O	6.13	6.80	6.59	3.98	2.79	1.55
NaO	2.31	0.24	2.74	1.99	2.04	0.41
H ₂ O —	0.05	0.21	Nil	Nil	0.02	Nil
H ₂ O +	1.08	1.13	1.23	1.80	2.27	0.71
FeS ₂	Trace	Trace	Trace	0.16	0.16	0.38
Total	100.60	100.41	100.28	100.27	99.70	99.68

Petrographic descriptions of these rocks are presented below:—

Specimen No. 59-189.—Fine to medium grained leucocratic rock, with sugary quartz grains, opaque white euhedral feldspar and pinkish feldspar showing pearly cleavage. Small flakes (about 1 mm across) of biotite show on newly fractured surfaces, and there is a half inch dark patch containing much tourmaline on a corner of the specimen.

In thin section the rock consists of a mosaic of opaque white euhedral crystals of altered, zoned plagioclase, anhedral cloudy feldspar, and transparent colourless quartz. Small ragged patches of biotite sometimes altered to chlorite are scattered through the section. Much of the feldspar shows an ill defined micropertitic twinning, including the largest anhedral masses. Fairly fresh albite is present and in one instance a euhedral crystal of albite has a core of altered zoned plagioclase.

The rock is an aplite and appears to be closely related to the granodiorite specimen No. 59-192.

Specimen No. 59-190.—Dark purplish coloured rock containing innumerable pink platy fragments up to 5 mm across and 1 mm thick with planar orientation, and colourless glassy grains of quartz in a fine dark matrix.

In thin section the rock consists of cleavage flakes of feldspar, grains of clear quartz and brownish quartzite in a siliceous matrix containing magnetite and hematite. There are also a few ragged flakes of biotite.

Specimen No. 59-191.—Pinkish granular leucocratic rock, with sugary quartz, white opaque feldspar, and larger euhedral feldspar with pearly cleavages.

In thin section the rock consists of glassy anhedral quartz grains, euhedral and anhedral feldspar largely altered, and less altered feldspar in bigger lath-like crystals, cloudy but less altered, and showing micropertitic twinning and undulose extinction. There are also a few ragged wisps of biotite and chlorite.

The rock is an aplite and shows affinities with granodiorite specimen No. 59-192.

Specimen No. 59-192.—Medium even-grained holocrystalline rock containing black biotite, sugary quartz, and greenish, pinkish and colourless mica, the last with bright pearly cleavages.

Thin section shows an allotriomorphic texture with some euhedral feldspars and hornblende, whilst most of the feldspar and biotite grains show irregular outlines. Quartz is interstitial and there are smaller euhedral crystals of apatite. There are occasional masses of epidote and epidote is a prominent secondary mineral in the altered feldspar. Black opaque octahedra and irregular masses of magnetite are associated with the ferromagnesian minerals.

Feldspars are of three kinds. The first to crystallize was plagioclase which is present as zoned euhedral crystals now altered to a very fine grained aggregate of albite, epidote, sericite, &c. A small amount of relatively fresh albite is present as small anhedral grains with lamellar twinning. Larger interstitial masses of micropertite contemporaneous with quartz comprises about half the amount of total feldspar.

The rock is a granodiorite.

Specimen No. 59-193.—Medium grained rock containing black prisms of hornblende, greenish feldspar and white granular quartz. There is also a white feldspar with bright pearly cleavages.

In thin section the large hornblende crystals contain inclusions of euhedral, altered and zoned plagioclase; large untwinned masses of orthoclase contain euhedral crystals of plagioclase and hornblende. There is some anhedral quartz and smaller lath-like crystals of little altered albite with lamellar twinning.

The rock is a granodiorite.

Specimen No. 59-194.—Fine grained dark purplish coloured rock with irregular pink fragments, grains of glassy quartz, black flakes of biotite and disseminated fine grains and small masses of pyrite.

In thin sections the rock consists of angular fragments of quartz, feldspar, quartz and feldspar, and quartzite in a fine grained matrix containing crystals of magnetite and pyrite. There are also a few ragged plates of biotite and chlorite, and much fine grained chlorite in the matrix.

DOLCOATH GRANITE

This granite outcrops as a small stock about 2 miles in diameter centred about the northern boundary of the Quadrangle on grid line 414E. Only about half of the stock was mapped in the Middlesex Map Sheet.

In the field this rock is much more uniform than the Dove Granite, but it is also extensively weathered. The granite outcrops on the steep side of the Forth Valley as typical granite tors intersected by strong but widely spaced joint systems. Narrow aplite veins occur within the granite and intruded along joints in the surrounding Cambrian porphyry.

This granite is the source of numerous tin-tungsten deposits in the area and narrow quartz veins, infilling joints, within the granite carry chiefly wolfram and molybdenite as well as minor quantities of tin. Some wolfram and molybdenite is disseminated through the granite just below the road at the highest point of the granite on the east side of the Forth River.

In hand specimen the granite is a medium to coarse grained flesh coloured rock containing abundant glassy quartz crystals up to 5 mm across and altered feldspars 3-4 mm across and 10 mm long plus some biotite. The creamy pink colouration is due to decomposition of the feldspar. The following petrological description was prepared by M. L. Longman. The specimen was obtained by blasting open a boulder 10 feet across but is still somewhat weathered. It can be taken as typical of the granite except that biotite is more abundant in the hand specimen.

<i>Composition</i>	{	Quartz 40%	
		Microcline—perthite 40%	
		Plagioclase 20%	
		Biotite }	Trace
		Zircon }	
<i>Grainsize</i>		1.0 to 5.0 mm, average 4.0 mm	
<i>Texture</i>		Granitic	

Description

The plagioclase occurs as normally zoned subhedral laths with combined Carlsbad and pericline twins, varying in composition between andesine $An_{32} Ab_{68}$ and oligoclase $An_{24} Ab_{76}$ rimmed by albite $An_{10} Ab_{90}$ when in contact with microcline. The albite veins are clear in contrast to the cores which are slightly saussuritized. Microcline, more extensively altered to kaolin, is intergrown with albite with the 010 direction parallel forming perthite, and shows Carlsbad and (rarely) polysynthetic twinning. Quartz occurs as crystal aggregates up to 10 mm in size and is corroded by microcline. Inclusions of bubbles arranged in rows and mosaic extinction are common. Biotite forms small green and brown ragged laths extensively corroded by the other constituents.

Re-examination of slides from the Department of Mines collection has provided the following descriptions.

Slide No. 37/R/5. Pegmatite, Tin Spur.—The specimen in thin section shows a coarse grained hypidiomorphic texture consisting of grains of quartz, completely and partly altered feldspar and white mica. Accessory minerals include fluorite and a little zircon.

Quartz is crowded with liquid inclusions, each with a mobile bubble. The inclusions tend to be arranged in lines.

Some of the feldspar (the orthoclase) is completely altered to sericite, the rest shows partial alteration which often forms a pattern suggesting perthite with the orthoclase altered and the albite remaining unaltered.

Fluorite is not uncommon and occasionally forms a crystal of a size in keeping with the general grain size. A little of the fluorite is a violet colour.

Zircon occurs in rare shattered crystals.

Slide No. 45/Q/13. Granite, Lorinna Road.—This rock is similar in texture and grain size to the granite of Tin Spur but contains fresher feldspar. The varieties of feldspar present are microcline, micro-perthite and a zoned plagioclase. All show much the same degree of alteration, with possibly the smaller albite crystals a little less cloudy. Quartz shows liquid inclusions arranged in lines and the perthite may enclose smaller euhedral and subhedral crystals of quartz.

Irregular ragged masses of brown and green biotite are common and may enclose fluorite with an irregular violet colouration.

Jurassic Dolerite

The general form of the dolerite intrusions, their structure, physiographic expression and weathering characteristics are described elsewhere in this bulletin. The petrological characteristics of the Tasmanian dolerites have been described previously by many workers but the authoritative source is Edwards (1942). No further petrological work has been carried out on the dolerite of the Middlesex Quadrangle. It appears to conform to normal tholeiite which is the common rock type in Tasmania.

Tertiary Basalt

Basalt is widely distributed throughout the Quadrangle. It forms the top of Maggs Mountain, the Borradaile Plains and Emu Plains, the plateau west of Lorinna and the lower hills north of Mole Creek and Chudleigh.

The distribution of the basalt has been determined by the pre-basalt drainage system as described by Spry (1958) and Rundle (1958). The accounts of these authors are in accord with all present information.

The total thickness of basalt extruded was enough to overtop the pre-existing divides and to introduce lava flows into the Mole Creek valley.

The extrusion centre has not been identified but there is some evidence for a location in the vicinity of the hills behind Gisborne's hut.

The petrology of the basalt was discussed by Spry (1958) and no further studies have been made since that time.

TECTONIC HISTORY			
AGE	SEDIMENTS	IGNEOUS ROCKS	TECTONISM
QUATERNARY	SCREE, TALUS, GLACIALS AND ALLUVIUM.		
TERTIARY	TERRESTRIAL SAND AND CLAY	BASALT EXTRUSIONS	LATERITIZATION.
CRETACEOUS	NO DEPOSITION		EPEIROGENY
JURASSIC		DOLERITE INTRUSIONS.	PENEPLANATION.
TRIASSIC	FRESH WATER SANDSTONE AND SHALE		BLOCK FAULTING, EPEIROGENY AND WARPING
PERMIAN	MARINE MUDSTONE AND GREYWACKE WITH COAL MEASURE INTERCALATIONS		
CARBONIFEROUS	NO DEPOSITION ?		PENEPLANATION
DEVONIAN	?	GRANITE INTRUSIONS.	TABBERABERAN OROGENY
SILURIAN	MARINE SANDSTONE AND SHALE.		LOWER PALEOZOIC BASIN SUBSIDENCE
ORDOVICIAN	LIMESTONE MARINE SANDSTONE QUARTZ CONGLOMERATE.		JUKESIAN MOVEMENT.
CAMBRIAN	GREYWACKE AND PYROCLASTICS	INTERMITENT BASIC TO ACID LAVAS.	INTERMITENT TECTONISM IN LOWER PALEOZOIC BASIN
PRECAMBRIAN	GARNETIFEROUS SCHIST AND META QUARTZITE.		STICHTAN MOVEMENT.
			OROGENY ?

FIGURE 7.

TECTONICS

The rocks in the Middlesex Quadrangle may be divided into several tectonic units, each of which has been affected by one or more of the processes indicated in the tectonic history set out in Fig. 7. These major tectonic units are as follows:—

- (1) Precambrian nucleus.
- (2) Lower Palaeozoic fold belt and granite intrusions.
- (3) Block faulted, warped and intruded Permo-Triassic sediments.
- (4) Dolerite intrusions.
- (5) Basalt extrusions.

The important features of these units are described below.

PRECAMBRIAN NUCLEUS

This is the severely deformed block of metasediments in the south and west of the Quadrangle. It forms the nose of the Tyennan Nucleus of Carey (1953). This block was generally emergent from perhaps late Proterozoic time till the beginning of Permian sedimentation and was subsequently uplifted during the Tertiary epeirogeny.

The rocks composing the Tyennan Nucleus are strongly folded about E-W axes in the central portion of the Quadrangle but the axial trends swing away to the SW in the southern and western portion. Outside the Middlesex Quadrangle further west and south they continue to swing until they become aligned N-S parallel to the Lower Palaeozoic basin on the West Coast. (See Carey, 1953, Fig. 3).

To the east of the Middlesex Quadrangle the rocks in the Precambrian nucleus are obscured by Jurassic dolerite and Permo-Triassic sediments but they appear again in the vicinity of Golden Valley (Wells, 1957) where the structures trend toward the SE.

Regionally, then, these rocks appear to form portion of the nose of a geanticline aligned N-S and pitching toward the north. However, this anticlinal form is probably a morphological feature rather than a structural one.

Lower Palaeozoic sediments and volcanic rocks were deposited in a deep structural trough around the nose of this "fold" though it is not clear just how this trough was formed. The distribution of Cambrian rocks along the north side of the Dove River indicates that the Cambrian rocks overlap unconformably onto the Precambrian nucleus and suggests that the basin margin has been downwarped. However, the persistent granite intrusions and the presence of abundant volcanic material along the boundary of the trough suggests a deep seated structural weakness.

LOWER PALAEOZIC FOLD BELT

Within the sedimentary trough which formed around the nose of the Tyennan Nucleus greywacke sediments and volcanic debris rapidly accumulated to a total thickness probably in excess of a mile.

A striking feature of this sedimentation is that the material forming the sediments was very largely derived from within the trough itself and the Tyennan Nucleus only contributed minor quantities of sediment. Such material as was derived from the Precambrian rocks is similar in metamorphic grade to the Precambrian rocks exposed on the nucleus today. Thus it is clear that the Tyennan rocks had suffered considerable deformation prior to the onset of the Cambrian sedimentation.

Since most of the rock fragments in the Cambrian greywackes were derived from within the Cambrian sedimentary basin it follows that tectonic movement probably continued after the formation of the trough right through the Cambrian sedimentary cycle. Evidence from the Barrington district north of the Middlesex Quadrangle indicates that uplifts commenced early in the sedimentary cycle and that the central portions of the trough were uplifted first and most. As this would be normally the deepest portion of the trough it indicates that this uplift was real and that the sediments were not entirely produced by turbidity currents eroding within the basin, although there is abundant evidence that turbidity currents were active.

The Cambrian rocks were folded and had developed a mild regional schistosity before the beginning of the Ordovician sedimentation.

The Cambro-Ordovician unconformity is exposed at many places in the Middlesex Quadrangle but may be seen best just north of the map boundary in road cuttings near Cethana. (See Jennings, 1958, Fig. 3).

Locally the angular discordance between the two units may appear to be considerable but when they are viewed regionally it may be seen that the discordance is mainly in the magnitude of the dips and that the general strikes are consistent. The local exposures of the unconformity are exaggerated and confused by widespread subsequent decollement action between the Cambrian and Ordovician systems during the Tabberabberan Orogeny.

The Jukesian Movement caused not only folding in the Cambrian sediments but also uplift of the Tyennan Nucleus which then became the source area for the material forming the Roland Conglomerate.

Much of the pre-Ordovician folding in the Cambrian rocks may well be of sedimentary origin but it is necessary to postulate sufficient tectonic movement to produce the sheared greywacke and porphyry pebbles in the basal beds of the Roland Conglomerate.

The terrestrial gravels of the Roland Conglomerate are followed by at least 4000 feet of marine sediments extending from Lower Ordovician up to Lower Silurian but the record is incomplete in the Middlesex Quadrangle. By correlation with West Coast areas the post Cambrian sedimentation may have extended up till the Lower Devonian and the total thickness of sediment deposited may have been in excess of 2 miles.

Wade and Solomon (1958) showed that some movements continued after the beginning of the Owen Conglomerate sedimentation in the Queenstown area but as far as is known at present no angular discordances are present within the correlates of the Junees and Eldon Groups in the Middlesex Quadrangle. In spite of this

there is clear evidence to show that the Lower Palaeozoic sedimentary basin continued to subside from the beginning of Ordovician time to a depth in excess of 4000 feet by Lower Silurian time and perhaps to a total depth of more than 10,000 feet by Lower Devonian time.

This sedimentation was brought to a close in Lower or Middle Devonian time by the Tabberabberan Orogeny which resulted in widespread folding, faulting and uplifts of the Cambrian and younger sediments, the intrusion of the Dove, Dolcoath and perhaps the Lone Pine Granites together with their associated mineralization. The major Tabberabberan folds are aligned E-W and NW-SE and are accompanied, in the Ordovician rocks, by a conjugate set of breakthrusts trending toward the NW and dipping to the NE and SW. The already folded Cambrian rocks were refolded along similar axes but in contrast to the concentric folds and breakthrusts in the Ordovician rocks, they deformed by shear folds accompanied by wrench faults, particularly in the incompetent beds.

Following the Tabberabberan movements the uplifted pre-Devonian rocks were subjected to prolonged peneplanation which lasted up till the Lower Permian.

GRANITE INTRUSIONS

Direct evidence of the age of the granites in this area is lacking. However, just north of the Middlesex boundary they have produced widespread metamorphism in rocks up to and including the Gordon Limestone. By correlation with other areas, a Lower to Middle Devonian age seems reasonable. As the Lone Pine Granite is intruded solely into Precambrian rocks its age is even less definitely established, but there is a similarity of mineralization between it and the Dolcoath Granite.

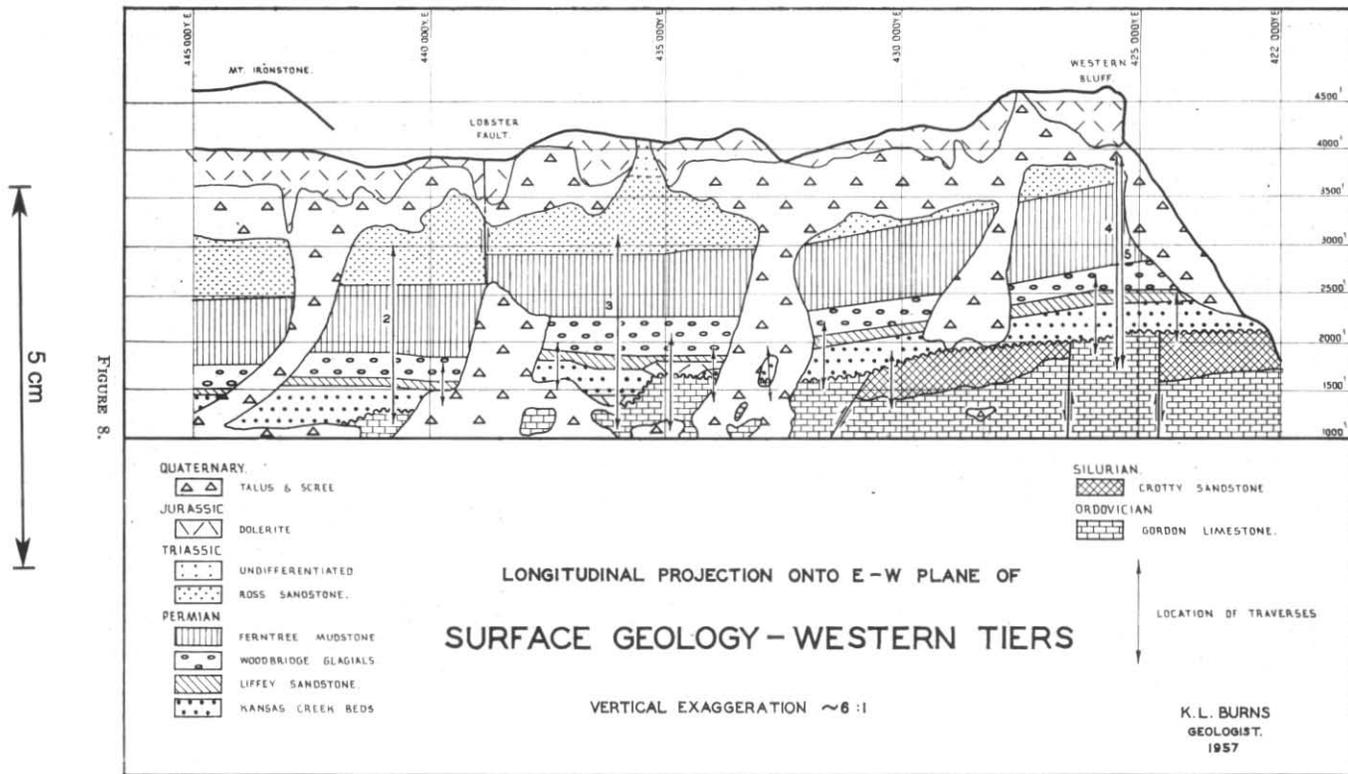
Evidence is presented elsewhere in this report to indicate that the probable sequence of events surrounding the granite emplacement was:—

- 1st Folding
- 2nd Breakthrusts
- 3rd Granite emplacement
- 4th Mineralization

This sequence is supported by evidence from the Round Hill area (Jennings, 1958, Fig. 3).

However, it is stressed that all of these events were part of a continuous process and that a good deal of overlap between them is inevitable and realistic.

The Dolcoath Granite outcrops as a small stock about 2 miles in diameter, only the southern half of which lies in the Middlesex Quadrangle. Although it was suggested earlier (Elliston, 1954b) that this granite was formed from "reconstituted Cambrian sediments" the overwhelming mass of field evidence refutes this and substantiates an intrusive origin. The Round Hill Synclinerium just NE of the granite has been tightly compressed by the intrusion, fold axes have been deflected and the overlying folds "arched up" over the granite and now plunge away from the centre of the



stock. Around the granite the Ordovician rocks have suffered local contact metamorphism only and there are no tectonic or metamorphic features in the vicinity which support a granitization hypothesis.

The Dove Granite was emplaced along, or close to, the edge of the Lower Palaeozoic basin. It also appears to be intrusive. In the Mersey Valley the granite occupies the core of an anticline in Moina Sandstone whilst on the Five Mile Rise the earlier conjugate shear joints related to the regional fold system have been reopened as normal faults and subsequently mineralized by the intruding granite.

BLOCK-FAULTED PERMO-TRIASSIC SEDIMENTS

The prolonged peneplanation following the Tabberabberan Orogeny was terminated by the deposition of marine and glacial sediment over wide areas of the State. It seems likely that at one time the whole of the Middlesex Quadrangle was covered by Permian and Triassic sediments. The more resistant monadnocks of pre-Permian rocks may have stood out above sea level up to Liffey times but the presence of Permian sediments on the highest parts of the pre-Permian surface indicate that eventually the whole area was submerged.

The marine sedimentation was interrupted by at least one fresh water phase during the Middle Permian, and towards the end of the Permian the sea gradually retreated and coal measures were formed, followed by thick Triassic freshwater beds.

This period of sedimentation yielded at least 2500 feet of sediment but as the upper part of the Triassic sequence has been removed it is probable that the total original thickness may have been double that figure.

The Permo-Triassic rocks were intruded by huge masses of dolerite, mainly as sills, during the Jurassic. Irregularities in the intrusional forms and the tectonic conditions which accompanied the intrusion undoubtedly led to considerable uplift and disruption of the intruded sediments. However, no Jurassic faults have been demonstrated in the Middlesex Quadrangle although elsewhere in the State they are well established.

Further epeirogenic movements occurred in the Tertiary prior to the basalt intrusions. This resulted in block faulting of the Permo-Triassic-dolerite block together with uplift and the formation of a strong joint system, which shows out clearly on the dolerite areas as a complicated set of linears.

The overall result of both the Jurassic intrusion and the Tertiary epeirogeny was the development of the central plateau mass consisting of a huge slab of block faulted and warped Permo-Triassic sediments and dolerite.

The distortion of the mass is shown in the projected section of the Western Tiers (Fig. 8). This indicates that the warping is a regional feature and not merely local drag dips near fault zones. Although Brill and Hale (1954) and Burns (1957) referred to folds in Permian and Triassic rocks, most authors have been reluctant to regard these rocks as folded. However, with the disclosure by Campana and King (1958) of strong thrust faulting

and folding in the Permian rocks near Zeehan and evidence which is accumulating in other areas it is clear that the tectonic features of these rocks must be studied more critically. Certainly, the widely accepted view that all flexures in Permian and Triassic rocks are simply contiguous to faults must be treated with reserve.

DOLERITE INTRUSIONS

The youngest Permo-Triassic sediments still preserved in the Middlesex Quadrangle are sandstone and shale, probably equivalent to the Cluan Formation of McKellar (1957), which outcrop along the face of the Western Tiers north of Lake McKenzie. Evidence from elsewhere in Tasmania suggests that this period of sedimentation continued until the middle of the Triassic Period when it was ended by widespread dolerite intrusions.

In the Middlesex Quadrangle the dolerite formed a huge roughly conformable sill intruded at about the top of the Ross Sandstone and a number of small discontinuous sills at or near the base of the Permian System. The main intrusion which now forms the escarpment of the Western Tiers is between 600 and 1000 feet in thickness and forms the Central Plateau of Tasmania, extending over some thousands of square miles SE of the Middlesex region.

The geological map indicates that in the Middlesex Quadrangle the dolerite is roughly concordant with the Mesozoic rocks. However, further east near Poatinah McKellar (1957) noted that the base of the dolerite is considerably higher in the Triassic than at Western Bluff, indicating an upward transgression towards the east. Insufficient evidence is available at present to determine whether this transgression is a simple shelving across the bedding or whether it was effected as one or more "steps".

Ford (1960) set out evidence to show transgression of the base of the sill from a low point at the Devil's Gullet (upper Fisher River) upwards toward Western Bluff in the north and the Little Fisher River in the south. He concluded that the base of the dolerite there is shaped like a shallow inverted cone. The transgressions indicated by Ford were substantiated by this survey and by work in neighbouring areas (MacLeod *et al.*, 1961, p. 34) which showed that in the vicinity of the upper Fisher River the base of the dolerite in section has a blunt wedge-shaped profile, but the inference that the dolerite here is intruded as a cone sheet would be difficult to demonstrate from the available outcrops.

The abundance of scree around the foot of the dolerite cliffs along the Western Tiers effectively conceals the base of the dolerite everywhere and minor transgressions which have escaped notice may well occur there.

The only mappable anomaly along the Tiers is the occurrence of discontinuous outcrops of Triassic rocks right up to the top of the escarpment about 2 miles north of Lake McKenzie. This block of sediments is terminated east and west by nearly vertical intrusive contacts and it appears to have been covered by dolerite to the south.

The top of the main dolerite sill has not been observed in this area, but quartz sand on some of the beaches of the highland lakes, discussed elsewhere, suggests that some of these lakes may be underlain by rafted blocks of Triassic sediments.

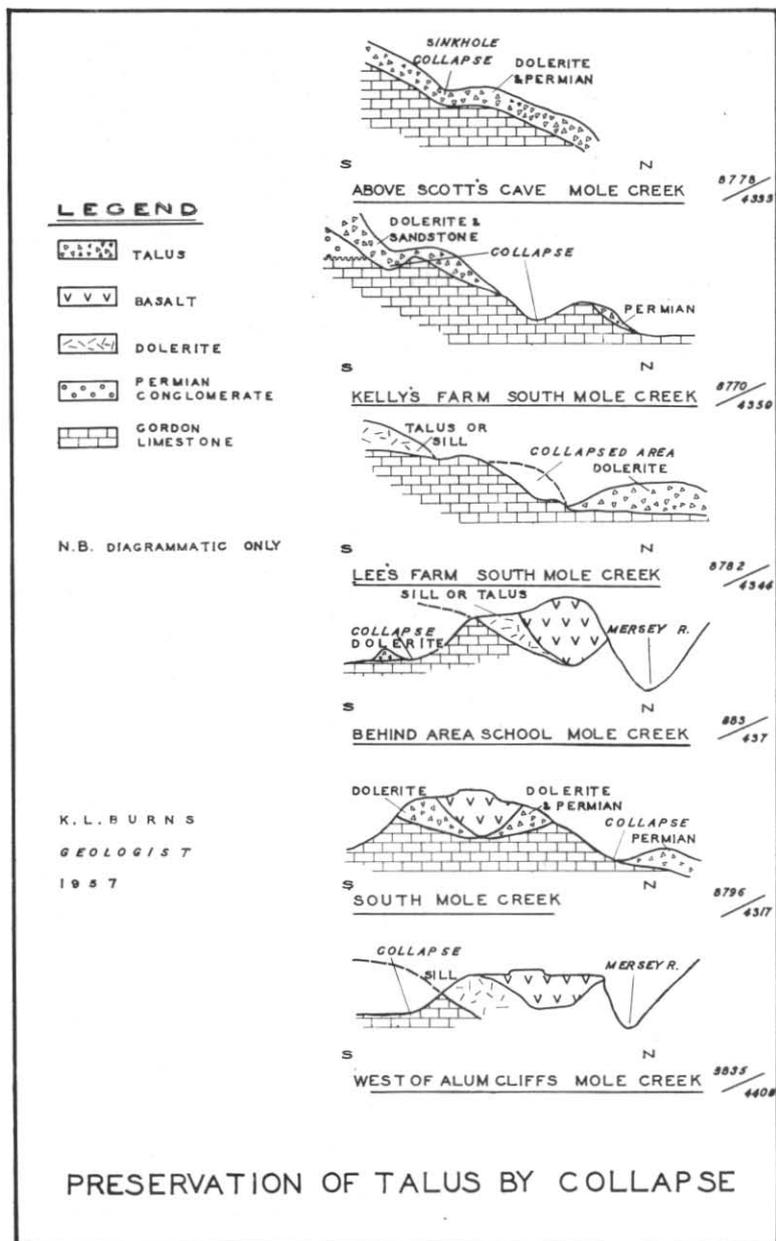


FIGURE 9.

← 5 cm →

Along the foot of the Western Tiers and on small hills in the Mole Creek Valley there are numerous accumulations of dolerite talus together with some outcrops which are regarded as dolerite in situ. In many of these areas the outcrops are poor, being for the most part concealed by heavy superficial deposits. Thus, whilst all care has been taken in interpreting the dolerite as shown on the geological map, it must be recorded that the map in these areas is largely interpretive. In the field most of these areas are often simply occupied by dolerite talus containing blocks up to 50 feet across, which appear to be quite disorientated. Sections showing the probable field occurrences are set out in Fig. 9. These indicate that the dolerite "talus" appears to underlie the basalt and therefore precludes a glacial origin.

The field relationships are consistent with a relatively thin sill intruded discontinuously along the Permian unconformity, which has collapsed where the underlying Gordon Limestone has been removed by erosion or solution.

BASALT EXTRUSIONS

Carey (1953, Table 1) gave an outline of the general sequence of events in Tasmania following the Jurassic dolerite intrusions. He indicated a long period of peneplanation lasting from the Upper Mesozoic until the early Tertiary, followed by strong epeirogeny and later extensive basalt extrusions. This pattern is followed generally in the Middlesex Quadrangle although it is clear that the peneplanation did not proceed very far.

During the dolerite intrusions an enormous volume of material was injected into the Permo-Triassic sediments and older rocks, resulting in considerable uplift of the land surface. Vigorous erosion of these newly uplifted highlands was initiated and continued up till the Lower Tertiary epeirogenesis. In other parts of Tasmania bauxite was formed on the dolerite surfaces during the final phases of this period of peneplanation. Though it has been generally accepted that the land surface was reduced to a mature profile, it seems clear that at the time of the basalt extrusions the Western Tiers must have exhibited considerable relief.

No evidence can be found in this Quadrangle for any Tertiary faulting which may have initiated the Western Tiers which must be considered as a purely erosional form. The top of the Tiers reaches an elevation of 4671 feet a.s.l. at Western Bluff and the base of the nearest basalt to the escarpment lies at an elevation of about 1200 feet. The Western Tiers must therefore have exhibited about 3500 feet of local relief at the time of the basalt extrusions.

Elsewhere in Tasmania there is a good deal of evidence to indicate that the basalts were preceded by a period of strong epeirogeny. Epeirogenic movements are represented in the Middlesex area by the fault along Lobster Creek, by several small faults in the Permian rocks south of Chudleigh and by the strong linears impressed on the dolerite sills. No faults are known to disrupt the basalt flows here and the joint patterns in the basalts are indications of contraction rather than tectonic features.

More than 1000 feet of basaltic lavas and pyroclastics were extruded during the vulcanism but the centres of extrusion are not known, though the abundance of coarse pyroclastic material and the disposition of the lava flows suggests that a centre was located a mile or so south of Gads Hill.

STRUCTURAL GEOLOGY

INTRODUCTION

(See Figs. 12, 13, 14)

The Precambrian rocks suffered considerable deformation before the beginning of Cambrian sedimentation, but the number of movements involved, their character and age are at present unknown.

If the writer is correct in correlating the Cambrian sediments here with the Middle to Upper Cambrian rocks of the Dundas Group it would seem that movement which initiated the sedimentation began in late Lower Cambrian time. However, we have no knowledge of the sediments which may be present in the central portion of the trough north of the Middlesex boundary and the possibility that extensive thicknesses of Lower Cambrian rocks are present there cannot be precluded. Thus the movement could have begun at any time between the Late Proterozoic and Middle Cambrian.

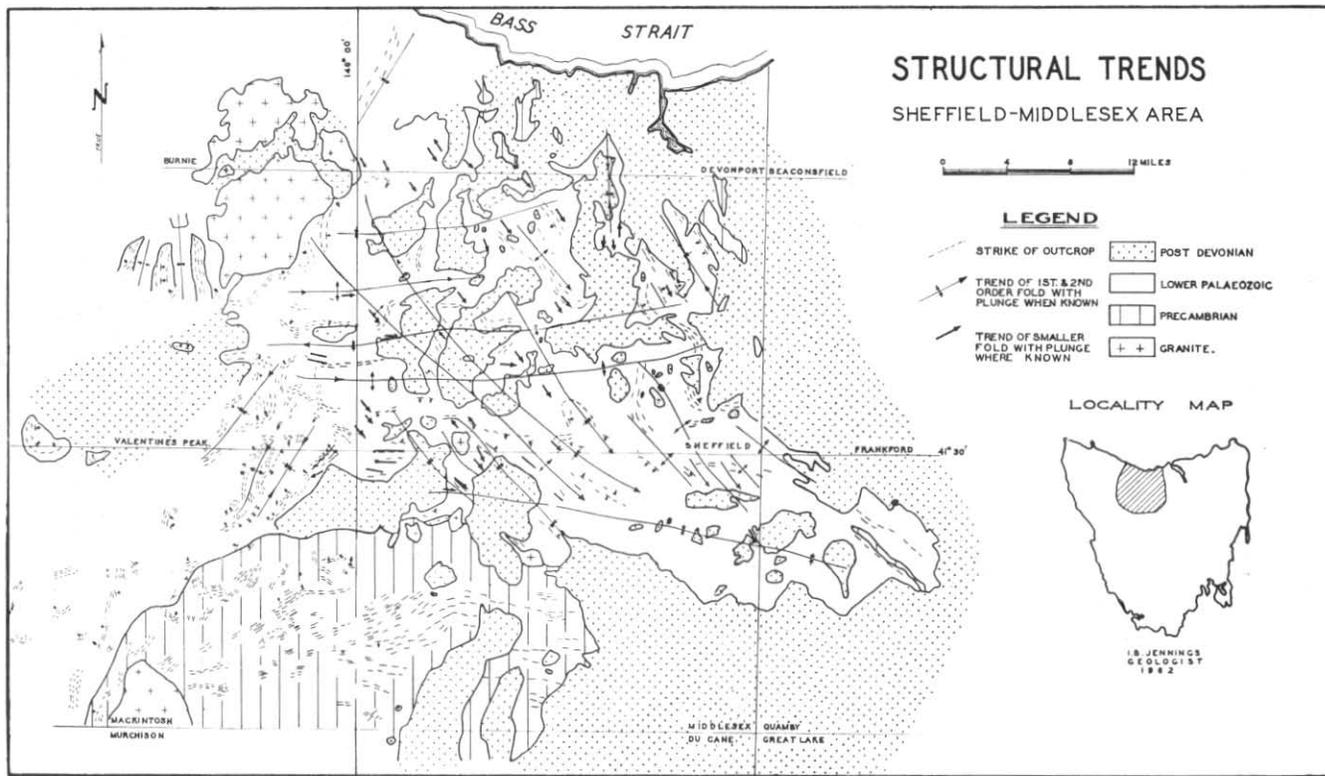
Carey and Banks (1954) defined the angular discordance between Junee Group rocks and pre-Dundas Group rocks as the Tyennan Unconformity. Within the Tyennan Unconformity they defined the Stichtan Movement between the Carbine Group and the Dundas Group and the Jukesian Movement between the Dundas Group and the Junee Group. However, the rocks correlated by them as Carbine Group on the Sticht Range seem more likely to be older Precambrian and their definition of the Stichtan Movement is considered to be open to doubt. The term is therefore not used in the present work.

The evidence so far presented indicates that movement commenced in Late Proterozoic or Middle Cambrian time. Milder movements continued throughout the Cambrian Period and were rejuvenated with the Jukesian Movement prior to the Lower Ordovician.

Throughout the Ordovician and Silurian the sedimentary basin was depressed by perhaps as much as 2 miles without interruption to the sedimentation. Thus there is some evidence for continuous tectonic activity right through the Junee and Eldon Group sedimentation culminating in the intense Tabberabberan Orogeny.

Up till the onset of the Tabberabberan movement the tectonism resulted mainly in the formation and development of the Lower Palaeozoic trough but it produced some folding within this basin in the Cambrian rocks.

The Tabberabberan movements on the other hand first exaggerated the earlier Tyennan folds and then impressed upon them a strong NW directed fold pattern. Thus it is difficult to establish not only when the Tyennan movements began but also when they ceased and the Tabberabberan commenced. The picture seems to be one of continuous tectonism from Late Proterozoic right through until the Middle Devonian with occasionally renewed and vigorous pulses of orogenic activity.



PRECAMBRIAN ROCKS

The dominant schistosity and the main compositional banding in the Precambrian rocks has a regional E-W trend over much of the Middlesex Quadrangle. This is most marked in the Forth and Mersey Valleys where strikes other than E-W are rare and generally related to the closures around plunging folds oriented along E-W axes. However, in the southern and western portions of the Quadrangle the structural trends swing towards the SW.

The lack of NW structural trends around the margins of the Precambrian craton is somewhat surprising as the Lower Palaeozoic rocks are dominated by folds aligned in that direction. The regional pattern of these folds, as shown on Fig. 10 indicates that they tend to swing parallel to the craton as they approach the edge of the basin. Although the 1st order NW trending Tabberabberan folds do not penetrate the Precambrian rocks, there are abundant sets of small scale folds present which are considered to be of Tabberabberan age. It may be noted on Plate 9 that these folds cut cleanly across the earlier structures and that their plunge is parallel to the dip of the earlier schistosity. This indicates that these folds have developed normal to the existing foliation at a late stage of tectonic history.

Several 1st order structures within the Precambrian rocks are indicated on the geological map and these have been determined by the rock distribution and dips of the main foliation planes. As they are intersected by later, presumably Tabberabberan, structures and are parallel to the Lower Palaeozoic basin they must be of Tyennan age or earlier. Within these major folds several sets of smaller scale folds are present. The 1st order folds are 2 to 3 miles across; another prominent set is a few hundred feet across and numerous complicated folds a foot or so across may be found at many places (see Plate 10). The internal features of a portion of one of these smaller folds are shown in Plate 11 which shows that smaller scale folding is present on all visible scales.

An interesting feature of the fold pattern is that whilst the 1st order folds appear to plunge to the west, the 2nd order folds generally plunge to the east. The 3rd order folds (1 foot across) on the other hand plunge both east and west. These folds are best displayed in the thinly bedded quartzite and meta-pelite sequences. Sometimes the axis of one of these small folds may be traced on the surface for a few feet and the change in plunge may be observed. One fold in Fisher Group rocks is exposed above the road cuttings on the west side of the Mersey River about $1\frac{1}{2}$ miles south of the Fisher River. This fold has been observed to change in plunge from about 45° toward the west to 60° toward the east in a distance of 10 feet along the axis and a few feet further on the plunge appears to be overturned and dips steeply to the west. Plate 12 shows steeply plunging minor folds of this kind in blocky quartzite of the Fisher Group.

The fold styles are influenced considerably in detail by variations in lithology. Plate 10 indicates the smooth closure of the quartzite bands whilst the interbedded meta-pelites are sheared and attenuated in the axial region.

The small corrugations shown on Plate 9 are a few inches across and are common in the thinly bedded quartzite and schist. Superficially they resemble ripplemarks and plunge at variable angles (usually about 30°) both east and west.

CAMBRIAN ROCKS

The Cambrian rocks exposed in this Quadrangle are for the most part sheared and altered Cambrian porphyries which lack bedding and are therefore unrewarding from a structural viewpoint. There is, however, a strong contrast in metamorphic style, ranging from quartz porphyry which has been dynamically altered to quartz-sericite schist to relatively unaltered greywacke siltstone. The volcanic rocks in the Bull Creek Formation have suffered most deformation while some of the keratophyres just north of the Gog Range have suffered very little.

The exposures on this Quadrangle are too limited to justify generalization but if we consider the Cambrian rocks here together with those in the Quadrangle immediately to the north (Sheffield), a regional pattern emerges. Over this area the Cambrian rocks have developed similar type folds with strong axial plane cleavage, particularly in the axial regions of the 1st order folds. The pattern is complicated considerably by the variations in intensity of shearing within individual folds and by the varying degree of accommodation to stress offered by the various formations. Thus the competent, thick keratophyre bands tend to deform in concentric folds with accommodation by bedding plane slip at the expense of less competent greywacke and pyroclastic formations which are isoclinally folded and possess a well developed schistosity parallel to the axial plane.

Minor folds in the Cambrian rocks plunge at variable angles to the SE and NW in a similar fashion to the smaller folds in the Ordovician rocks and they often diverge in trend from the regional schistosity. These features suggest that the smaller NW trending folds are late Tabberabberan structures.

JUKESIAN MOVEMENTS

Several lines of evidence indicate that the Cambrian rocks had suffered deformation before the Ordovician sediments were deposited. These are:—

- (1) In the Iris River, on the Gog Range, at Cethana, Tin Spur and other places there is a well marked unconformity above the Cambrian sequence.
- (2) The basal Ordovician sediments contain sheared pebbles of Cambrian rocks.
- (3) The strong axial plane schistosity of the Cambrian rocks does not persist into the Ordovician system except locally near demonstrably Tabberabberan structures.
- (4) There is a contrast in fold style from similar type folds with accommodation by axial plane schistosity in the Cambrian rocks to concentric folds with bedding plane slip in the Ordovician sediments.
- (5) The schistosity in the Dolcoath Anticline (Burns 1961) appears to fan, indicating refolding.

The Jukesian movements were therefore strong enough to develop folds and a regional schistosity in the less competent Cambrian beds. Some uplift and erosion must have accompanied this folding as shown by the presence of fragments of Cambrian rock in the Roland Conglomerate and by the terrestrial conditions prevailing during the early part of the Ordovician sedimentation.

However, the Jukesian uplifts were probably quite small and local and there does not seem to be sufficient time interval for a long period of erosion between the cessation of Cambrian sedimentation and the beginning of deposition of the Roland Conglomerate. Even if such a time interval were postulated there are no known deposits which have accumulated from the erosion of extensive highlands of Cambrian material. The most important features of Jukesian time are the cessation of volcanic activity and the rise of the Precambrian craton to the south which became the source area for the Roland Conglomerate and Moina Sandstone. Following or contemporaneous with these movements, the Cambrian basin began to subside so as to receive at least 5000 feet and possibly 10,000 feet of Lower Palaeozoic sediment.

No evidence has been found here to indicate that the Jukesian folds were divergent from the earliest Tabberabberan movements. They appear to be parallel to the margins of the Cambrian basin and so in the Middlesex Quadrangle are aligned roughly E-W. Demonstrable Jukesian faulting in this district would be difficult to prove as most of the faults moved again during the Tabberabberan.

ORDOVICIAN AND SILURIAN ROCKS

These rocks were strongly folded and faulted during the Tabberabberan and the resulting structures are well preserved, particularly in the Roland Conglomerate and Moina Sandstone. The fold styles developed are characteristic of the rocks over a wide area of the North West Coast and are similar to the structures mapped on the West Coast Range by numerous workers.

The Roland Conglomerate and Moina Sandstone are competent units with well developed bedding planes and they were deformed by bedding plane slip into concentric folds accompanied by break-thrusts, the "Owen type" folds of Carey (1953).

A feature of the fold pattern here, as elsewhere, is that at least two fold trends are present.

This fold style indicates compression parallel to the basin with relief upwards. The already deformed Cambrian rocks being under some cover yielded by shear folds with conjugate wrench faults resulting in relief along the basin.

The major elements of the fold pattern for a wide area surrounding the Middlesex Quadrangle are indicated on Fig. 10. Of the folds indicated on that map, the major syncline which runs roughly west from Quamby Bluff through the Mole Creek valley to Lorinna is the only 1st order E-W structure which affects the Ordovician rocks in this area. It is referred to in this Report as the Mole Creek Syncline.

A number of NW trending folds cut across the Mole Creek Syncline. These are:

- (1) A syncline which crosses the Forth River near Lorinna, here called the Lorinna Syncline.

- (2) Another syncline which crosses the Mersey River about $1\frac{1}{2}$ miles south of Liena. This is the SE extension of the Claude Creek Synclorium of Jennings (1958).
- (3) An anticlinorium which forms Standard Hill, here referred to as the Standard Hill Anticline.
- (4) A syncline which cuts across the Fossey Mountains between Mts Roland and Claude, here called the Vandyke Syncline.
- (5) A number of smaller but important folds which cut across the Roland Conglomerate and Moina Sandstone on the southern side of the Gog Range of Mole Creek and Chudleigh.

Mole Creek Syncline

This is a 1st order flexure, at least six miles across, which may be traced for at least 30 miles along its strike. The northern link of the structure is formed by the southerly dipping Ordovician rocks along the Fossey Mountains. Extensive outcrops of Gordon Limestone occur along the axis of the fold and where it has been intersected by the Claude Creek and Vandyke Synclines the interaction of the folds has depressed the axial region sufficiently to preserve outliers of Crotty Sandstone near the Den and SE of Mayberry and Liena.

The southern limb of the syncline is obscured by Permian and younger rocks east of Western Bluff but elsewhere the limited exposures indicate that it overlaps onto the Precambrian craton. Dips on the southern limb are generally somewhat flatter, about 15° to 20° , than on the northern limb where they average about 30° . The Mole Creek Syncline therefore occupies the position and has roughly the same symmetry, though in a subdued form, as the "marginal synclorium" of the West Coast (Carey, 1953, Fig. 7).

The Mole Creek Syncline continues to the west of the Middlesex Quadrangle and is probably responsible for the structural basin at the Vale of Belvoir by interaction with a synclinal structure trending NNE up the Mackintosh River from near Mt Farrell.

Lorinna Syncline

This structure runs SE from Moina to Lorinna but much of the detail is obscured by basalt. Beyond Lorinna the structure is deeply buried beneath the thick pile of Tertiary basalt on Gads Hill. The deflection in the boundary of the Moina Sandstone against the Gordon Limestone in the Mersey Valley about 3 miles south of Liena is probably an expression of the structure there.

The NE boundary of the Lorinna Syncline is formed by a powerful fault zone, the Shepherd and Murphy Fault of Elliston (1954b). This fault system is exposed on the Cradle Mountain road near Moina and has a crushed zone about 40 feet wide. The Moina Sandstone for 250 feet on either side of the crush zone is thoroughly shattered by numerous smaller faults and dragged up into a series of tight isoclinal folds. Most of the subsidiary faults are steeply dipping and strike either parallel to or normal to the Shepherd and Murphy fault. Both normal and reverse faults are

present, a few of which show wrench movement. The main fault itself consists of a wide zone of completely shattered Moina Sandstone which seems to have a near vertical dip.

Veins carrying small quantities of tin, tungsten, chalcopyrite and galena together with pyrite and quartz occur in the vicinity of the fault and some but not all of them have been brecciated by the fault movements. These observations, taken in conjunction with the linear trace of the fault and the rock distribution, indicate that the Shepherd and Murphy Fault is a near vertical reverse fault of Tabberabberan age. The regional rock distribution and minor structures near the fault zone suggest that some wrench movement, south block west, probably also occurred.

The H.E.C. damsite in the Forth River at Lorinna is located on a block of Cambrian sediments thrust up into the axial region of the Lorinna Syncline. This thrust is obscured by basalt talus to the west and by superficial deposits to the east. Drilling by the H.E.C. indicated that the limestone is continuous around the Cambrian rocks from the flats downstream from the Lorinna bridge to the mouth of Oliver Creek below Norton's property.

The southern limb of the Lorinna Syncline in the Forth Valley is formed by regularly dipping Moina Sandstone on the Five Mile Rise. No faulting of consequence or minor folding has been noted in that region. On the Tasmanian Board Mill's road to Borradaile Plains this limb of the structure is also exposed but the intrusion of the Dove Granite has disturbed the uniformity and resulted in some faulting and minor folding.

Claude Creek Synclinorium

This structure was described in some detail in the Round Mount district by Jennings (1958). From Round Mount the structure continues to the SE and can be traced to near Western Bluff where it is overlapped by the Permian rocks.

At Round Mount the NE limb of the Claude Creek Synclinorium is bounded by the Claude Creek Thrust, a powerful breakthrust dipping at 30°-35° to the NE, and to the SW by the Tin Spur Thrust. The Claude Creek Thrust continues along the east side of Claude Creek from Round Mount and appears on the Middlesex Map Sheet forming the boundary between the Moina Sandstone and Gordon Limestone SW of Standard Hill. In the Mersey River north of Liena the Claude Creek Thrust runs into a complicated zone of thrust and wrench faults formed by crossing of the Standard Hill Anticline and the Mole Creek Syncline. Beyond the Mersey the restricted thickness of Moina Sandstone between the Cambrian rocks in the Liena Gorge and the Gordon Limestone north of Liena suggests that the fault may still be present there although obscured by talus. Beyond this point it probably runs into the Gordon Limestone south of Mayberry and is lost. The outcrop of Silurian rocks along the foot of the Tiers south of Mayberry may be bounded to the north by the continuation of the Claude Creek Thrust but the available exposures are insufficient to prove this.

In the Round Mount district the Claude Creek Synclinorium is tightly compressed by the Dolcoath Granite and it plunges to the NW at 15°. In the vicinity of Olivers Hill the synclinorium opens out considerably as it is no longer restricted by the granite, the Tin Spur Creek fault also dies out and the SW limb of the

structure is formed by a series of small SE plunging folds with only minor thrusting. The appearance of Silurian rocks in the axis of the synclinorium NW of Western Bluff indicates that the SE plunge of the major structure is maintained in that direction.

The SW boundary of the Silurian rocks is not well exposed and there is some evidence to suggest thrust faulting along this margin. If this is so, the limestone between the Eldon Group and the Moina Sandstone further south probably represents the continuation of the Dolcoath Anticline of Burns (1961) and the Claude Creek Syncline would then retain the asymmetry noted at Round Hill (Jennings, 1958).

Standard Hill Anticlinorium

This is a compound asymmetrical west facing anticlinorium complementary to the Claude Creek Synclinorium. The NW limb is formed by the Claude Creek fault whilst the NE limb is unfaulted east of the Mersey River. Toward the northern boundary of the Quadrangle a NW trending thrust begins to swing toward a N-S orientation and passes into a complex wrench fault separating Mt. Vandyke from Mt. Claude and forms the NE edge of the structure. The Standard Hill Anticlinorium is best exposed in the section through the Liens Gorge. It consists of three SE plunging 2nd order folds separated by breakthrusts or synclines. As far south as approximately 8835N the whole structure plunges at about 5° but beyond this the plunges of the two western folds increase rapidly to more than 20° and the Moina Sandstone is brought down to plain level and disappears beneath the Gordon Limestone. The other 2nd order fold continues to plunge at less than 5° to the SE for almost another 4 miles before it too increases abruptly at 8818N/4325E and the Moina Sandstone is replaced by Gordon Limestone at plain level. The reason for these abrupt changes in plunge along a line between 882N and 883N is not clear but it is undoubtedly due to a flexure on the limb of the Mole Creek Syncline. The Standard Hill Anticlinorium illustrates an interesting structural pattern as it cuts across the northern limb of the Mole Creek Syncline. The crossing is effected by a pair of NW trending thrusts which pass into N-S trending wrench faults.

In the centre of the cross folding, these two fault systems are connected along the Mersey River between 4213E and 4228E by a series of smaller thrusts and wrench faults. The effect of the system as a whole is to displace the east block south. The overall pattern is similar to cross folding in the High Atlas as shown by De Sitter (1956, p. 315).

As described earlier the Claude Creek Synclinorium, near Round Mount, simply cuts straight across the northern limb of the Mole Creek Syncline by means of a conjugate pair of powerful break-thrusts.

Vandyke Syncline

The broad synclinal structure which cuts across the Fossey Mountains between Mts Claude and Roland may be traced for more than 20 miles. NW of the Middlesex Quadrangle it may be traced from Gunns Plains through South Nietta, where in cross-folding the Loongana Syncline it forms another complex basin-

like structure. SE of Mt Vandyke the structure continues with a more easterly trend along the Mole Creek Valley toward Chudleigh.

As shown by Fig. 10 the structure tends to swing more toward a N-S alignment at its NW end and towards an E-W trend at its SE end. These changing trends probably reflect the proximity of the basement rocks in both cases.

The outcrops of Silurian rocks near the Den Plain indicate that the Vandyke Syncline is asymmetrical in the same sense as the Standard Hill and Claude Creek structures. That is, the anticlines are SW facing.

In the vicinity of the Den and along the northern slopes of Standard Hill the structure is open and the limbs appear to be unfaulted. Further NW the southern limb crosses the Mole Creek syncline by means of the dextral wrench and associated thrusts described earlier, and there is evidence that the same kind of fault system may be operative on the northern limb also. Just north of the Gog Range (8895N/4511E) the Roland Conglomerate is displaced almost 2000 feet by a dextral wrench fault. This fault does not displace the Moina Sandstone on Standard Hill so it must either change character to a thrust similar to the Standard Hill Anticlinorium fault system, die out or change strike between the Gog Range and Standard Hill. The talus accumulations on the southern slopes of the Gog Range prevent examination of the fault there but no evidence could be found for its existence in the limestone further south. The similarity of tectonic setting to the Standard Hill Anticlinorium suggests that it may swing toward the SE and pass into a thrust running along the lower slope of the Gog Range north of the Den Plain.

THE STRUCTURE OF THE GOG RANGE

The Gog Range is formed by the outcrop of the Roland Conglomerate and Moina Sandstone on the northern limb of the Mole Creek Syncline. Cambrian sediments and keratophyre along the northern slopes of the range occupy the core of the complementary anticline to the north. The Ordovician rocks have a regional E-W strike and dip south at about 35°. They are cut by four major NW trending crossfolds and associated thrusts. The fault exposed at 8856N/4387E near Alum Cliffs may be taken as typical of these faults and is well exposed in the gorge of the Mersey River.

The regional strike of the main fault here is roughly NW and it dips at about 30° to the NE but the accompanying minor faulting tends to obscure the overall picture in limited exposures.

In common with many flat breakthrusts of this kind the main deformation associated with the fault is restricted to the upper plate of the fault. On the lower plate the Moina Sandstone is only mildly disturbed within a few feet of the fault and no minor faulting cognate with the main structure was observed. The upper plate has been distorted into a system of tight isoclinal folds arranged in a fan-like manner and separated by steep reverse faults which spring from the main fault. Many of the minor folds on the upper plate are truncated by the main thrust. Clearly, relief was achieved by upward movement and lateral compression. The general picture is similar to the Claude Creek fault (Jennings, 1958)

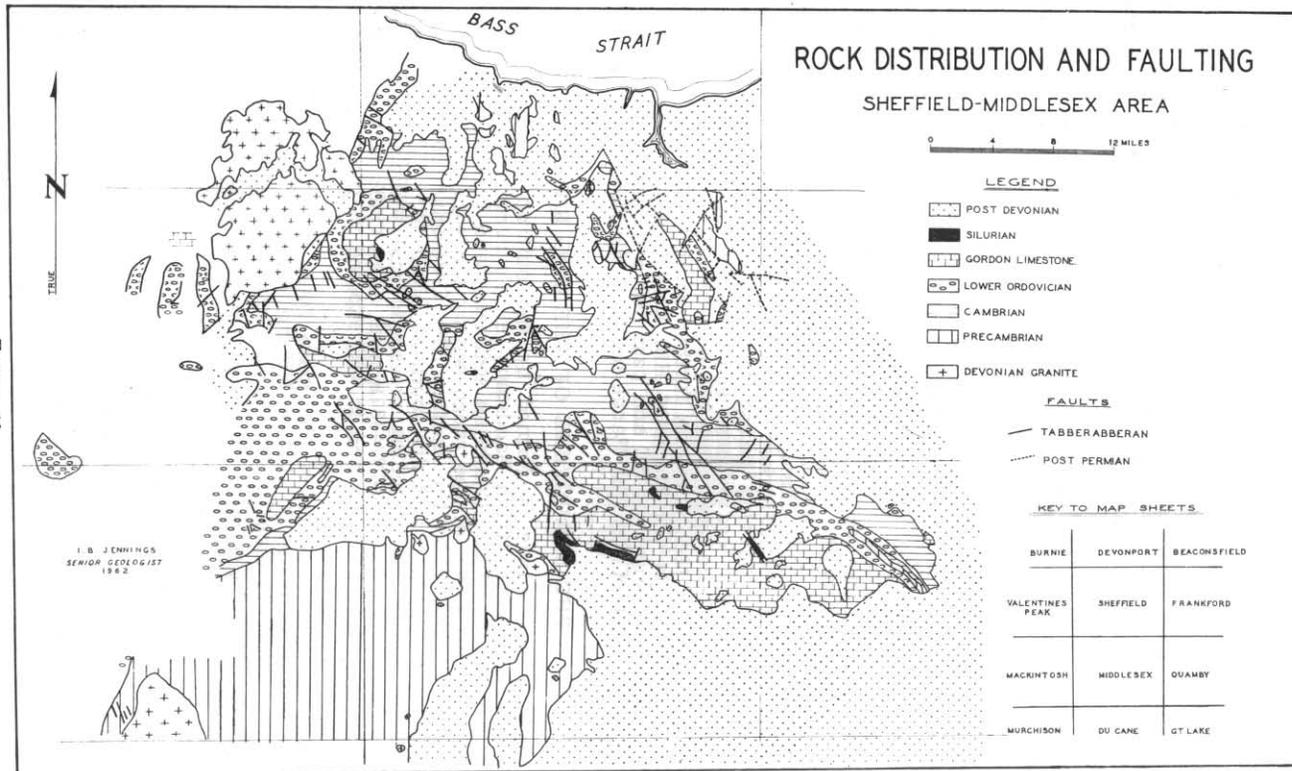


FIGURE 11.

and is characteristic of the Roland Conglomerate and its correlates here and elsewhere in Tasmania. It is considered that these thrusts penetrate to the base of the Ordovician System and then run along the Cambro-Ordovician unconformity. They are probably related to decollement between the competent, concentrically folded Ordovician quartzite and conglomerate and the sheared and folded, less competent, Cambrian formations.

The NW cross folds in the Gog Range all plunge to SE. The plunge is roughly of the same magnitude as the apparent dip of the northern limb of the Mole Creek Syncline measured parallel to the NW fold axis. This suggests that these folds developed normal to the existing foliations after the folding of the Mole Creek Syncline.

TABBERABBERAN OROGENY

The Lower Palaeozoic sedimentation was brought to a close by a period of strong folding, faulting and granite intrusion. In the Middlesex Quadrangle all rocks up to (probable) Silurian age are affected by the folding and these are overlain unconformably by unfolded Permian sediments. The age of the orogeny therefore cannot be fixed with any precision in this area but Blissett (1962) presented a summary of the evidence by means of which the movements have been assigned to the Middle Devonian. Most authors correlate the movements with the Tabberabberan Orogeny in SE Australia.

The Tabberabberan fold pattern for the Middlesex and surrounding districts is indicated on Fig. 10. Two intersecting fold systems are present, one of which is sub-parallel to the margin of the Palaeozoic basin and the other trends towards the NW. In the Middlesex Quadrangle the marginal folds are E-W whilst at the Vale of Belvoir and on the Dial Range they trend NNE.

The marginal folds are large scale, symmetrical, open folds with a semi-wavelength of about 3 miles. They rarely display plunges of more than a few degrees and second order folds of the same trend are uncommon except where they are aligned parallel to the NW set, as in the Railton district.

The NW folds are generally smaller and consistently asymmetrical (anticline SW facing), and they are accompanied by 2nd, 3rd, and 4th order dragfolding. The limbs of these folds are characteristically the site of deep seated breakthrusts in the Ordovician quartzite and conglomerate. Plunges are variable in the NW folds as they "ride up" over the marginal folds. This is shown particularly by the behaviour of the 2nd order folds on Fig. 10 and by the cross folds on the Gog Range.

The cross folding is effected by one of the following methods:

- (1) By "riding over" the marginal folds, producing sigmoidal outcrop patterns and double plunges.
- (2) By cutting straight across the earlier folds with a pair of marginal thrusts.
- (3) By the system of wrenches and thrusts described earlier (Standard Hill Anticlinorium).

Towards the edge of the Palaeozoic basin the NW folds tend to swing parallel to the edge of the basins. They are also deflected and "arched" up around the Dolcoath Granite.

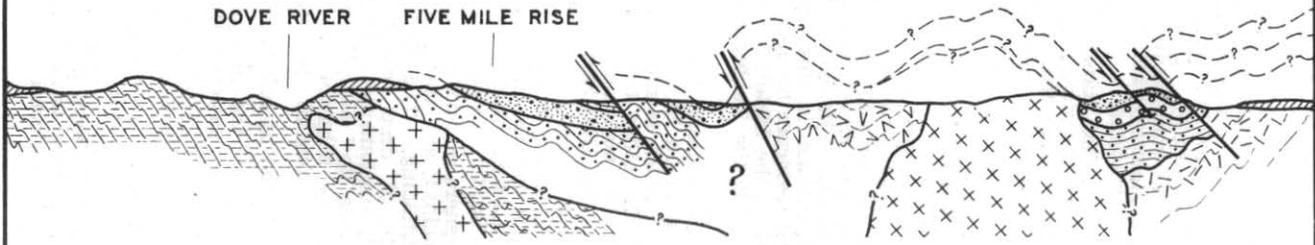
SSW.

NNE.

GEOLOGICAL SECTION ACROSS DOLCOATH GRANITE



DOVE RIVER FIVE MILE RISE



5 cm

FIGURE 12.

		TERTIARY BASALT	ORDOVICIAN		ROLAND CONGLOMERATE
DEVONIAN	{				BULL CREEK FORMATION
					LORINNA GREYWACKE
ORDOVICIAN	{		CAMBRIAN		KERATOPHYRE
			PRE-CAMBRIAN		DOVE GROUP
		MOINA SANDSTONE			

I. B. JENNINGS
SEN. GEOLOGIST 1961

The Tabberabberan fault system is indicated on Fig. 11. Most of the faults are thrusts in the Ordovician rocks as these are much more easily identified than faults in the Cambrian rocks which may be the result of earlier movements.

The breakthrusts are clearly later than the main period of folding as they cut both the marginal and NW folds. However, they are earlier than the mineralization and some of them (Claude Creek and Shepherd and Murphy faults) acted as channels for mineralization.

As mentioned previously the granite intrusion and mineralization occurred later in the orogenic cycle. The granites are unstressed, and they have been intruded along pre-existing structures in the Cambrian and Ordovician rocks and have deflected the existing folds. Regionally the granite intrusions occur along or close to the edge of the Palaeozoic trough, the Dove Granite to the south, the Housetop Granite in the NW and that at Granite Tor in the SW.

AGE RELATIONS OF THE FOLD SYSTEMS

Wherever the Tabberabberan orogenic structures have been studied in Tasmania, at least two intersecting fold patterns have been recognized. This has led to a good deal of speculation as to the number of movements involved and their order of occurrence.

Carey (1953) in his tectonic analysis, based mainly on the structure of the West Coast, suggested that the intersecting fold systems were the product of simple shear along the Great Lyell Fault Zone and many workers since that time have accepted this interpretation.

However, the structural pattern on the North West Coast (Figs. 10 and 11) is much more complicated than that of the Queenstown area as several axial trends are present and no structure similar to the Great Lyell Fault Zone can be recognized.

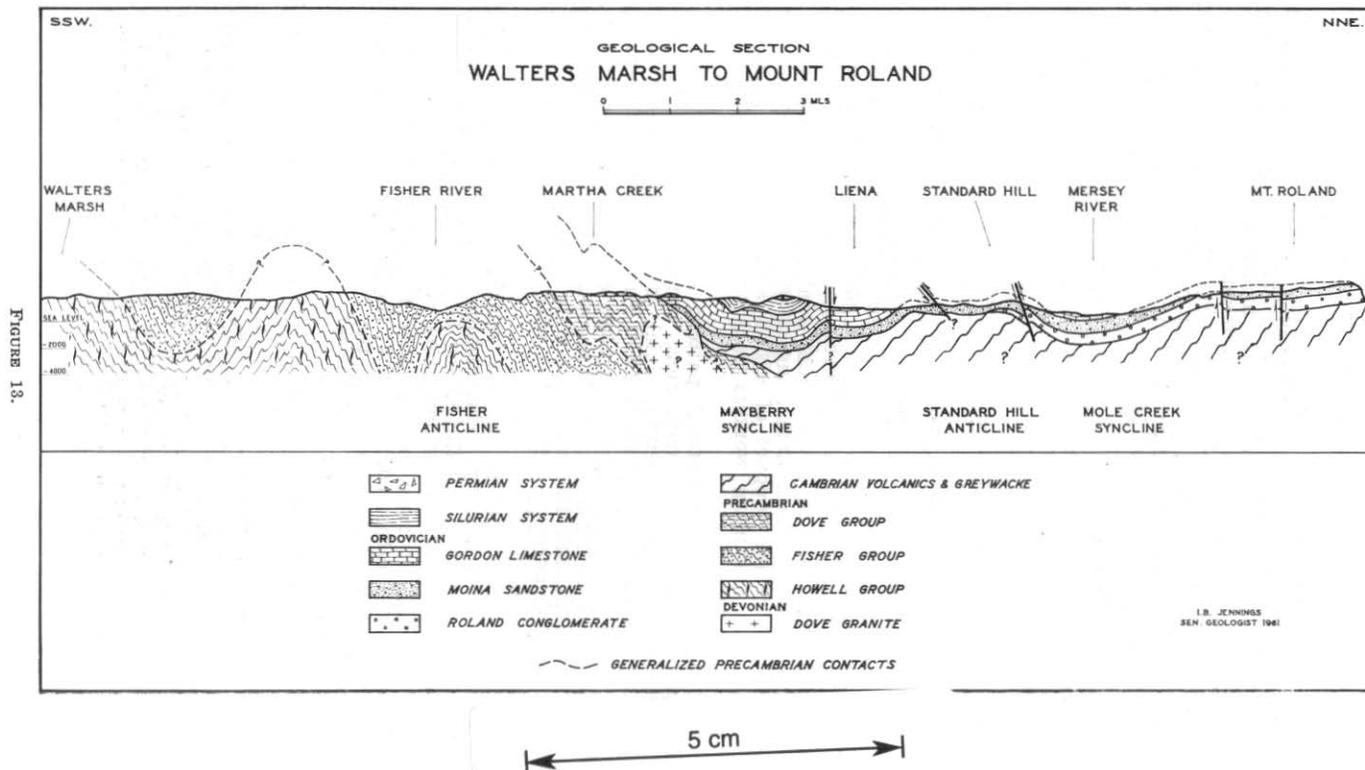
The author considers the problem can be simplified by regarding the folds as belonging to two groups, one parallel to the margins of the basin and the other trending towards the NW. In the Middlesex Quadrangle we are left with E-W trending folds crossed by NW trending folds.

Precise information on the relative ages of the folding is lacking. Good cleavage relationships in the critical areas would resolve the problem but the Magog Group formations, in which the folds are best exposed, seldom show good cleavage.

Although it must be accepted that the following thesis is unproven the author considers that the field evidence suggests that the E-W folds are earlier than the NW folds, although the time interval between the two is not great.

Evidence supporting this view is:—

- (1) The NW folds, in places, cut directly across the E-W folds by a set of strong faults.
- (2) The plunges on the NW folds where they ride up over the northern limb of the Mole Creek Syncline are similar in magnitude to the dip of that limb. This suggests that these folds developed later than the Mole Creek Syncline and that the plunging folds were formed normal to the existing foliation. This pattern is repeated over the whole area shown on Figs. 10 and 11.



- (3) In the Forth River between Cethana and Staverton sheared Cambrian volcanics possess two sets of closely spaced cleavage, one set striking at $300^{\circ}M$ and the other at $085^{\circ}-090^{\circ}M$. The NW directed cleavage disrupts the E-W cleavage. This phenomenon has been observed in one locality only.

A broader view of the prevailing tectonic conditions also supports this view generally. The Palaeozoic basin had been depressed by at least 5000 feet during the Ordovician sedimentation. It would seem logical to expect that an intensification of these tectonic conditions would lead first to further developments of folding parallel to the basin.

It is therefore considered here that in the Middlesex district the E-W folding around the nose of the Tyennan Geanticline which had been in progress since at least Middle Cambrian time was intensified by the first Tabberabberan movements. Later, the forces were resolved into compression from the NE and SW leading to the development of overiding NW directed folds and breakthrusts.

It has been shown that the Dolcoath and other granite masses were probably intruded later in the orogenic cycle. As these intrusions deflect the NW folds, although belonging to the same period of orogenesis, it follows that there was no considerable time lag between the two sets of folding. Indeed they may have been contemporaneous in some areas.

POST-PERMIAN FAULTING

The strong joint pattern impressed on the Permian and Triassic sediments and dolerite sills is clear evidence of post-Permian tectonic activity.

The only demonstrable faults assigned to these movements are the Lobster Creek fault, a fault in the Triassic rocks along the face of the Tiers near the headwaters of the east branch of Westmorland Creek and several small faults in the Permian sequences along the Tiers. The latter faults are too small to be indicated on the geological map but have been noted in the stratigraphic section.

As noted earlier, no evidence can be found for the initiation of the scarp of the Western Tiers by post-Permian faulting. The differences in elevation of the base of the Permian between the foot of the Tiers, the Mole Creek valley and the top of the Gog Range may all be explained by the regional dip of the Permo-Triassic rocks and by local topographic variations in the pre-Permian basement. Whilst post-Permian faulting may be present in these areas it is not specifically demanded by the rock distribution.

Post mineralization movement is evident on many, perhaps even most, of the Tabberabberan faults and it is possible to demonstrate post-Permian movements on Tabberabberan structures north of Railton. However, post-mineralization movement does not necessarily imply post-Permian movement on all these faults.

As some Permian sediments were deposited at an elevation of 2400 feet on top of the Gog Range and basal Permian beds are also exposed in the Beulah and lower Beulah districts, it is difficult to avoid the conclusion that Permian seas once covered most of the Sheffield and Middlesex Quadrangles.

GEOLOGICAL SECTION ACROSS WESTERN TIERS AND GOG RANGE

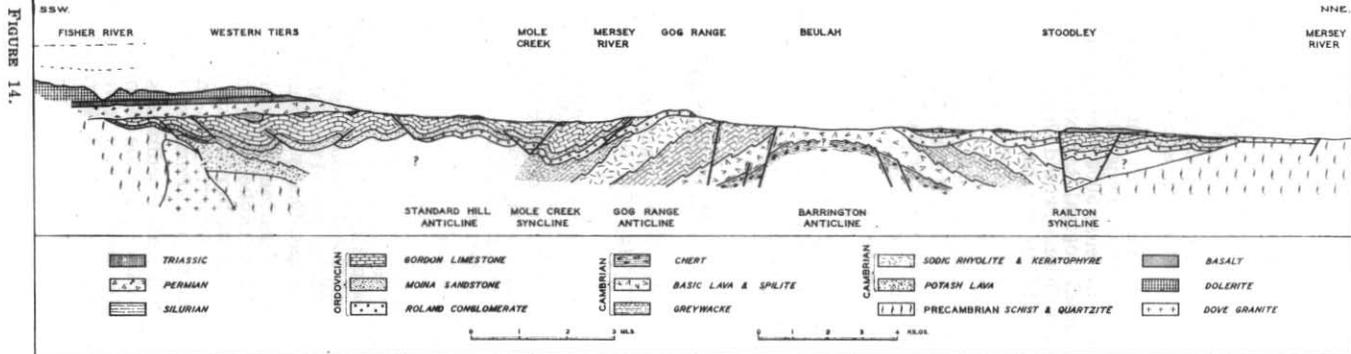


FIGURE 14.

5 cm

Perhaps the most striking feature of the distribution of post-Permian rocks is their virtual exclusion from all but the marginal areas of the Lower Palaeozoic sedimentary basin over an area of almost 1000 square miles, north, east and west of the Middlesex Quadrangle.

Thus the emergence of the Lower Palaeozoic fold belt has been re-expressed in post-Permian, probably Tertiary, epeirogenesis. The post-Permian faulting shown on Fig. 11 indicates that, at least in the Melrose-Paloona district, the faults downthrow away from the basin. The marked NW alignment of the Tertiary grabens in the Derwent and Tamar valleys, at Macquarie Harbour, Port Sorell and elsewhere is probably a reflection of Lower Palaeozoic tectonism.

ECONOMIC GEOLOGY

The country in the NW corner of the Middlesex Quadrangle has been from time to time the centre of considerable prospecting activity. During the 1880s great hopes were held for the mining fields around Lorinna but although a number of mineral occurrences were located and worked no important mines were established.

The pattern of mineral exploration in this district is similar to that in many other places throughout Tasmania. The interest began with a few sporadic discoveries which were followed by a wave of feverish prospecting and mining activity. However, the more easily worked and richer deposits were quickly worked out and this combined with new discoveries elsewhere led to the virtual abandonment of the field by the early 1890s. Since that time efforts have been made from time to time to reopen some of the mines, but no substantial production has resulted.

The early prospecting in the area was hampered a good deal by difficulty of access and the mineral discoveries in the area provided an impetus for the development of access routes. It is probably true that more money was expended on prospecting, mining speculation and access to the mines than was returned from the mines, but beneficial results are still being felt from the opening up of large areas of land for agricultural and forestry purposes.

No mines are at present working in the district and there has been no significant metal production from any of the mines in the Middlesex Quadrangle for many years.

HISTORY OF MINING EXPLORATION

The first mineral discovery was that of alluvial gold at the "Golden Point" 2 miles north of Lorinna by James Smith in 1859.

Stimulated by this report the government engaged R. C. Gunn to explore a wide area of the North West Coast in an effort to locate further mineral deposits. During this survey Gunn revisited the site of Smith's original discovery and located gold at other points on the Forth River. However, all the discoveries made up till this time were uneconomic although they served to induce prospectors to examine the district more closely.

The first gold mine in the area was the Campbells Reward discovered by the Campbell Brothers in the early 1880s. The ore was primary gold in a vein of kaolinized porphyry not far from the site of Smith's discovery. The discovery was prospected for a few years by the Campbell brothers, but in 1887 the lease was held by J. H. Glover; in 1890 the Campbells Reward Company was formed and took over the leases from Glover. The records of production from the mine are sketchy but there does not appear to have been any worthwhile production from it.

In the meantime the Campbell brothers and others continued to prospect in the Lorinna district in hope of finding more promising ore and in 1887 payable gold was located on the western slopes of the Forth valley opposite Lorinna in the area known as the Five Mile Rise. A minor gold rush resulted and within a year dozens of sections were taken up and hundreds of men were engaged in

the area. The abandoned workings testify to the energy and enterprise of these early workers. The alluvial leads which were found were quickly followed up to their source and underground workings were commenced on the various lodes.

The next few years were the hey-day of the Five Mile Rise goldfield, but despite vigorous exploration and development the alluvial gold was quickly worked out and all of the lodes failed to yield payable gold below shallow depths. Within a few feet of the surface the gold bearing reefs proved to be impoverished in gold and carried increased values of unworkable sulphides.

By 1891 the Five Mile Rise was virtually abandoned and enthusiasm had waned to such an extent that Glover (1892) reported that "Middlesex Plains has hitherto yielded no satisfactory results and at present affords but little promise of doing so."

The discovery of gold near Bell Mount in 1892 diverted the remaining miners from the field and in 1893 Montgomery noted that although the Five Mile Rise had yielded "a good deal" of gold in the past, no work of consequence was going on at that time. In 1899 Smith reported that the Bell Mount goldfield was practically abandoned but that a little work was being done on three of the mines on the Five Mile Rise.

By the time of Waller's visit in 1901 the field was again abandoned but the Devon Silver Lead Mine, in the Dove River, was in operation and had sent out regular shipments of ore since 1899. This mine continued sporadic production up to 1912 after which the leases were abandoned, though prospecting was carried out by the Mt. Farrell Mining Co. in 1923-24 prior to Nye's visit in 1928. Since that time the only recorded production from the Devon mine was a small parcel in 1937.

Twelvetrees (1913) re-examined the Five Mile Rise area and at that time the field was abandoned and most of the mines inaccessible. In 1919 Reid also carried out a geological survey of the district and he noted that all of the mines were abandoned except the Thistle which was being worked for silver-lead.

In 1916 tin and wolfram discoveries in the upper Forth valley attracted some attention and a lease in the vicinity of the Lone Pine Granite was taken up by P. Hartnett in 1918. However, by the time of Reid's visit these workings were apparently abandoned although the wolfram deposits at Commonwealth Creek, a few miles to the south, produced small quantities of ore up until 1948.

RELATION OF THE GRANITES TO MINERALIZATION

The pattern of mineralization in this district demonstrates clearly that the Dolcoath and Lone Pine Granites are related to the tin-tungsten mineralization. It is particularly noticeable that no tin or tungsten deposits have been reported in association with the Dove Granite.

The silver-lead and gold deposits are much more widely distributed and correlation of these with any particular mass of granite is less certain. A wider area around the Dolcoath Granite must be examined to obtain a more realistic picture of this distribution. Elliston (1953) discussed the zonal distribution of ore-bodies around the Dolcoath Granite, taking into account the mineral deposits at Moira and Round Hill in addition to those on the

Middlesex Quadrangle. His account indicates a reasonable zonation of mineralization around the Dolcoath Granite, with tungsten-molybdenite in and near the granite surrounded by successive "haloes" of gold, silver-lead and copper deposits further out. This account does not mention the Dove Granite.

The structure of the orebodies on the Five Mile Rise suggests that they are controlled by structures formed during the emplacement of the Dove Granite. There is also a suggestion that these orebodies at depth pass into hematite lodes carrying small quantities of sulphides and gold. Such lodes were encountered in the lower workings of the Union mine. Hematite lodes of this kind seem to be restricted to the vicinity of the Dove Granite and related to it so that it must be conceded that there is as much evidence to indicate a relationship of the gold and silver-lead to the Dove Granite as there is to the Dolcoath Granite.

These problems require further study to determine the order of mineralization in the hematite lodes and the relative ages of the granites.

THE FIVE MILE RISE GOLDFIELD

This field includes all the small mines located on the west bank of the Forth River opposite Lorinna. Access to the field is obtained by following the old Van Diemen's Land Company's route from Lorinna across the Forth toward Middlesex Plains. Although this route is still open and easily followed it is poorly surfaced and usually inaccessible during the winter. The main mines on the Rise, such as the Thistle, Golden Hill, Golden Cliff and Union can be located easily and in most cases the workings are accessible.

In the vicinity of the mines the ground falls fairly steeply to the NE affording good opportunities to explore the various deposits by means of adits. The Great Caledonian Mine was the only exception to this and this lode was worked from a shaft situated on the flat country high up on top of the Rise.

Although an early report advised driving a long adit in under the field from the lower ground in order to drain the field as well as explore it, there are no records of any of the mines being seriously hampered by excess of water. Indeed, lack of water for sluicing seems to have been a retarding factor during the early life of the field.

The Five Mile Rise is occupied by sandstone and shale of the Moina Sandstone and it forms the southern limb of a major syncline trending towards the NW. The axis of this fold crosses the Forth River near the bridge at Lorinna where a small inlier of Gordon Limestone has been preserved overlying the Moina Sandstone. On the Five Mile Rise the Moina Sandstone dips regularly at between 15° and 20° to the NE and approximates closely to the land surface. For this reason the surface exposures do not provide good stratigraphic sections. Although the surface exposures are poor there is no evidence to suggest that the major structure is complicated by strong second order folds. The main structures present are a conjugate set of fractures striking roughly 140° and 230°. These structures show out clearly on the air photos and it is notable that all the lodes so far discovered are along small faults striking at or close to 140°. The other set of fractures is occupied by weak beds and obscured by detritus and may well be mineralized also. The fractures are mainly tension cracks but some show both transcurrent and normal movement; in all cases recorded the amount of movement is small.

The lodes outcropped as gold-rich rubbly gossans which, though payable at the surface, became impoverished underground and passed into mixed sulphide ores, generally silver-lead and pyrite with minor amounts of arsenopyrite, chalcopyrite, gold, sphalerite and sometimes bismuthinite. In the lower adit of the Union mine small hematite lodes were encountered which may have been the downward extension of the sulphide veins.

The Moina Sandstone is underlain unconformably by Cambrian greywacke and porphyry and where the lodes were traced across the contact they passed into the Cambrian rocks without alteration. The surface enrichment of the lodes is clearly due to subtractive weathering of the sulphides from the upper portion of the lodes.

Although the Five Mile Rise Goldfield has been abandoned for many years and an examination of the mines indicates that there is little prospect of further development in the area, the following points emerge from a study of the old mines. These may prove useful in interpreting the geological conditions affecting mineralization in neighbouring areas.

(1) Gold enriched veins at the surface cannot be expected to persist more than 30 to 50 feet below the surface before becoming impoverished mixed sulphide veins.

(2) The veins are irregular in size both vertically and laterally and they are generally limited to a few inches in width.

(3) All the lodes which have been worked strike about 140° . However, another set of fractures striking at right angles to this does not seem to have been examined properly.

(4) The lodes occupy tension cracks formed by reopening of conjugate shears related to the Tabberabberan folds.

(5) There is evidence of a little secondary sulphide deposition in favourable beds where such beds abut against the lode channels.

(6) The lodes pinch and swell sympathetically with variation of the attitude of the fault planes. This would also be related to variations in the rock type and therefore related to (5) above.

MINERAL DEPOSITS

The following types of mineral deposits have been found in the Middlesex Quadrangle.

(1) DETRITAL DEPOSITS

(a) Alluvial gold in creek beds on the Five Mile Rise and along the Forth River.

(b) Colluvial gold on Olivers Hill in the vicinity of the Devonian Mine.

(c) Colluvial tin and wolfram on the steep slopes around the Dolcoath Granite.

(2) LODE DEPOSITS

(a) Auriferous lodes in fault zones on the Five Mile Rise and Olivers Hill. These are characterized by surface enrichment and the presence of sulphides at depth.

(b) Auriferous silver-lead lodes forming the deeper portion of (2a) above.

(c) Auriferous silver-lead zones in and near the Dove Granite at the Devon Mine and elsewhere in the Dove River. They are probably similar to (2b).

(d) Specular hematite lodes in and around the Dove Granite. These may be the downward extensive of (2b) and usually carry traces of silver-lead or zinc and sometimes gold.

(e) Tin and tungsten bearing veins and disseminations in and around the Dolcoath and Lone Pine Granites.

(f) Ferromanganese deposits in the Moina Sandstone on Olivers Hill.

THE MINING PROPERTIES

(a) GOLD MINES

O'Rourke's Hydraulic

In the early days of prospecting on the Five Mile Rise Gold-field a considerable proportion of the gold won seems to have been obtained from small alluvial workings. However, of all the work carried out on detrital deposits O'Rourke's Hydraulic is the only working which achieved anything approaching permanency. The workings extended over three creeks in the vicinity of the Union Mine at 88285N/40930E and were described by Waller (1901).

Robinson (pers. comm.) described the workings as being 10 to 13 feet deep, about 30 feet wide and extending for 300 to 500 feet along the creeks. The material worked was a coarse angular talus in which coarse gold and vein quartz with gold attached were found. Although much of the sluicing was done in an effort to locate the veins from which the gold was shed, apparently they were not found. There are no records of the production of this mine, but the total is believed to be small.

The workings were situated high up on the Rise and worked intermittently for many years but were severely handicapped during the summer months by lack of water.

As the area has been thoroughly prospected in the past it seems unlikely that any similar deposits of appreciable size have remained undetected. Nevertheless, there are doubtless still numerous small patches of alluvial ground which could be profitably treated by single prospectors during favourable periods.

The Thistle Mine

This mine (Fig. 15) was one of the early mines in the Lorinna district, being discovered by the Campbell brothers about 1887. The leases are situated about three quarters of a mile SW of the Lorinna Bridge at 88315N/41025E.

The mine was established on some gossanous outcrops of quartz and sandstone which carried free gold. Reid (1919a) stated that at the surface the gold was found as facings on the stone which could easily be detached by washing. The early workings were put in to develop the surface enriched gold bearing lodes but at shallow depths the lodes turned to galena, sphalerite, arsenopyrite and pyrite with comparatively little gold. At the time of Montgomery's visit in 1893 the mine was still being worked for gold but Montgomery reported that galena was said to have been found in the workings. The developments at that time consisted of a 45 foot crosscut adit (the top adit) with some drives on No. 3 vein.

When Twelvetrees (1913) visited the mine it was apparently deserted but the drives from the adit had been extended for 100 feet to the NW. He noted that a vein of galena 3 inches wide was showing in the face, the clean ore from which assayed:—

Lead 70%

Silver 26oz. 16dwt. per ton

Gold 19dwt. 14gr. per ton

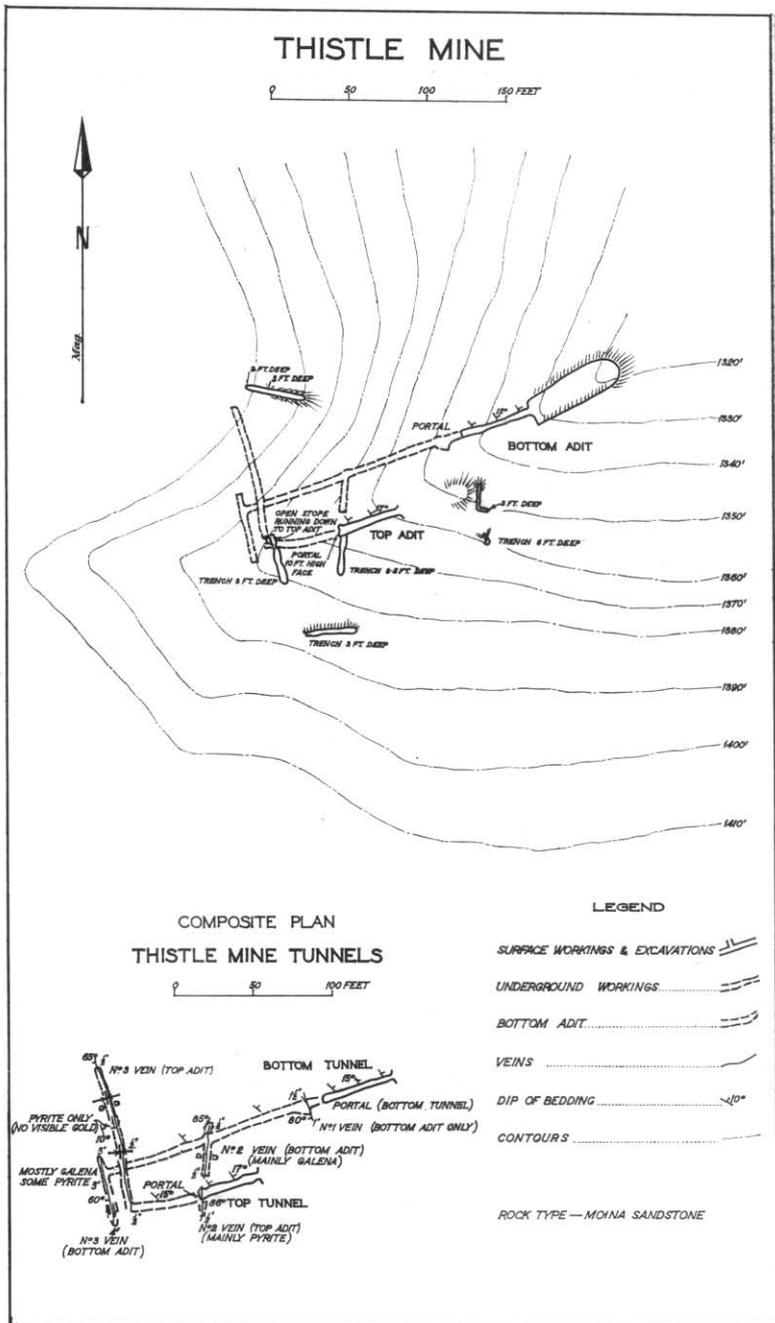


FIGURE 15.

5 cm

However, he stated that no galena appeared to have been taken away from the mine.

In 1919 Reid examined the mine and further developments were then in hand. The bottom adit had been driven to intersect three veins and some driving was being done on No. 3 vein. At this time the mine was being developed mainly as a galena prospect and such gold as was produced was contained in the galena.

After Reid's visit comparatively little work was done although the leases were held by various people up till 1925. No records are available of production of either gold or galena from this mine although from Reid's account it seems clear that at that time galena was being shipped to Staverton railway terminus.

Geology and Orebodies

The mine workings are all in sediments of the Moina Sandstone, which around the mine strike NW and dip regularly at about 15° to the NE. In the workings the sediments are cut by three tensional faults which strike NW and dip steeply to the NE and SW. The worked lodes consist of quartz and sulphide infillings of these fault zones. At the surface the sulphides have been leached out resulting in relatively high gold values.

Robinson (pers. comm.) noted that the galena ore was not brecciated, indicating that it is post faulting in age. The veins are parallel to those found at the other mines on the Five Mile Rise.

The primary orebodies consist of auriferous and argentiferous galena, sphalerite, arsenopyrite and pyrite with some chalcopyrite in a quartz gangue. Reid (1919a) noted that the arsenopyrite occurred in distinct bands which give way abruptly to galena though both of these minerals were also found in parallel and in intimate association. The sphalerite occurred in bands with the galena. The ore minerals occurred chiefly as fracture fillings, often with vughs lined with euhedral quartz crystals, and only to a minor extent as disseminations in the enclosing sandstone.

The lodes were numbered from 1 to 3 from east to west as indicated on Fig. 15. Reid recorded that Nos. 1 and 2 lodes were 2 inches wide in a formation 2 feet wide whilst No. 3 lode was 9 to 12 inches wide. However, Robinson (pers. comm.) stated that No. 3 lode is $\frac{1}{2}$ inch wide in the top adit and 3 inches average width in the bottom adit and that the other two lodes are less than 2 inches wide everywhere. Most of the stoping has been carried out on No. 3 lode.

Development

The mine workings are indicated on Fig. 15. They consist of two crosscut adits with drives on the lodes and a number of trenches on the surface. The top adit and surface works were put in prior to 1916 when the lodes were worked for gold, whilst the bottom adit is later and was put in primarily in search of economic galena veins.

The top adit was driven for 42 feet on a bearing of 230° and intersects No. 2 lode at the portal and No. 3 lode at the face. No. 3 lode was driven on for about 90 feet to the NW and stoped through to the surface workings at the intersection of the crosscut and drive. No. 3 lode was stoped underhand on the surface for 30 feet to the SE of the upper adit. No. 2 lode was trenched on the surface to a depth of 3 feet 6 inches for about 25 feet to the SE of the top adit.

The bottom adit is about 29 feet lower down the hill and slightly NW of the top adit. It was driven as a crosscut for about 140 feet on an average bearing of 320°. No. 1 lode was cut at 12 feet from the portal, No. 2 at 75 feet and No. 3 lode at the face (about 140 feet).

No. 1 lode was not developed and Reid described it as a 2 inch vein of galena to the east and as two 1 inch galena veins separated by 2 feet of sandstone on the west side of the crosscut. No. 2 lode was driven on for 40 feet along a bearing of 135° but no stoping was carried out.

No. 3 lode was driven on for 35 feet to the SE and about 10 feet toward the NW.

All of the lodes have the same strike, about 340°, but No. 2 lode dips east at 85° whilst Nos. 1 and 3 dip west at 80° and 65° respectively.

The variations in width of the No. 3 vein between that now exposed (3 inches) and the width (9 to 12 inches) recorded by Reid may indicate the presence of "swells" in the lodes similar to those noted in the Golden Hill mine.

CONCLUSIONS

The only prospect of locating further gold bearing lodes is by surface prospecting to the SE and NW along the strike of the lodes and this generally does not appear to be very promising. The lodes appear to have been fairly thoroughly tested as a galena prospect but the small size of the veins, their irregularity and the distance of the mine from transport facilities seem to have been prohibitive factors. Nevertheless, this mine has disclosed some of the most promising galena veins in the Five Mile Rise area and could perhaps repay prospecting by a small party during times of higher metal prices. The prospecting should be directed toward locating further "swells" in the No. 3 lode by further driving, rising and winzng on this vein from the bottom adit.

SAMPLING.

The following samples were taken by Elliston during an inspection of the mine in 1953.

Sample No. 1

Chip sample of 6 inch vein at intersection of top adit and No. 3 lode.

Gold	1 dwt. 4 grs. /ton
Silver	17 dwt. 6 grs. /ton
Lead	16.3%
Zinc	2.9%

Sample No. 2

Chip sample on narrow vein, No. 2 lode, top adit.

Lead	0.1%
Zinc	0.1%
Copper	0.01%
Silver	3 dwt. 4 grs. /ton
Gold	nil

Sample No. 3

Chip sample on No. 3 lode in face of drive on top adit.

Lead	5%
Copper	0.01%
Bismuth	Less than 0.01%
Zinc	Less than 0.1%
Gold	1 dwt. /ton
Silver	7 dwts. 9 grs. /ton

Sample No. 4

Selected galena from No. 2 lode, bottom adit.

Lead	17%
Zinc	10%
Copper	1.0%
Gold	5 dwts. /ton
Silver	10 oz. 3 dwts. /ton

Sample No. 5

Selected galena from No. 3 lode, bottom adit.

Lead	66.4%
Zinc	4.9%
Gold	1 dwt. 14 grs. /ton
Silver	35 oz. 2 dwts. /ton

Sample No. 6

Vein material, No. 1 lode, bottom adit.

Lead	31.8%
Zinc	17.1%
Gold	9 dwts. 4 grs. /ton
Silver	15 ozs. 8 dwts. /ton

The Union Mine

This is one of the early mines on the Five Mile Rise. The original property consisted of two 10 acre sections situated on the north side of the Five Mile Rise track about 2 miles SW of Lorinna at approximately 88275N/40930E.

The mine had been abandoned for some years when Montgomery visited the field in 1893. In 1917, E. C. James carried out some further developmental work on the leases but shortly after this the mine was again abandoned and it has not been worked since.

As with other mines in this area, early development was stimulated by the discovery of gold bearing gossans at the surface. However, at depth the lodes proved to consist mostly of sulphides with reduced gold values.

The surface workings are in Ordovician Moina Sandstone but porphyritic Cambrian rocks were encountered in the lower levels. In the adit level the lode occupies a small fault which forms the boundary between the Ordovician and Cambrian rocks.

Development

The main shaft was 105 feet deep and from the bottom of this a drive to the west cut the lode at 11 feet. About 30 feet NW of the main shaft G. Sloane and party put down an underlay shaft on the lode to a depth of 25 feet whilst a further 10 chains to the NW Reid (1919a) recorded another underlay shaft 30 feet deep on gossan, presumably on the same lode.

A crosscut adit about 100 feet below the collar of the shaft was commenced by the original workers but this was abandoned before intersecting the lode. Reid (1919a) stated that it was driven to its present length of 264 feet by James in 1917. The adit was driven along a bearing of 288° in sandstone and quartzite for the first 204 feet but beyond this it is in porphyritic Cambrian rocks. The lode outcropping at the surface was cut at the boundary of the two rock types and consists of a mineralized fault zone striking at 342° and dipping east at 75°.

The orebodies

At the surface the lode outcropped as rubbly ferruginous sandstone which carried some free gold and cerussite. Below the water table the lode contained galena and sphalerite with a good deal of quartz and pyrite and only a little gold. Reid described the lode in the adit as being 18-20 inches wide and containing quartz, galena, sphalerite and pyrite together with much chlorite. A recent sample from the fault zone gave the following assay:—

Lead—0.2%
Zinc—0.1%
Gold—Trace
Silver—10 dwts/ton

At about 230 feet from the portal a small fracture contains some pyrite and specularite giving the following assay:—

Gold—Nil
Silver—Trace
Lead—0.05%

At the end of the adit another specularite lode averaging about 2 inches wide was cut. This assays:—

Gold—Nil
Silver—Nil
Tin—Nil
Copper—0.1%

CONCLUSIONS

The lodes encountered in this mine were too small and too low grade to warrant mining below the water table. The indications are that only small selected areas above the water table were workable and these have probably been stoped out.

The main lode is of interest only in that it exhibits the same features as other lodes on the Five Mile Rise and has the same trend. The specularite veins are quite uneconomic but nothing can be said as to their persistence and size at depth. Robinson (pers. comm.), considering the whole district, suggested that they may indicate mineral zoning in the area in the following manner:—

- (1) Secondarily enriched gold bearing gossans.
- (2) Secondarily enriched sulphides.
- (3) Primary sulphide deposits.
- (4) Specularite lodes with minor sulphide mineralization.

The mine offers no inducement whatsoever for further work.

The Golden Cliff Mine

This old mine is situated about sixty chains south of the present Lorinna Bridge along the old road leading to property originally owned by Winspear. The mine workings are 600 to 700 feet above the Forth River at approximately 88243N/41080E.

The lode was discovered in 1893 by J. Thomas and outcropped as a narrow quartz vein in a cleft in cliffs of Moina Sandstone. The first report on the mine is that by Waller (1901) when O'Rourke was beginning to put in drives in the broken country under the cliffs. Twelvetrees (1913) and Reid (1919a) reported on the mine but the workings were abandoned before Twelvetrees's visit. In 1953, Nixon sampled the accessible parts of the workings and later Robinson also examined the workings but neither Nixon nor Robinson published a report. This account was compiled from the early published reports and the note made by the later workers.

The upper adit and workings at the mine are in sandstone (Moina Sandstone). The lower adit was described by the early workers as in granite but Robinson (pers. comm.) regarded the host rock in the lower adit as Cambrian sub-greywacke of the Lorinna Formation. The boundary of the Dove Granite lies a few chains south of the mine workings and it is considered that the Cambro-Ordovician unconformity lies between the upper and lower adits. The lower adit is now inaccessible and it is not clear from the available descriptions whether the lode was ever found there.

The workings consisted of an open cut, 30 feet deep, 30 feet long and 4 feet wide, 2 adits and a shaft from the floor of the open cut to the upper adit 40 feet below. The lower adit was 100 feet below the upper.

The upper adit was described as a drive 60 feet long on the vein and although in poor condition it may still be entered through a fall in the roof near the portal.

The lower adit was driven for 120 feet along a bearing of about 32°, but because of the dip of the lode to the SW it failed to cut the vein. From the end of this adit a crosscut was put in for 40 feet toward the west. From the end of the crosscut a rise was made in search of the lode but it is not recorded whether this was successful. This adit has been inaccessible for many years now.

The lode outcropped in the cliffs as a quartz vein 2-4 inches wide. However, Reid (1919a) noted that the gold was not in the quartz but on the walls and in the interstices between quartz particles or implanted on drusy quartz crystals. Waller mentioned that O'Rourke had picked up fragments of quartz studded with flakes of gold in the talus at the bottom of the cliff.

In the open cut and in the end of the upper drive the lode was described as a 1 inch vein in a band of clayey shale. Below the surface the vein carried sulphide and Reid reported the presence of pyrite and arsenopyrite. He stated that the high gold values at the surface were due to secondary enrichment. Some ferro-manganese was associated with the lode.

The strike of the vein is consistently recorded as being between 320° and 340° and Reid (p. 166) mentioned a dip of 40° to the SW (although it is not clear that he was referring to the gold bearing

vein). Twelvetrees noted that the vein had a flat underlay to the SW and Robinson (pers. comm) stated that the vein dips to the SW at 75°.

It seems clear that the vein was similar in most respects to the other lodes discovered on the Five Mile Rise:—

- (1) It was narrow, averaging less than 2 inches and relatively impersistent.
- (2) It carried reasonable gold values at the surface but contained sulphide and was unpayable below the surface.
- (3) The strike was about NW-SE and it dipped at (probably) variable angles to the SW.
- (4) It was probably an infilled joint or fault zone.

All workers seem to have agreed that this mine had little chance of success. Waller (1901) remarked that it was "doubtful if the reef will be payable". Twelvetrees (1913) noted that the vein was of good quality, narrow, "of course, unpayable" and that it showed no tendency to increase in size underground. Robinson (pers. comm.) stated that the mine showed no prospect of justifying further work.

Results of sampling by Nixon are set out below.

Sample No. 1

From iron stained fracture zone at face.

Lead—over 0.3%
Copper—under 0.01%
Zinc—under 0.1%
Silver—Trace
Gold—Nil

Sample No. 2

At face of drive on small fault.

Gold—Nil
Lead—0.05%
Silver—Nil

Sample No. 3

6 feet from face of drive in buff coloured clay.

Gold—Nil
Silver—Trace
Lead—0.05%
Copper—0.01%

The Golden Hill Mine

This is one of the old mines of the Five Mile Rise goldfield which was abandoned and inaccessible long before Twelvetrees inspected it in 1913. Waller (1901) described the property as comprising four 10 acres sections 1475-1478/93G held by L. J. Bryant.

The mine is situated low down on the Five Mile Rise, only a few hundred feet above the Forth River and about 100 yards north of the track at approximately 88230N/41075E. It was connected by a tramway to a machinery site on the west bank of the Forth River. In September 1898, 11.5 oz. gold was produced from 50 tons of ore and prior to that 6 oz. gold from 12 tons of ore was recorded.

No mining has been carried out on the property for more than 60 years but a 10 acre section, No. 57M-51, covering the mine workings, was taken up in 1951 by A. Smith of Lorinna who carried out some prospecting in the vicinity, chiefly on alluvial ground above the adit. No production resulted. The area is now vacant.

The mine workings were described by Waller (1901) and Twelvetrees (1913). However, when Twelvetrees visited it, the mine was already inaccessible and his report is drawn largely from Waller's earlier description. In 1953, Nixon made a detailed survey of the mine and carried out an extensive sampling programme. Later, Robinson re-examined the mine and summarized his own and Nixon's views in an unpublished note to the author. The following account has been drawn from all available material but chiefly Nixon's and Robinson's work. The plans (Figs. 16, 17, 18) have been prepared from Nixon's survey notes.

Geology

The bedrock in the vicinity of the mine is quartzite, shale, calcareous shale and limestone belonging to the Moina Sandstone. These rocks are intersected by a conjugate set of fractures trending 140° and 230° which are symmetrically related to the regional fold axis, a major syncline trending roughly NW. The orebodies are confined to small tensional faults parallel to the 140° fractures.

In the mine workings the quartzite and shale strike 292° and dip 30° to the NE; little variation from this has been noted anywhere in the mine. These rocks are cut by 3 small normal faults striking at 140° with high dips generally to the SW. These fault zones have been mineralized and in the underground workings carry gold, silver, pyrite, galena and sphalerite together with small amounts of copper and bismuth. At the surface the mineralized fault zones were enriched by the removal of the sulphides and cropped out as narrow ferruginous gossans carrying quartz and relatively high gold values.

The faults are tensional structures generally downthrown to the SW but with some wrench movement. The total displacement is always less than 5 feet. Due to the transcurrent component of movement on the faults, the overall displacement, where it can be determined, is SW block down and northwards. The information available is insufficient to determine whether the displacement was effected in a single movement or by two separate movements.

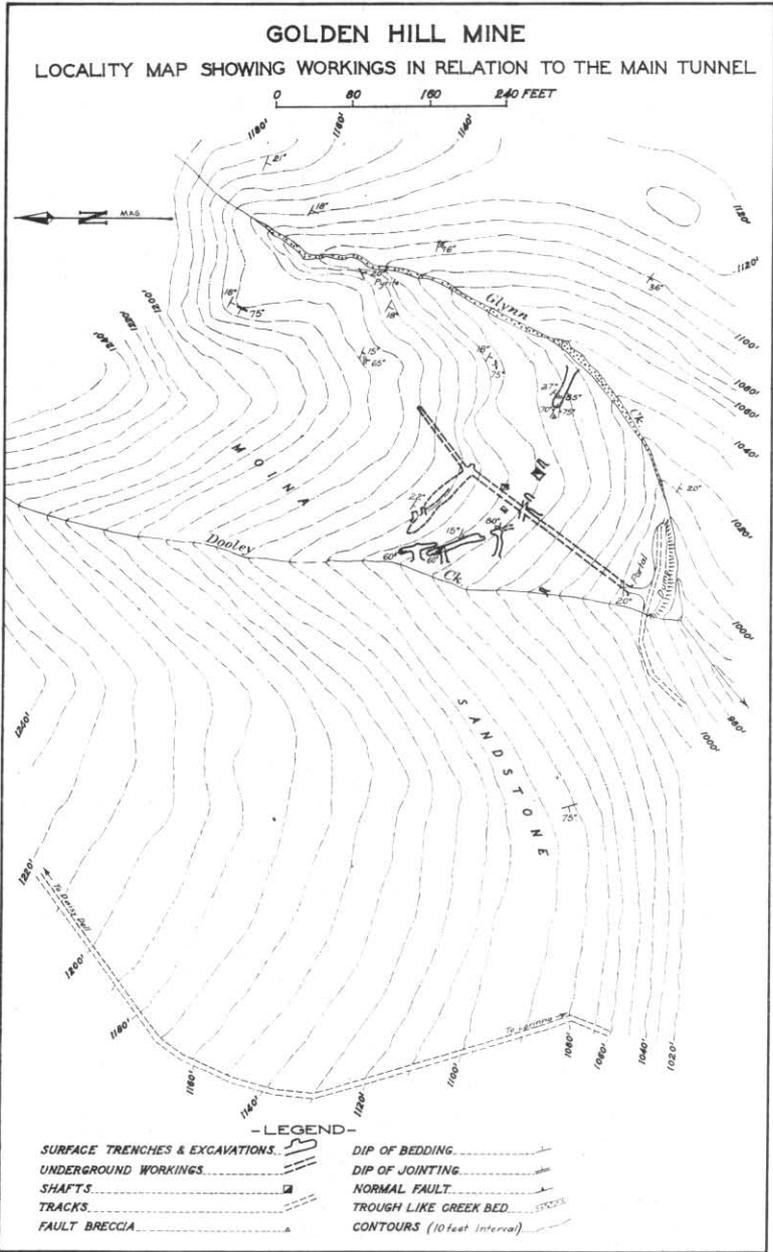


FIGURE 16.

5 cm

Development

This comprises several surface cuts and trenches and a main crosscut adit 800 feet long with associated drives. Three veins were intersected in the crosscut and numbered 1 to 3 consecutively from the portal inwards.

No. 1 vein was cut at 130 feet from the portal and No. 2 vein a further 20 feet in. The ground in the vicinity of these veins was stoped out to the surface and is now quite inaccessible. Waller (1901) noted that the No. 1 vein was risen on for about 20 feet but it was apparently small and most of the work was done on the No. 2 vein. This was risen on and it "widened considerably" toward the surface when it had been stoped underhand from an underlay shaft for about 150 feet. Gossanous material from a 6 inch vein at the end of these stopes assayed:—

Gold—18 dwts. 19gr. /ton

Silver—1 oz. 19 dwts. 5 gr. /ton

No. 3 vein was cut at 210 feet from the portal and was driven on to the SE and NW. The NW drive is only 9 feet 6 inches long in shale on the NE side and breccia on the SW side. At the face 2 faults 2 feet apart are exposed and the ground between the faults has been brecciated. The "lode" here was only a fraction of an inch wide.

To the SE there are two drives on the intersection of a mineralized shale band with the fault. The fault has a displacement of about 5 feet, and the drives are separated by this distance as indicated by Waller (1901, Plate 2).

The ground above these drives in the vicinity of the adit has been stoped out and is now inaccessible.

The mining activities in the vicinity of No. 3 vein were directed not only to the vein proper but also to sulphide orebodies which occurred in the shale band. In places along the drives, up to 2 feet of massive sulphide ore was encountered. Waller regarded the sulphide ore as being primary ore replacing a favourable bed and that the orebody therefore showed promise. However, both Nixon and Robinson considered that the sulphides were due to secondary deposition of material leached from the vein. The lack of other primary sulphide replacement bodies in this area together with the localization of the mineralization in weathered portions of the No. 3 vein suggests that this later view is more probably correct.

Nixon's description of the two SE drives in No. 3 vein are as follows:—

(1) Upper drive:—90 feet long. For the first 60 feet the sulphide bearing shale band has been mined out along the bedding plane to the east. At 70 feet a quartz vein carrying pyrite and averaging 3 inches in width occurs. At the end of the drive this vein has pinched out to a mere crack.

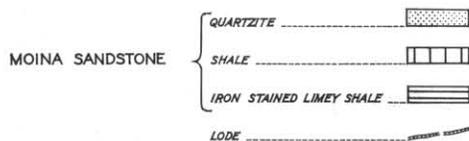
(2) Lower drive:—This follows the same vein as the upper adit for 65 feet. Only a little stoping has been done on the shale bed from this level.

The interesting features of this vein are the secondary sulphide deposition in the shale band in the vicinity of the fault and the variation in thickness of the vein. Nixon noted that the vein

GOLDEN HILL MINE—LONGITUDINAL SECTION

0 20 40 60 80 FEET

—LEGEND—



N.B. THE LITHOLOGY SHOWS THE DISPLACEMENT ON THE MAIN FAULT AND DOES NOT INDICATE 'FAVOURABLE BEDS' TYPE DEPOSITION. THE LOCALISATION OF THE ORE SHOOTS IS CAUSED BY VARIATIONS IN STRIKE AND DIP OF THE FAULT.

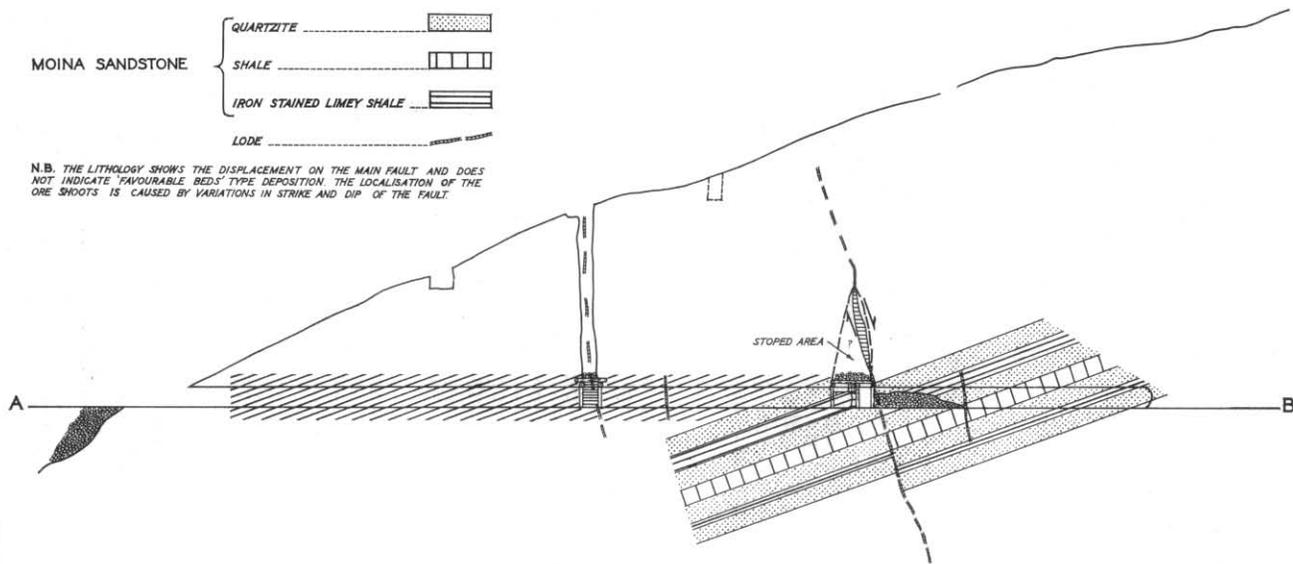


FIGURE 18.

5 cm

was widest when the fault steepened and the strike was at 140°. If either one of these factors did not apply the vein was thinner and if both factors were absent the vein became a mere crack. It seems clear that the vein has filled apertures left in the fault zone by variation in strike and dip of the fault.

As it stands, the mine is worked out and further prospecting should be directed along the fault in the hope of picking up further "swells" of ore. It would be well to confine the driving to the intersection of the fault and the porous shale and thus any further sulphide bodies associated with the veins would also be picked up.

CONCLUSIONS

- (1) The lodes consist of infilled fault zones.
- (2) Secondary enrichment due to extractive weathering produced relatively rich ore at the surface but the grades decreased abruptly underground and were uneconomical for the most part.
- (3) The "swells" in the ore bodies were due to variation in strike and dip of the fault plane and could be important in localizing high grade ore. The variation in the fault attitude may well be controlled by variations in competency of the various beds.
- (4) The ore bodies underground contained sulphides both in the veins and as secondary sulphide deposits in favourable beds.

SAMPLING

The results of Nixon's sampling programme are tabulated below. The sample numbers refer to localities indicated on Fig. 17.

Sample No.	Type of Sample	Result
1.	Channel 66" x 3" x 1"	Gold 3 dwts. 11 grs.
2.	(A) Channel 48" x 3" x 1" in quartzite	Au. Trace
	(B) Channel 48" x 3" x 1" in shale	Pb <0.05% Nil for Cu, B, Zn, Co. Sn, W, Au, and Ag.
3.	(A) Channel 54" x 3" x 1½" in shale	Gold—Tr.
	(B) Channel 9" x 3" x 1" in quartzite	Gold—Tr.
4.	(A) Channel 28" x 3" x 1" in quartzite	Gold—Tr.
	(B) Channel 45" x 3" x 1" in shale	Gold—Tr.
5.	Channel 66" x 3" x 1"	Gold—Tr.
6.	Channel 66" x 3" x 1"	Gold—2 grs.
7.	Vein material on fault	Gold—2 oz. 4 dwts. 21 grs.
8.	Channel 48" x 3" x 1"	Gold—Trace
9.	Channel 48" x 3" x 1"	Gold—Trace

Sample No.	Type of Sample	Result
10.	Channel 48" x 3" x 1"	Gold—2 grs.
11.	Channel 72" x 3" x 1"	Gold—Trace
12.	Channel 60" x 3" x 1"	Gold—2 grs.
13.	Channel 50" x 3" x 1"	Gold—2 grs.
14.	Chip sample from face of drive	Gold—8 dwts. 16 grs. /ton
15.	Chip sample of quartz vein	Lead 0.3% Copper 0.05% Bismuth 0.01% Zinc 0.1% Gold 11.7 dwts. /ton Silver 79.7 dwts. /ton
16.	Chip sample of quartz vein	Lead 0.5% Copper 0.05% Zinc 1% Gold 1.5 dwts. /ton Silver 9.5 dwts. /ton
17.	Chip sample from E wall of drive	Lead 0.2% Copper 0.01% Zinc 0.3% Silver 3.4 oz. /ton
18.	From small fissure vein	Lead 0.2% Copper 0.01% Zinc 0.7% Cobalt 0.01%
19.	Chip sample	Gold—Trace Silver—Trace
20.	Chip sample	Nil
21.	Chip sample	Silver—Trace
22.	Chip sample	Nil
23.	Chip sample	Nil
24.	Chip sample from shale bed	Lead 0.08% Copper 0.01% Zinc 0.1% Silver—Trace
25.	Chip sample in shale bed	Nil
26.	Chip sample from ½" vein	Gold 10 dwts. /ton Silver 3.7 oz. /ton Lead 4% Zinc 10%

Sample No.	Type of Sample	Result
27.	Chip sample	Lead 1% Copper 0.05% Bismuth 0.01% Zinc 8% Gold 20.4 dwts. /ton Silver 59.3 dwts. /ton
28.	Chip sample	Lead 0.1% Zinc 0.1% Silver—Trace

Note: All samples were tested primarily for gold. Where no gold result has been indicated it may be taken as absent.

Campbells Reward Mine, Lorinna

This mine is located close to the east bank of the Forth River about a mile downstream from Lorinna a short distance below the old road at 41170E/88663N.

The mine is in weathered volcanic rocks of the Bull Creek Formation in which the mineralization was restricted to a kaolinized feldspar vein. As this mine was the first discovered in the district and has been abandoned now for a great many years, the adit is in a rather poor condition. Twelvetrees (1913) reported that the workings were "not in a condition for inspection". Mr. A. Campbell, one of the original discoverers told him that gold was free milling and in a barbed wire form, contained in a narrow vein of kaolin which widened out and carried a foot to 15 inches of barren quartz. The gold was reported to contain a good deal of silver and only brought a low price.

The workings appear to have been cleared out a little since Twelvetrees's visit, and the adit, though still in poor condition, is accessible for 230 feet from the portal, beyond which it is blocked by fallen ground. The vein worked is not exposed in the workings at present but similar altered feldspar veins may be seen.

It would appear that this mine is worked out. Similar feldspar veins may be found in the same general area but no gold mineralization is known to be associated with them.

The Glynn Mine

This old mine was inaccessible at the time of Twelvetrees's visit in 1913 and has not been located during this survey. The original sections held by the company were Nos. 730, 721, 1010 and 1011-93M totalling 30 acres. The workings were situated on section 1011-93M which Twelvetrees (1913) described as being high up on the Five Mile Rise at an elevation of about 2000 feet.

The only description of the workings is that given by Smith (1899) and this is summarized below.

The mine is sited in sandstone and slate (Moina Sandstone?) which strike E-W and dip gently to the north. Tertiary basalt occurs to the NE of the mine.

Workings

From an open cut a winze 16 feet deep was sunk and connected by a crosscut to a shaft 35 feet deep which had been sunk from a ridge to the west of the lode. Later an adit was put in 25 feet below the old workings and cut the lode at 49 feet. The lode was 3 feet wide at this point and it was driven northwards for 26 feet but was pinching out in the end of the drive.

The material worked was crushed sandstone with broken ferruginous quartz. Smith considered that the lode would continue to depth but that it would contain pyrite. From this description it would seem that the mineralization was contained in one of the small fault zones so common in the area.

Production

Prior to Smith's visit tributors had crushed 55 tons of ore, of which 35 tons were seconds, for a return of 19 oz. of gold. The company crushed 117 tons of mixed firsts and seconds for a return of 36½ oz. of gold valued at £3 2s. per oz. in the quarter ending 30th September, 1898. In the next quarter 150 tons of stone were treated yielding 61 oz. of gold. Smith reported that the gold was of poor quality, being highly argentiferous, and worth only about £2 10s. per oz.

No further returns from the mine are recorded after December 1898 and apparently the leases were abandoned after that time.

The Great Caledonian Mine

Located at 88265N/40638E, this is topographically the highest mine in the district.

It was discovered by J. Aylett in 1887 and following promising returns from the outcrop a 15 head battery was transported to the site. After a few crushings it became apparent that the lode was unpayable at depth and the mine was abandoned. The stamp battery was later transferred to the Golden Hill mine and the remaining buildings were destroyed by fire. The workings are now flooded and quite inaccessible.

The mine shaft was sunk in Moina Sandstone and passed into Cambrian greywacke and porphyry at depth. The unconformity occurs on the surface a few chains south of the mine, and the shaft sunk on Johnson's reef a little distance south of the main shaft encountered the Cambrian rocks at the surface.

The following information has been extracted from earlier reports, chiefly that of Reid (1919a).

The workings consisted of a shaft 50 feet deep with a cross-cut driven westerly for 60 feet from which point a winze 50 feet deep was put in.

The lode outcropped as a small irregular vein of ferruginous quartz and sandstone but at depth the material encountered seems to have been a ferruginous sandstone. At the outcrop the lode is said to have returned 12 dwts. of gold per ton for a couple of crushings but it was apparently unpayable below the surface.

At Johnson's reef an outcrop of dense hematite contained a vein of pyrite 4 to 12 inches wide which was said to have carried gold at the surface. This vein also must have been unpayable below ground as workings were abandoned within a few feet of the surface.

In 1934 the shaft was unwatered and a parcel of ore broken from below the 50 foot level. This returned 14 dwts. of gold from $2\frac{1}{2}$ tons of stone. The tunnel level was extended 12 feet and a crosscut put out for 24 feet. In the following year the mine was taken over by J. Godwin who unwatered the shaft to the 50 foot level and carried out some driving and crosscutting.

The Devonian Mine

This mine was on section 416-93G, 10 acres, taken up by J. J. Wilson in 1895. It lies at an elevation of about 2400 feet a.s.l. about a mile to the NE of Olivers Hill, $2\frac{1}{2}$ miles NE of Lorinna at approximately 414250E/888400N. The workings lie close to the ferromanganese deposits on Olivers Hill and are indicated on Fig. 19.

The mine has been abandoned for many years now and the shaft is inaccessible. Only the surface workings consisting of some trenches may be examined. Twelvetrees (1913) described the lodes as a main vein 4 inches wide and another vein on either side of the trench with other veinlets between them. He also stated that at the surface one dwt. of gold to the dish could be obtained.

The lode is contained within the crush zone of a NW trending thrust fault in Moina Sandstone. Since the original works were carried out the dump has been retreated but the results of this have not been recorded.

Samples taken during a recent survey of the area showed the following results:—

- (1) From a 9 inch vein in underlay shaft.

Au —nil
 Ag —7 dwts. 20 grs./ton.
 Pb —0.8%
 Mn—Trace
 Fe —2.5%

- (2) Flat 3 inch vein in underlay shaft.

Au —1 dwt. 20 grs./ton.
 Ag —3 dwt 7 grs./ton.
 Pb —1.8%
 Mn—Trace
 Fe —1.3%

- (3) Ferruginous sandstone from dump.

Au —nil
 Ag —nil
 Pb —nil
 Mn—0.14%
 Fe—32.1%

The indications are that the lode here was probably similar to those on the Five Mile Rise. That is, a mineralized fault zone relatively rich in gold at the outcrop but passing into sulphides with poor gold values at depth.

(b) IRON PROSPECTS**The Powerful Mine, Lorinna**

In earlier reports this mine is sometimes referred to as Reardon and Day's mine.

It is situated at approximately 8810N/4114E on the east side of the Forth River near its confluence with the Dove River.

The mine was started about 50 years ago by S. Reardon and a local syndicate to explore some bold outcrops of a quartz and specularite lode which carried small quantities of gold. The lode occurs in the Dove Granite about a mile north of its boundary with Precambrian schist of the Dove Group. In the vicinity of the mine the granite is everywhere deeply weathered and no specimens of the country rock suitable for petrological examination were found. The granite is medium to coarse grained and consists of kaolinized pink and green feldspars with rounded and embayed quartz crystals and altered biotite.

The mine was described by Twelvetrees (1913) and Reid (1919a) who regarded the granite as a member of the "porphyroid" series, i.e., the Cambrian rocks thereabouts. Despite this, Reid noted that the granite "greatly resembled" the Devonian biotite granites.

The assumption that the Dove Granite was a plutonic member of the Cambrian rocks was considered by Twelvetrees to indicate that at depth the lode might prove to contain economic sulphide mineralization. It has been noted elsewhere in this report that the Dove Granite is associated with sulphide deposits in contrast to the marked tin-tungsten association of the Dolcoath Granite. This supports Twelvetrees's view, though the relegation of the Dove Granite to the Cambrian is not considered to be valid. Development work on the mine indicated that the lode showed no sulphide mineralization at the depths explored and had little economic value.

The detailed workings were described adequately by Twelvetrees and Reid. They consist essentially of a number of small trenches and open cuts on the hillside above the road and an adit driven in from road level for about 100 feet.

This consists of a quartz hematite lode containing varying quantities of pyrite. Robinson (pers. comm.) stated that the lode strikes 320° M and dips to the west at about 75° , whilst Twelvetrees gave the strike as NW and the dip 30° to the SW. As Twelvetrees's observations were made upon outcrops which have since been removed and Robinson had access to exposures in the adit which were not available to Twelvetrees it seems probable that both writers are partly correct and that the dip of the lode is variable. This may account for the variation in thickness given by Reid (1919a) and Robinson (pers. comm.). Reid estimated the lode to be from "8 to 14 feet wide" from the surface workings; Twelvetrees gave 40 to 50 feet for the width of the lode system together with "horses" of granite, and Robinson considered the horizontal width to be 190 feet. In the adit only 7 feet 6 inches horizontal width is encountered but the adit has not been driven far enough to prove the overall lode width.

Twelvetrees (1913) quoted some early assays of the ore from surface workings which indicated that it carried small quantities of gold and silver. Exploration was carried out in the hope that the gold value would increase below the surface and that massive sulphide would be encountered.

Recent samples from the lode from both the surface workings and the adit have not shown any values of gold, silver, copper, wolfram, tin or bismuth.

CONCLUSIONS

This lode was developed as a potential source of either gold and silver or massive sulphide but all the work carried out indicates that no such mineralization of an economic grade is present. Thus its only possible use, as known at present, is as an iron ore. Unfortunately, the exploration and assays which have been carried out so far are not sufficient to delimit accurately the size and grade of the deposit as iron ore. Robinson considered that the lode is faulted at the southern end and that the mineralization gradually weakens to the north. He suggested a strike length of 700 feet whilst Reid (1919a) indicated that the lode had been cut in trenches on the surface over a distance of six chains.

The relative remoteness of the deposit from markets, the poor access and its small size, has led all previous workers to assume that the lode would be uneconomic as a source of iron ore. This view is probably correct as transport costs would be still very high.

To explore the deposit thoroughly and determine its true dimensions and grade it will be necessary to continue the adit for at least another 100 feet until a true section of the lode can be measured and sampled.

(c) SILVER-LEAD MINES

The Devon Mine

This mine has not been worked for many years and the workings are now inaccessible. The information upon which this account is based has been obtained from early reports and from examination of surface outcrops in the vicinity of the mine.

The Devon Mine is situated on the south bank of the Dove River at 880000N/407000E. At this point the Dove River has cut a precipitous gorge more than 1500 feet deep and this presents a formidable problem for access to the mine. Pack tracks were cut along the north side of the gorge through a property locally known as "Winspear's" and from the top of the Five Mile Rise and all mining equipment had to be packed in by horses. The ore was transported out by the same method and the resulting freight charges severely limited the success of mining operations. At present the old tracks are completely overgrown and the Dove River must be forded at the mine.

The mine was reported on by Smith (1899), Waller (1901), Twelvetrees (1908, and 1913), Reid (1919b) and Nye (1928).

The mine is situated close to the boundary of the Dove Granite and Precambrian schists of the Dove Group. The mine workings proper are in porphyritic granite and do not enter the enclosing

schist. The plateau north of the Dove River is occupied by sandstone and shale of the Moina Sandstone underlain unconformably by Cambrian greywacke and lava. Tertiary basalt occurs NE of the mine along the old track through Winspear's property. The porphyritic granite at the mine is not typical of the Dove Granite as a whole but represents a marginal phase.

The original lode was discovered by Malcolm Campbell in 1892 but no work other than prospecting was done until the leases were acquired by the Devon Mining Co. N.L. in 1897.

Smith (1899) reported that a tunnel had been advanced to 85 feet and Waller (1901) noted that the company had been sending out regular shipments of ore since 1899. From May 1899 to September 1902, 248 tons of argentiferous galena was produced from Nos. 1 and 2 Adit Levels.

In 1903 a start was made in sinking a shaft but no further production was recorded until 134 tons of galena was produced between March, 1907 and December, 1908.

The next record of production was 18 tons in 1912 and the leases were abandoned in 1915.

The Mt Farrell Mining Company took up the leases and prospected the area during 1923-24 but no production resulted and the leases were abandoned again.

In 1937 the Dove River Prospecting Syndicate took over the leases, cleared out the tracks and commenced operations. However, the only production recorded was 15.7 tons of galena ore which yielded 6 tons of lead, 931.7 oz. of silver and 6.3 oz. of gold.

In 1939 the leases were taken up again with the intention of installing pumping machinery but little progress had been made by the end of the year. The last production from the mine was 1.93 tons of concentrates in 1941 containing 1.23 tons of lead, 149.6 oz. of silver and 0.34 oz. of gold.

The total recorded production from the mine to date is about 418 tons of galena.

The following account of the mine workings and ore bodies is quoted from Nye's (1928) report on the mine.

" Mine Workings

The mine workings consist of two main adit levels (Nos. 1 and 2) and the drives from these on the lodes. A main winze or shaft has been sunk from the No. 2 adit and the No. 3 level opened up from it. Another winze connects the Nos. 2 and 3 levels, and the latter is also connected to the surface by a shaft sunk to the north of the No. 2 adit. Three other adits occur above the Nos. 1 and 2 adits, two of which have been driven in recent years for prospecting purposes.

The No. 3 level was worked chiefly from the winze in the No. 2 adit level which was equipped with a pumping and winding plant.

The Orebodies

Devon Lode—The above workings were all carried out in order to prospect and mine the Devon lode. This lode was exposed in open cuts and at the surface and in the drives at Nos. 1, 2 and 3 levels.

The following description has been prepared from the previous reports, the material on the dump, and the limited observations during the present trip:—

The lode had a general north and south strike being generally west of north at the north end and west of south at the south end. The dip was generally high to the east but above the No. 2 adit it was certainly reversed and at high angles to the west.

The lode formation was 2 or 3 feet wide and consisted of country rock, gangue and ore minerals. The gangue was chiefly quartz, together with a smaller amount of siderite. The primary metallic minerals were galena, chalcopyrite, sphalerite and pyrites. The oxidized minerals resulting from these were cerussite, malachite, azurite and limonite.

It is reported that the galena was the most plentiful of the metallic minerals and occurred in veins ranging in thickness from a few up to 15 inches. In the second grade ore on the dump, the galena, &c., is more or less mixed with the quartz gangue.

During the active mining operations the clean galena was kept separate and was sent to market. The reported assays of the marketed ore are as follows:—

Lead—56-70%

Silver—72-87 oz. per ton

Gold—2-5 dwts. per ton.

The ore was of good grade for hand picked ore with a high lead content, silver to the amount of $1\frac{1}{2}$ oz. per unit of lead and the unusually high gold content.

The clean galena apparently occurred in shoots in the lode and these have been stoped out down to the No. 2 level at least. The information available does not refer to any stoping from the No. 3 level, but it is probable that all shoots of payable ore between the No. 2 and No. 3 levels were stoped out. The main ore shoot had a northerly pitch.

The future of mining operations on this lode therefore depends upon the location of any other ore shoots to the north and south of those worked (there is no geological evidence for or against the existence of such shoots) and upon the location of payable ore below No. 3 level. Deeper sinking would entail heavy pumping and winding costs and viewing the position generally it would appear that these would be too great unless the payable ore shoots attained greater dimensions than those already worked in the mine.

Other lodes. Several other small veins and lodes have been exposed in the underground workings. One of these was cut in the entrance of both Nos. 1 and 2 adits but was not apparently wide or rich enough to warrant any development work. It dipped west and might junction with the Devon lode at depth.

In Bulletin 30 Reid described the Nos. 2 and 3 lodes west of the Devon (No. 1) lode. Both these lodes were driven on north and south but apparently payable shoots were not proved by development work. The No. 3 lode is stated to have a gossan outcrop at the surface assaying 8 dwts. 4 grs. of silver per ton.

At the north end of the surface workings on the Devon lode a formation (called the Diagonal lode) with a little galena appears to run into the footwall to the SSW. If this continues to the south it might possibly be connected with the No. 2 lode in the No. 1 adit.

Further up the hill, and about 50 to 80 feet west of the Devon lode, a gossan formation (called the Big lode) is exposed in two places. At the northern exposure a vertical seam of gossan, two feet wide, has a bearing of 161° . At the southern exposure, two seams of gossan occur at the surface with a horse of mullock between, but these unite at depth and a vertical seam of gossan four feet wide is formed. The strike is 170° . A sample across the vertical part gave the following assay results:—

Lead—0.3%

Silver—18 dwts. 7 grs. per ton

Gold—Trace.

It is stated by Mr. Horton that this lode has not been cut underground. It would appear however, that this is the gossan outcrop correlated by Reid with this No. 3 lode. As the No. 3 lode was 80 feet west of the Devon lode, there is little doubt that this represents the Big lode.

An adit was driven some six years ago from a point some 50 feet above the No. 1 adit in a westerly direction for 120 feet, but could not at the time of this visit be entered. It was stated that the Devon lode was not cut, but that a wall was passed through at 40 feet, and a lode formation at 60 feet. The latter is believed to be the Diagonal lode. It was said to be vertical and to consist of 2 feet of gossan. Pieces on the dump showed 2 to 3 inches of fairly clean galena in a white argillaceous matrix. If this lode is the Diagonal lode, then the Devon lode must have been cut at or near the entrance, and the face of the adit must be close to the Big or No. 3 lode."

CONCLUSIONS

Nye concluded that the only lode which had been developed was the Devon lode. This was narrow and all payable shoots of clean ore had been removed at least down to No. 2 level. Further work on this lode would depend on continuation in length and/or depth.

The other lodes seem to have been cut in the underground workings and proved to be of no value.

As it stands, no quantity of payable ore is developed in the mine and future work must be directed toward providing extensions of the Devon lode. There is no geological reason why such extensions should not exist but the small size of the lodes worked so far does not encourage outlay of capital for further developmental work.

The mine is badly situated with respect to access routes and the problems associated with bringing equipment to the mine and transporting ore out are not encouraging. The total production from all workings so far is only a little more than 400 tons of ore. Future prospects for this mine are not promising.

Other prospects in the Dove Valley

In addition to the Devon mine several other small galena prospects have been noted in the Dove Valley from time to time. Waller (1901) reported that the Sirdar Prospecting Association had driven about 12 feet on some small galena veins and considered that

the property was worthy of attention. However, further prospecting failed to disclose any worthwhile mineralization and the prospect has been abandoned for many years.

Other small galena veins near the Devon mine in leases 4665-93M, 1978-93M, 3289-93M and 3288-93M were prospected at various times when the Devon mine was operating but these also proved to be too small and erratic to be of value.

The Silver Dove prospect is located about a mile downstream from the Devon Mine and was considered by Reid (1919b) to be worthy of further attention. Reid reported a 3 inch vein of pyromorphite at this prospect and noted that a tunnel 20 feet long driven on the lode disclosed no improvement in value. This tunnel was subsequently extended to at least 150 feet (Nixon, field notes) without encountering any worthwhile mineralization.

The chances of locating payable lodes in the bed of the Dove River are slender. The river has cut a deep youthful gorge along its course and outcrops along the river are good. The stream has been thoroughly prospected in the past and has been traversed during the course of this survey and no signs of workable mineralization have been discovered although small veins and odd mineralized patches may be found at many places.

The valley sides are precipitous and covered by dense vegetation so that lodes outcropping along the upper slopes of the valley may well have escaped detection. Geologically there are no special structures or features in the Precambrian rocks which are particularly favourable for ore deposition. The unconformities between the Precambrian, Cambrian and Ordovician rocks along the north side of the valley appear to be the most favourable sites for future prospecting.

The difficulties of providing access into the Dove Valley are great and all the orebodies located so far have been small. It is clear that only large and/or high grade orebodies could be mined profitably in this area and future prospectors should bear this in mind before expending capital on an access route to prospects.

(d) FERRO-MANGANESE DEPOSITS

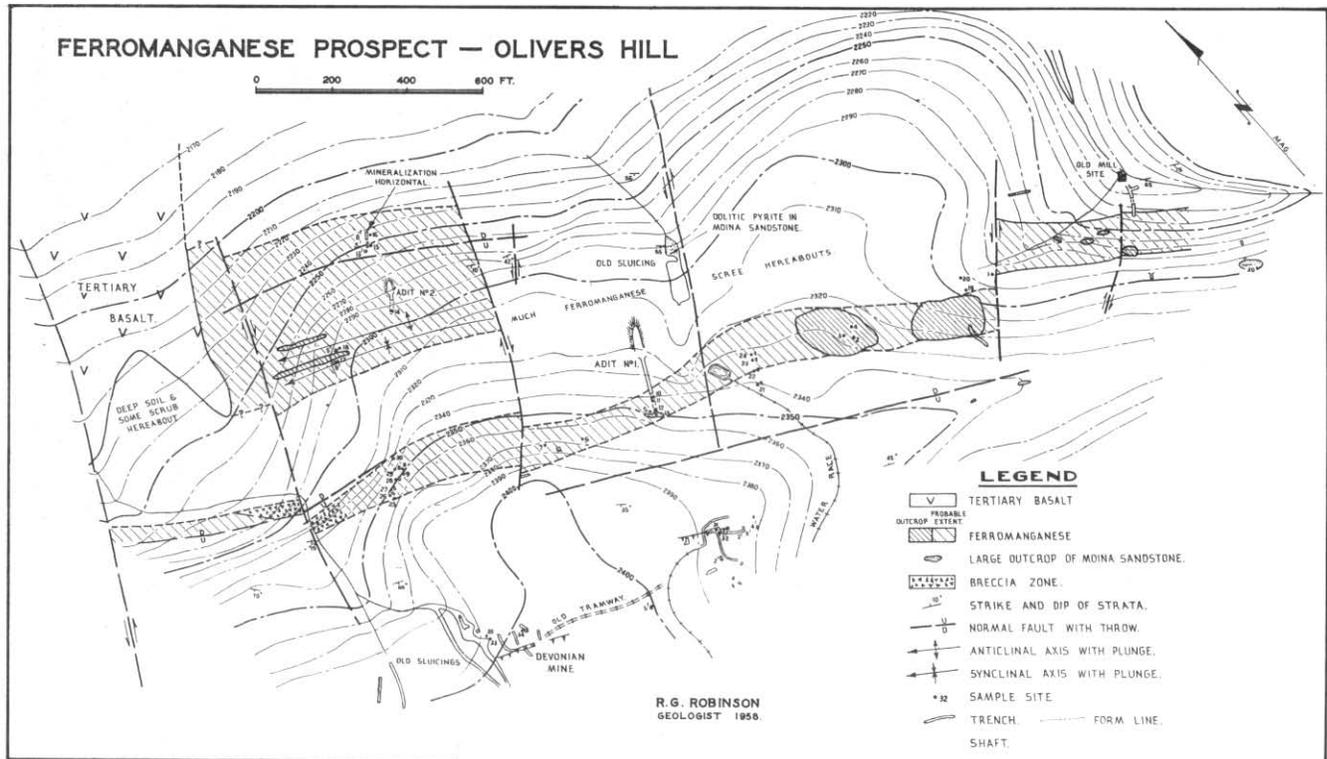
Olivers Hill

The conspicuous outcrops of ferro-manganese in this vicinity were noted by Reid (1919a) and doubtless attracted the attention of prospectors for many years. Several adits, small shafts and trenches were put in on the deposits in an effort to explore them but no production resulted. The gossanous nature of the material no doubt led prospectors to believe that the outcrops must be the capping of a sizeable sulphide orebody. Leases 7125M, Evenden and Hanson, 36 acres, 1915, and 11722M, Evenden and Stone, 1937, have been held in the vicinity of the deposits.

Reid considered the deposits as being worthy of further investigation as a source of ferro-manganese but made no mention of sulphide mineralization in connection with them. He quoted an assay of selected ore containing 22% iron oxide and 68% manganese oxide. This manganese content is far higher than in any of the samples taken during a recent survey of the deposit, carried out by Robinson following the discovery of silver-lead in association with the ferro-manganese. The following report is an extract of unpublished notes made by Robinson.

FERROMANGANESE PROSPECT — OLIVERS HILL

0 200 400 600 FT.



LEGEND

- TERTIARY BASALT
- PROBABLE OUTCROP EXTENT
- FERROMANGANESE
- LARGE OUTCROP OF MOINA SANDSTONE.
- BRECCIA ZONE.
- STRIKE AND DIP OF STRATA.
- NORMAL FAULT WITH THROW.
- ANTICLINAL AXIS WITH PLUNGE.
- SYNCLINAL AXIS WITH PLUNGE.
- * 32 SAMPLE SITE
- TRENCH
- FORM LINE.
- SHAFT.

R.G. ROBINSON
GEOLOGIST 1956

5 cm

FIGURE 19.

Introduction

The main ferro-manganese outcrops on Olivers Hill occur at 888250N/414400E and 888900N/413610E. They are conspicuous by the occurrence of large black outcrops of ferro-manganese which have attracted the attention of prospectors from the early days of gold mining in the vicinity. The early workers considered that the outcrops were the capping of tin or gold lodes but despite the amount of work done their efforts were unrewarded.

The present examination resulted from the discovery of lead in the deposits and work was diverted toward assessing the lead/ferromanganese potential of the occurrences. The survey was carried out by plane table and telescopic alidade and all the old workings together with the surface geology is indicated on the plan (Fig. 19).

Geology

The host rock in the area is the Moira Sandstone which here forms a cuesta with an average dip of 30° to the NE. The deposits are about 1 mile from the Dolcoath Granite but lie at a much higher elevation. The top of the granite is about 1000 feet a.s.l. whilst the ferro-manganese bodies lie between 2400 and 2300 feet.

Near the orebodies the Moira Sandstone is folded along a WNW trending axis and the individual folds have a shallow but variable plunge. The folds are cut by two sets of faults, thrusts trending parallel to the folds and wrench faults, sometimes with normal displacement also, which trend roughly NE.

Apart from the Moira Sandstone the only other rocks present in the area are Tertiary basalt and superficial deposits of talus and soil.

The Moira Sandstone consists of quartz sandstone, often ferruginous, together with about 10% of shale. The lowest beds are very often chocolate coloured and highly ferruginous.

Within the area several occurrences of pyritic spherulites have been noted. They suggest a single bed or group of beds which is repeated by folding or faulting. These beds would probably form a useful marker horizon for detailed mapping as they have also been recorded in the same formation elsewhere in the district (Jennings, 1958). The pyrite in these beds weathers to produce a gossanous outcrop which has been prospected widely by the early workers.

As shown on the accompanying plan, the ferro-manganese bodies outcrop as two roughly parallel lodes trending WNW and aligned parallel to the regional structure. The outcrops in the area are poor and whilst some care has been taken to depict the probable outcrop distribution accurately a good deal of extrapolation has been necessary. The continuity of outcrop is insufficient to establish whether all the outcrops represent a single mineralized bed but this seems to be indicated.

The "lodes" have been disrupted and offset by both NW and NE trending faults, which are presumably of Tabberabberan age.

Two adits were driven under the ferro-manganese outcrops and these both show that the mineralization does not persist even to shallow depths. No. 1 Adit was driven in a poorly cemented friable sandstone showing minor manganese staining and is in poor condition due to extensive falls from the back. The sandstone in

No. 2 Adit was more firmly cemented and coherent and some of the joints carried ferro-manganese coatings which appeared to be secondary. All of the shafts in the area, even those sited immediately alongside bold outcrops of ferro-manganese, bottomed in leached ferruginous sandstone.

It may therefore be postulated that the main outcrops are simply surface enriched cappings underlain at shallow depth by leached sandstone. The primary orebody, if it exists, has not been encountered in any of the openings so far made. Lead values in the surface outcrops are erratic but may average as much as 2.7% whilst in the leached material beneath the surface the average grade appears to be about 0.6%. Manganese and iron values are similarly low and erratic as indicated by the sampling programme. The deposits are therefore considered to be sub-economic by present standards. Details of the sampling are given below. The location of all samples is given on the geological plan (Fig. 19.)".

Sample No.	Au oz/ton	Ag oz/ton	Sn %	Pb %	Mn %	Fe %	Zn %
1	Nil	0.8	Nil	1.0	20.5	32.6	N.D.
2	Nil	1.6	Nil	3.3	18.1	36.7	N.D.
3	Nil	2.10	Nil	3.9	17.0	18.4	N.D.
4	Nil	2.4	Nil	5.3	22.9	23.9	N.D.
5	Nil	Trace	Nil	1.5	5.4	25.5	N.D.
6	Nil	0.6	Nil	0.7	23.6	11.1	N.D.
7	Nil	Trace	Nil	1.1	2.2	43.0	N.D.
8	Nil	Trace	Nil	0.4	0.2	34.7	N.D.
9	Nil	0.5	Nil	0.7	1.5	19.7	N.D.
10	Nil	Nil	Nil	0.1	0.98	5.8	0.2
11	Nil	Nil	Nil	0.1	0.16	10.5	0.15
12	Nil	Nil	Nil	0.1	Trace	3.8	0.15
13	Nil	0.33	Nil	0.1	0.61	12.5	0.2
14	Nil	1.64	Nil	0.2	0.92	11.9	0.1
15	Nil	Nil	Nil	1.0	1.02	12.9	0.2
16	Nil	0.72	Nil	1.8	0.98	23.8	0.2
17	Nil	0.36	Nil	1.4	1.08	11.8	0.2
18	Nil	Nil	Nil	0.1	0.04	3.8	0.2
19	Nil	Trace	Nil	Nil	0.49	7.5	N.D.
20	Nil	0.55	Nil	Nil	1.02	10.3	N.D.
21	Nil	Nil	Nil	Nil	Trace	3.2	N.D.
22	Nil	Nil	0.06	Nil	Trace	17.9	N.D.
23	Nil	Nil	Nil	Nil	Trace	10.4	N.D.
24	Nil	0.39	Nil	Nil	Trace	14.2	N.D.
25	Nil	Nil	Nil	Nil	0.16	5.2	N.D.
26	Nil	0.65	Nil	0.1	0.19	14.6	N.D.
27	Nil	Nil	Nil	1.0	1.38	32.3	N.D.
28	Nil	Nil	Nil	Nil	0.86	7.3	N.D.
29	Nil	0.39	Nil	0.9	3.46	12.7	N.D.
30	Nil	Nil	Nil	Trace	0.14	2.4	N.D.
31	Nil	0.39	Nil	8.8	Trace	2.5	N.D.
32	0.09	0.16	Nil	1.8	Trace	1.3	N.D.
33	Nil	N.D.	Nil	N.D.	N.D.	N.D.	N.D.
34	Nil	Nil	Nil	Nil	0.14	32.1	N.D.
35	Nil	Nil	Nil	Nil	Trace	1.0	N.D.
36	Nil	2.25	Nil	4.7	N.D.	8.2	N.D.
37	Nil	Trace	Nil	2.2	N.D.	41.1	N.D.

(e) TIN AND WOLFRAM DEPOSITS**Lone Pine Prospect**

A lease (8151-M, 80 acres) in the vicinity of the Lone Pine Granite was taken up by Messrs. Hancock, Hartnett and Atkins in 1918. At the time of Reid's (1919b) visit the lease was being prospected for tin and wolfram by means of two shallow open cuts.

Although Reid regarded the prospect as "very promising" no production has been recorded from the lease and little or no work appears to have been done since his visit. The lease was abandoned in 1924 and no worthwhile information can be gained from the exposures available at present. The following account is therefore extracted from Reid's description of the lease.

The lode consisted of a quartz vein 3 to 5 inches wide which apparently branched toward the SE where it was exposed as two veins 4 and 8 inches wide respectively. The ore minerals were cassiterite and wolframite together with pyrite and arsenopyrite. The tin and wolfram occurred on or near the walls whilst the pyrite and arsenopyrite were concentrated in the centre of the vein. The gangue was quartz with small amounts of fluorite, tourmaline and topaz. The lode had a general NE trend and dipped 75° to the SW. Both granite and quartzitic schists outcrop on the lease but the relationship of the lodes to the rock types is not recorded.

McCoy's Prospect

This occurrence consists of irregular veins of quartz carrying very small amounts of wolfram, traversing quartzite of the Fisher Group. It is situated close to the south bank of Borradaile Creek about 1 mile NW of the hut on Borradaile Plain. The Fisher Group rocks here strike about NE and dip at high angles to the SE and NW.

Blake (1937) examined the occurrence and reported minor traces of wolfram mineralization over a length of about 50 feet. However, he concluded that the lode had little continuity in length and width and that the prospect was not of economic importance. The present study has confirmed this view.

APPENDIX

by B. E. BALME

REPORT ON SAMPLES SUBMITTED TO SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANISATION COAL RESEARCH SECTION BY THE DIRECTOR OF MINES, TASMANIA

Coal from Jackey Shale, Western Bluff, Tasmania

Although the two samples submitted bore identical labels, they have been treated individually, on the assumption that they were taken at separate sampling points.

Sample: 6841

Hand Specimen:—Interbanded clarain and vitrain with mineralized bands and lenticles. Cleat and fracture surfaces showing evidence of leaching.

PALYNOLOGY

The coal was macerated and the mineral matter removed with hydrofluoric acid. Spores and pollen grains were very plentiful and particularly well preserved. The following types were identified:—

- Lueckisporites limpidus* Balme & Henn.
- L. multistriatus* Balme & Henn.
- Lueckisporites* spp.
- Bascanisporites undosus* Balme & Henn.
- Vestigisporites* new sp.
- Pityosporites* sp.
- Pilasporites* sp.
- Leiotriletes directus* Balme & Henn.
- Granulatisporites trisinus* Balme & Henn.
- G. micronodosus* Balme & Henn.
- Calamospora diversiformis* Balme & Henn.
- Verrucososporites* sp. cf. *V. hamatus* Balme & Henn.
- Acanthotriletes* cf. *ericianus* Balme & Henn.

REMARKS

This microflora is undoubtedly Permian but it is more difficult to decide in which stage of the system it should be placed. Almost all the palynological work on the Australian Permian has been carried out on samples from Western Australia and New South Wales and the absence of comparative material from Tasmania is a considerable handicap. The conclusions offered are, therefore, tentative and based on general evolutionary considerations and the palynological data available from the two mainland states mentioned.

Most of the forms listed are long-ranging Permian species although the absence of known Lower Permian types suggests that the microflora is post-Artinskian.

The distinctive *Bascanisporites undosus*, hitherto known only from the upper part of the Newcastle Group in New South Wales, may provide the key to the dating of the sample. Other features of the assemblage, the presence of *Acanthotriletes* cf. *ericianus* for example, also suggest a correlation with the Newcastle Group although the absence of genera such as *Nuskoisporites*, widespread in the Upper Permian of the mainland, is difficult to explain. Dulhunty and Dulhunty (1949) have however, previously noted dissimilarities between the microfloras of the Tasmanian and New South Wales Permian, which may perhaps be explained on palaeogeographical grounds.

To summarize, an Upper Permian age is suggested for the present sample, implying that the Jackey Shale may be, in part at least, correlated with the upper Newcastle Group in New South Wales. As there is little doubt that the Newcastle Group is, in turn, generally equivalent to the Upper Liveringa Formation in Western Australia, it follows that the Western Bluff coal is probably Tartarian.

Sample: 6840

In the hand specimen this sample was very similar to sample 6841 and on maceration yielded a qualitatively similar spore/pollen assemblage. However, important quantitative differences exist between the two microfloras, the most notable being the extreme abundance in sample 6840 of a new and distinctive conifer-type pollen, assignable to the genus *Vestigisporites* Balme and Hennelly. These quantitative differences could indicate slightly different ages for the two samples examined, but they may equally well be the result of minor climatic or geographical variations during the deposition of a single coal seam. Further sampling would be necessary to assess their significance.

On present evidence, an Upper Permian (probably Tartarian) age is suggested for sample 6840.

BIBLIOGRAPHY

- BANKS, M. R., 1957—The stratigraphy of Tasmanian limestones. *Miner. Resour. Geol. Surv. Tas.*, 10, 39-85.
- 1958—Recent additions to the knowledge of the Permian System in Tasmania; in *Gondwana Symposium. Internat. Geol. Cong., 20th Sess.: Mexico, 1956*, pp. 151-177.
- 1962—Permian; in *The geology of Tasmania. J. Geol. Soc. Aust.*, 9(2), 189-215.
- BLAKE, F., 1937—McCoy's wolfram prospect, Liena. *Rep. Dep. Min. Tas. (Unpublished)*.
- BLISSETT, A. H., 1962—Zeehan. *Explan. Rep. Geol. Surv. Tas.*, 1 mile Geol. Map. Ser., K/55-5-50.
- BRILL, K. G. and HALE, G. E., 1954—Geological map of the north-western end of Tasman Peninsula—a revision. *Proc. Roy. Soc. Tas.*, 88, 279-284.
- BROWN, F. R. and DE VRIES, M. H., 1958—The Subterranean hydrology of the Mole Creek area. *Bull. Tas. Caverneering Club*, No. 3, 9-15.
- BURNS, K. L., 1957—Geology of the Nook-Gunns Plains area. *Thesis, Geol. Dep., Univ. Tas. (Unpublished)*.
- 1961—Cambrian rocks of the Dolcoath Anticline. *Tech. Rep. Dep. Min. Tas.*, 5, 34-44.
- and RUNDLE, A., 1958—The geology of the Mole Creek caverns. *Bull. Tas. Caverneering Club*, No. 3, 3-8.
- CAMPANA, B., DICKINSON, S. B., KING, D. and MATHESON, R. S., 1958—The mineralized rift valleys of Tasmania. *Aust. Inst. Min. Metall. Stillwell Anniversary Volume*, 41-60.
- and KING, D., 1958—The age of the Zeehan Tillite, West Tasmania. *Aust. J. Sci.*, 20, 240-242.
- CAREY, S. W., 1947—Review of the Tasmanian "Porphyroids"; in *Report of the Government Geologist for 1945. Ann. Rep. Dep. Min. Tas. for 1945*, pp. 22-25.
- 1953—Geology and structure of Tasmania in relation to mineralization; in *Ore deposits of Australia. 5th Emp. Min. Metall. Congr. 1*, 1108-1128.
- and BANKS, M. R., 1945—Lower Palaeozoic unconformities in Tasmania. *Proc. Roy. Soc. Tas.* 88, 245-269.
- COTTON, C. A., 1945—Geomorphology. Whitcombe and Tombs, London, &c. (4th Edition).
- DAVIES, J. L., 1958—The cryoplanation of Mount Wellington. *Proc. Roy. Soc. Tas.*, 92, 151-154.
- 1959—High level erosion surfaces and landscape development in Tasmania. *Aust. Geogr.*, 7, 193-203.
- DE SITTER, L. U., 1956—Structural Geology. McGraw-Hill Book Co., New York.
- DULHUNTY, J. A. and DULHUNTY, R., 1949—Notes on microspore-types in Tasmanian Permian coals. *Proc. Linn. Soc.*, 74, 132-139.
- EDWARDS, A. B., 1942—Differentiation of the dolerites of Tasmania. *J. Geol.*, 50, 451-480, 579-610.

- ELLIOTT, D. M., 1958—Synopsis of Tasmanian caving areas. *Bull. Tas. Caverneering Club*. No. 3, 21-29.
- ELLISTON, J., 1953—The Moina district; in *Ore deposits of Australia*. 5th Emp. Min. Metall. Congr., 1, 1194-1199.
- 1954a—The geology of the Dundas district, Tasmania. *Proc. Roy. Soc. Tas.*, 88, 161-183.
- 1954b—Work programme, Lorinna Regional Geological Survey. *Rep. Dep. Min. Tas.* (Unpublished).
- ETHERIDGE, R., Jun., 1904—Trilobite remains collected in the Florentine Valley, West Tasmania, by Mr. T. Stephens, M. A., *Rec. Aust. Mus.*, 5, 98-101.
- FINUCANE, K. J., 1932—The geology and ore deposits of the Rosebery district. *Rep. Dep. Min. Tas.* (Unpublished).
- FORD, R. J., 1960—The geology of the Fisher River area. *Proc. Roy. Soc. Tas.*, 94, 25-32.
- GLOVER, —, 1892—Middlesex Plains, in *Ann. Rep. Sec. Min. Tas. for 1891-92*, p. 8.
- GOULD, C., 1860—Examination of the district between Chudleigh and Launceston. *Tas. Legislative Coun. Pap.* 16 (for 1860).
- 1861—Mersey coalfields. *Tas. House of Assembly Pap.* 135 (for 1861).
- 1866—On the position of the Gordon Limestones, relatively to other Palaeozoic formations. *Proc. Roy. Soc. Tas.* for 1866, pp. 27-29.
- HILLS, L., 1922—Geological conditions as affecting water conservation in the Chudleigh Lakes district. *Rep. Dep. Min. Tas.* (Unpublished).
- JENNINGS, I. B., 1957—Mole Creek, Chudleigh and Liena, in *Limestones in Tasmania*. *Miner. Resour. Geol. Survey. Tas.*, 10, 155-166.
- 1958—The Round Mount district. *Bull. Geol. Surv. Tas.*, 45.
- 1959—Geology of the Cradle Mountain Reserve. *Tech. Rep. Dep. Min. Tas.*, 3, 73-78.
- JENNINGS, J. and AHMAD, N., 1957—The legacy of an ice cap. *Aust. Geogr.*, 7 (2).
- JOHNSTON, R. M., 1888—Systematic account of the geology of Tasmania. J. Walch and Sons, Hobart.
- McKELLAR, J. B. A., 1957—Geology of portion of the Western Tiers. *Rec. Queen Vic. Mus., Launceston*, No. 7 (N.S.)
- MACLEOD, W. N., JACK, R. H. and THREADER, V. M., 1961—Du Cane. *Explan. Rep. Geol. Surv. Tas.*, 1-mile Geol. Map Ser. K/55-11-52.
- MATHER, R. P., 1956—Map Square 4386, the Lake McKenzie area. *Geol. Rep. Hydro-Electric Comm. Tas.* (Unpublished).
- MONTGOMERY, A., 1893—Report on the country between Mole Creek and the Mount Dundas silver field, and on the discovery of coal at Barn Bluff. *Ann. Rep. Sec. Min. Tas.* for 1892-1893.
- 1894—Report on the mineral discoveries in the neighbourhood of Bell Mount. *Ann. Rep. Sec. Min. Tas.* for 1893-1894, pp. xi-xx.

- NYE, P. B., 1928—Devon Mine, Dove River. *Rep. Dep. Min. Tas.* (Unpublished).
- PATERSON, S. J., 1960—The Lorinna dam site. *Geol. Investig. Rep. Hydro-Electric Comm. Tas.* 644/173/1 (Unpublished).
- POLAK, E. J. and DUGGIN, M. J. W., 1961—Mersey-Forth power scheme geophysical surveys, Tasmania, 1960. *Rec. Bur. Miner. Resour. Aust.* (Unpublished).
- REID, A. M., 1919a—The mining fields of Moina, Mt. Claude and Lorinna. *Bull. Geol. Surv. Tas.* 29.
- 1919b—The Mount Pelion mineral district. *Bull. Geol. Surv. Tas.* 30.
- RUNDLE, A., 1958—The evolution of the Mersey River Valley. *Thesis, Geol. Dep., Univ. Tas.* (Unpublished).
- SCOTT, B., 1960—Erosion surfaces in western Tasmania. *Rec. Queen Vic. Mus., Launceston*, No. 13 (N.S.)
- SMITH, E. M., 1957—Lexicon of the stratigraphy of Tasmania. *Publ. Bur. Miner. Resour. Aust.*
- SMITH, J. H., 1899—Report on the Bell Mount and Middlesex mineral fields. *Ann. Rep. Sec. Min. Tas. for 1898-1899*, pp. i-viii.
- SOLOMON, M., 1960—The Dundas Group in the Queenstown area. *Proc. Roy. Soc. Tas.*, 94, 33-50.
- SPRY, A., 1958—The Precambrian rocks of Tasmania, Pt. 3, Mersey-Forth area. *Proc. Roy. Soc. Tas.* 92, 117-137.
- 1962—Igneous activity; in *Geology of Tasmania. J. Geol. Soc. Aust.*, 9 (2), 255-284.
- STRZELECKI, P. E. de, 1845—Physical description of New South Wales and Van Diemen's Land. Longman, Brown, Green and Longmans, London.
- THUREAU, G., 1889—Special report upon the general geology of the route from Mount Claude to the Five Mile Rises, west of the River Forth, near Middlesex Plains, County of Lincoln, North Tasmania. *Tas. Parl. Pap.* 125 (for 1889).
- TWELVETREES, W. H., 1908—Report of the Bell Mount and Middlesex district. *Ann. Rep. Sec. Min. Tas. for 1907*, pp. i-xxx.
- 1913—The Middlesex and Mount Claude mining field. *Bull. Geol. Surv. Tas.*, 14.
- VOISEY, A. H., 1938—The Upper Palaeozoic rocks of Tasmania. *Proc. Linn. Soc. N.S.W.*, 63, 309-333.
- WADE, M. L. and SOLOMON, M., 1958—Geology of the Mt. Lyell mines, Tasmania. *Econ. Geol.*, 53, 367-416.
- WALLER, G. A., 1901—Report on the mineral districts of Bell Mount, Dove River, Five Mile Rise, Mount Pelion and Barn Bluff. *Ann. Rep. Sec. Min. Tas. for 1900-1901*, pp. 184-231.
- 1904—Report on the Mount Farrell mining district. *Rep. Dep. Min. Tas.*
- WELLS, A. T., 1954—An account of the geology of the Deloraine-Quamby Brook-Golden Valley area. *Thesis, Geol. Dep., Univ. Tas.* (Published in a slightly modified form as Wells, 1957).
- 1957—Geology of the Deloraine-Golden Valley area, Tasmania. *Rec. Queen Vic. Mus., Launceston* No. 8 (N.S.)



PLATE 1.—Roch moutonné with perched block, Mersey Valley, near Walters Marsh.

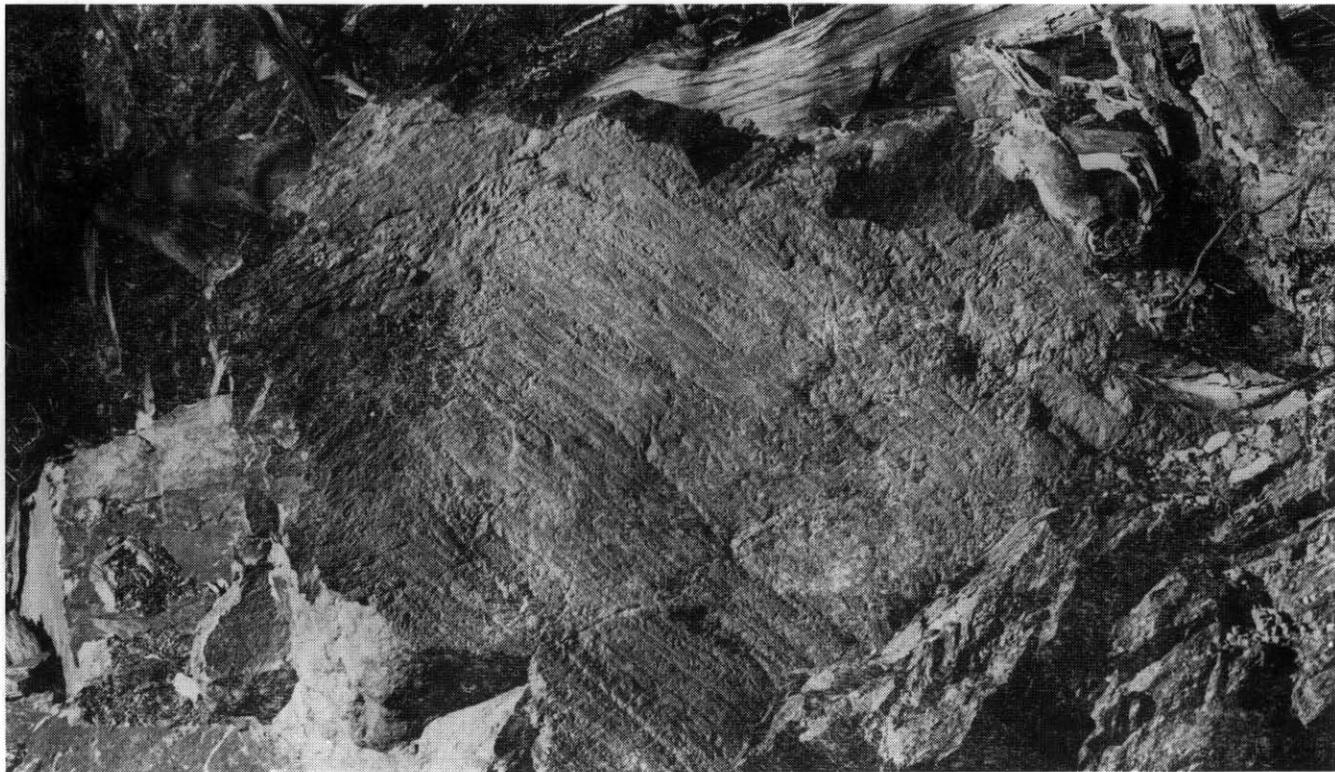


PLATE 2.—Glacial striae in Howell Group metasediments, vicinity of Walters Marsh



PLATE 3.—Resurgence in Gordon Limestone near Mayberry.

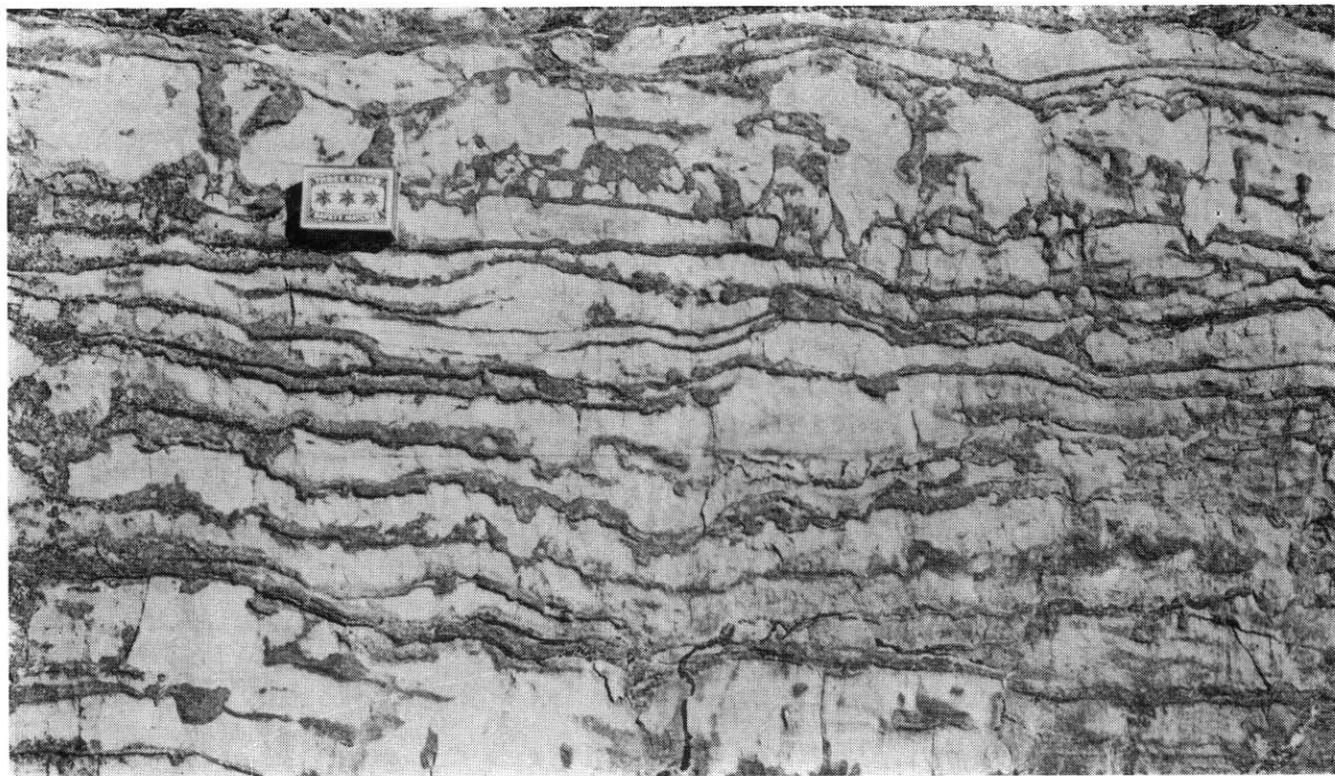


PLATE 4.—Stylolitic Gordon Limestone in the Mayberry District.



PLATE 5.—Quaternary glacial and periglacial deposits, Mersey Valley.



PLATE 6.—Pleistocene till overlying Precambrian metasediments, Mersey Valley.



PLATE 7.—Pleistocene till and alluvium, Mersey Valley.



PLATE 8.—Bedded river gravels showing imbricate texture. Mersey River at Liena.

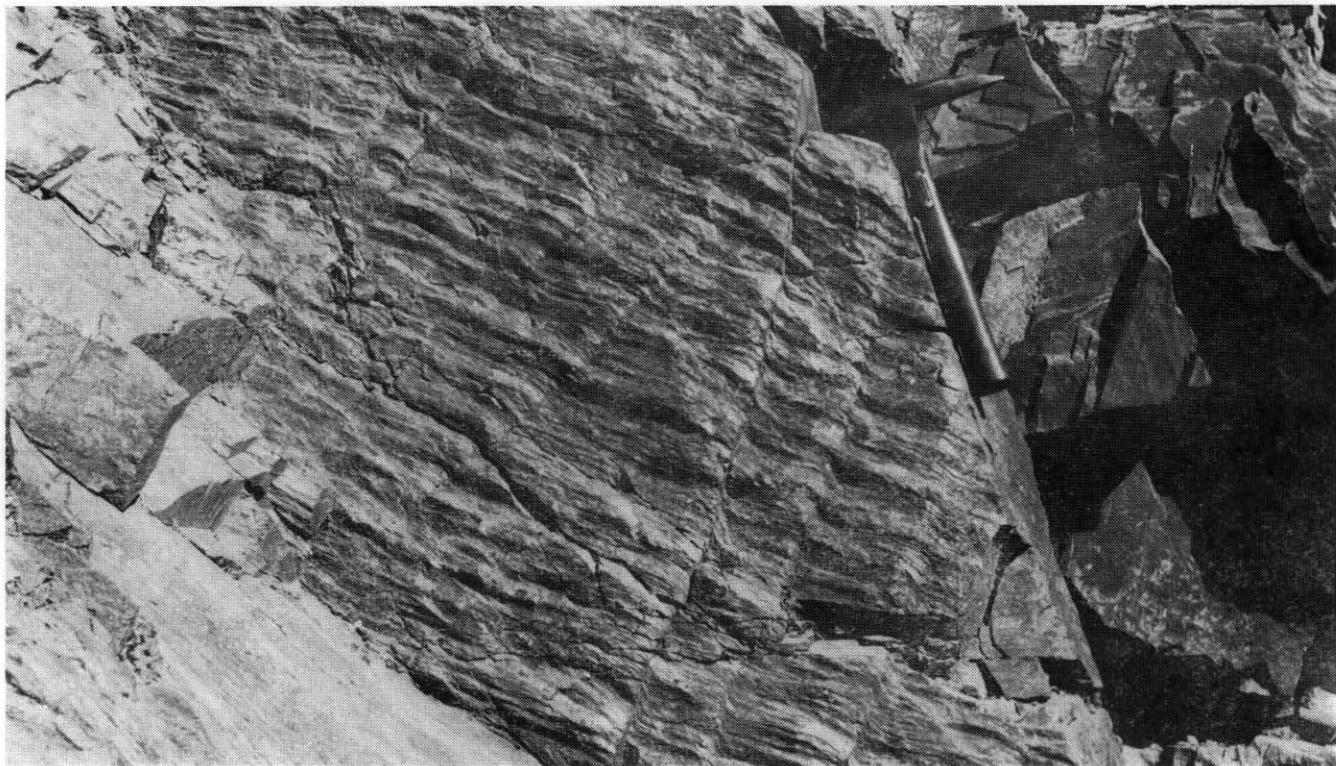


PLATE 9.—Double folding in quartzite of the Fisher Group, Mersey Valley Forestry Road.



PLATE 10.—Minor folding in Fisher Group rocks. Mersey Valley, about one mile south of the Fisher-Mersey confluence.



PLATE 11.--Internal structure of minor fold.

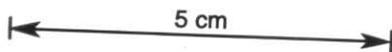




PLATE 12.—Steeply plunging minor folds in blocky quartzite of Fisher Group.



PLATE 13.—Lineation in garnetiferous schist of Dove Group.

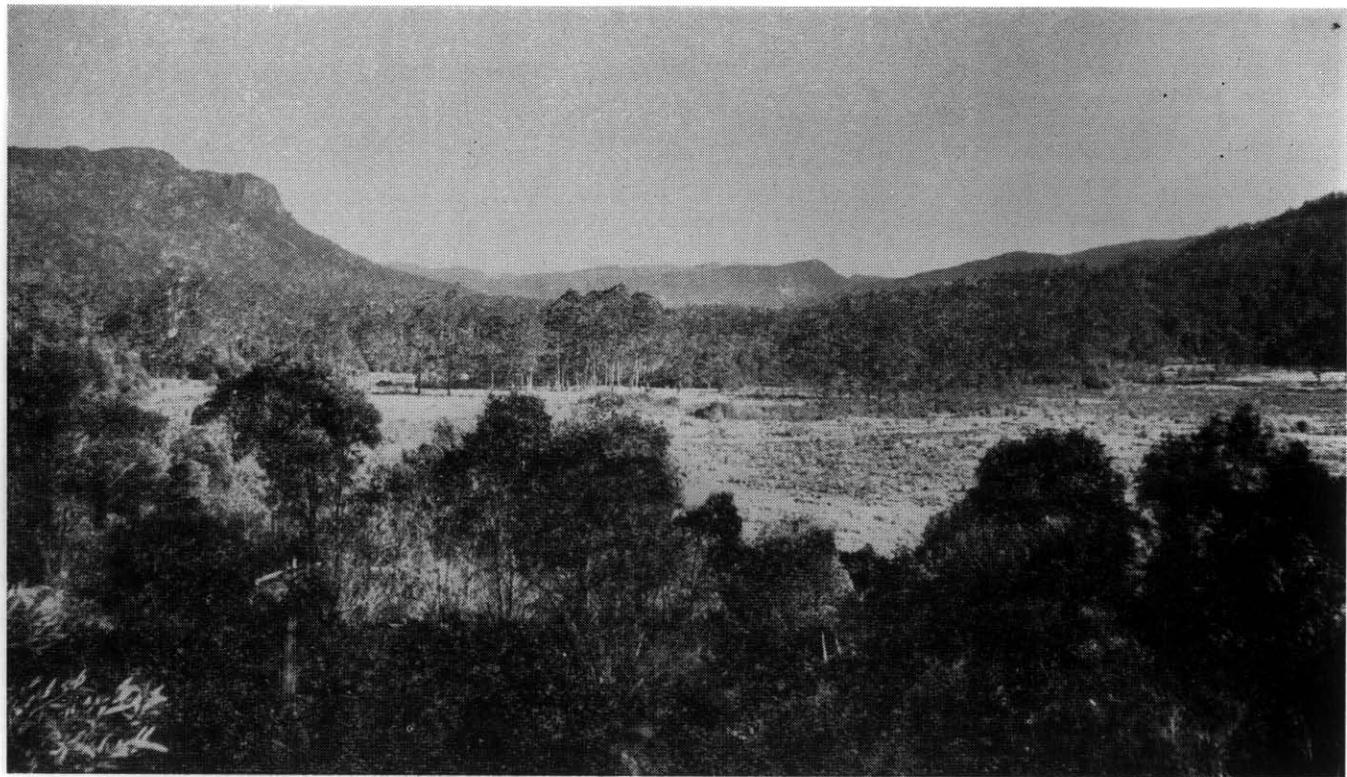


PLATE 14.—Upper Mersey Valley from Walters Marsh.