GEOLOGY AND STRUCTURE OF THE

MIDDLE DERWENT VALLEY

by

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ABSTRACT

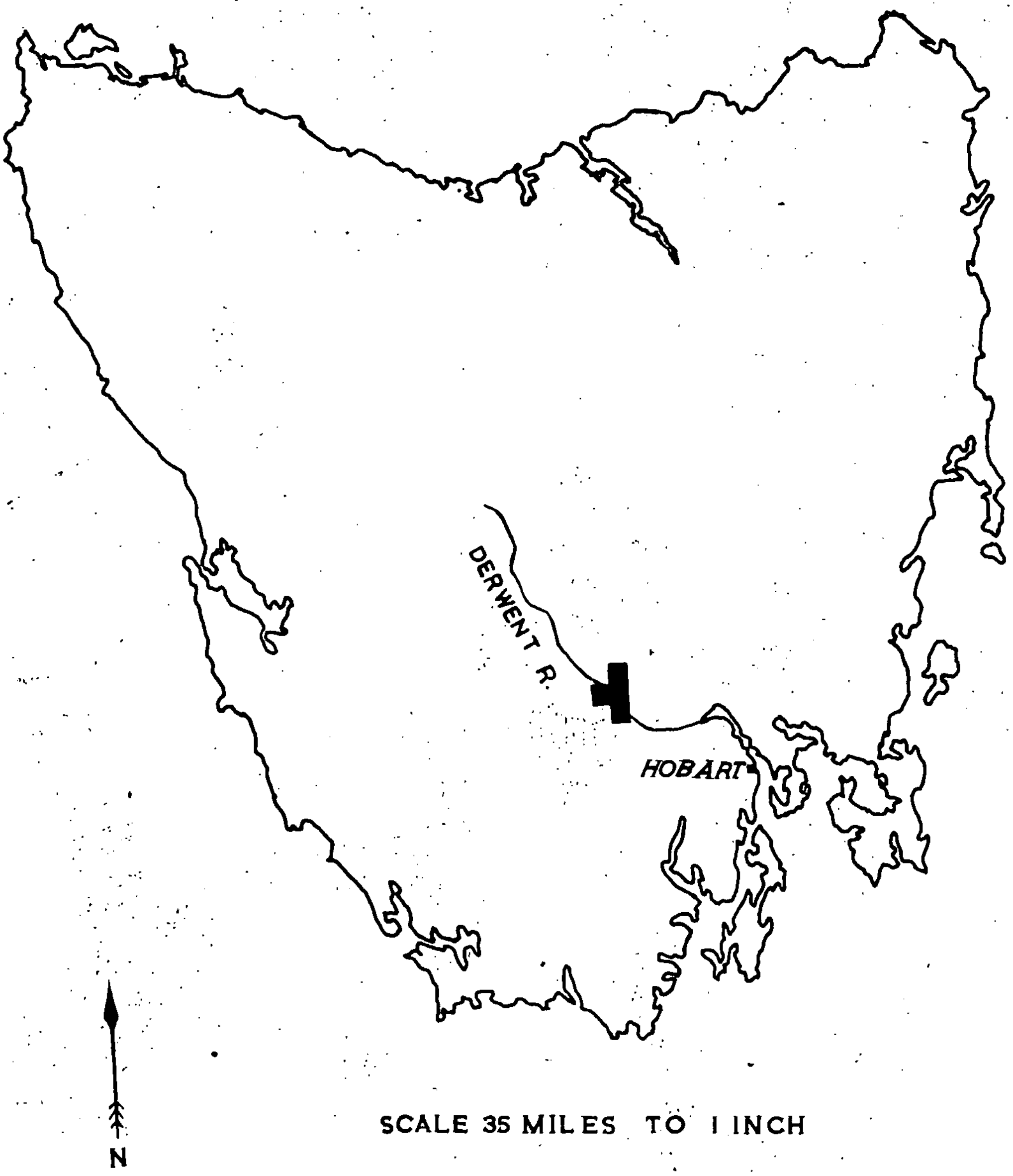
A geological study has been made of 130 square miles of the Middle Derwent Valley between New Norfolk and Hamilton, Tasmania. A Permian sub-greywacke type sequence consists of some 1300 feet of sandstone, siltstone, mudstone and limestone, deposited on a stable to mildly unstable shelf. Disconformably overlying the Permian are rocks belonging to the Triassic System which have been grouped tentatively into three formations. The Permian and Triassic are extensively and complexly injected by dolerite and mineralogical variations from the normal tholeiitic dolerite to granophyre have been traced. Liquid immiscibility is present towards the base of the sill. The Jurassic structure is interpreted as cauldron subsidence faulting accompanied by dolerite intrusion as transgressive to concordant sills, lopolithic near the root zone. Various Tertiary faults combine to form a stepped graben, the axis of which trends NW - SE en echelon, resulting in the formation of a chain of lakes and lowlands. In late Tertiary times, large outpouring of olivine basalt and associated tuffs at least 350 feet thick overran the lakes and filled the valley to a depth of some hundreds of feet. The basalts have been mapped into

several flows. Five periods of volcanism have been recognized, the inter-basaltic periods being marked by either lake sediments or fossil forests. The graben faulting controlled the drainage pattern both during the pre-basaltic times and subsequently.

INTRODUCTION

General

This thesis was undertaken under the direction of Prof. S. W. Carey, Professor of Geology, University of Tasmania. The area mapped lies in the Middle Derwent Valley (location map, Fig. 1) comprising four grid squares, namely 4873,4774, 4874, 4875. Each square is a ten kiloyard grid, roughly 32.283 sq. miles in area. The map squares for the sake of convenience have been called after either a township or prominent hill in that area. The southern square, 4873, has been called after Plenty, the western square, 4774, after Glenora, the eastern square, 4874, after Macquarie Plains and the northern square, 4875, after Mt. Spode, situated in the north-west corner of that square. The trignometrical control was provided by the courtesy of the Lands and Surveys Dept., Hobart, and the Hydro Electric Commission of Hobart. The compilation of the maps was done by the National Mapping Division at Melbourne for the use of the Soil Division C.S.I.R.O. of Tasmania. As the final base map was not ready, Mr K. Nichols, of the Soil Division, C.S.I.R.O. kindly enabled a tracing to be made of the positions of photo centers from which the writer compiled the base map. The Plenty


DERWENT R.
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SCALE 35 MILES TO 1 INCH

square is partly covered by the Styx area sheets and the positions of photo centers for that area were obtained by courtesy of the Forestry Commission, Hobart. While the positions of photo centers and grid are accurate, the physiographic details may not be of the same order of accuracy.

The field work was done during the months of December 1955 to March 1956, and from November 1956 to February 1957. Geological boundaries and other geological details were plotted on aerial photographs, flown to a scale of 4 inches to a mile (approximately), of Ellendale runs 3 to 10 and Styx runs 1, 2, and 4. The geological details were transferred to the base map by the use of a rectoplanograph. Rock specimens and thin sections made for the study are all lodged in the Geology Department, University of Tasmania under numbers 8595 to 8726. Tertiary basalts in the Glenora and Macquarie Plains area were mapped in great detail on a large scale map, 1 inch equals 400 ft, with 5 ft. contour interval, provided by the courtesy of the Hydro Electric Commission, Hobart. The details from this map have been transferred to the base map by the use of grids. Tertiary basalts in the rest of the area could not be mapped in great detail on account of poor exposures and the presence of pastures. Hence aerial photographs were used in those areas and also for the regional geology. Outcrops of sedimentary formations both Permian and Triassic, are equally poor, partly on account of the soft nature of the rocks, and partly on account of the cultivation; however, a few cliff sections along the river courses and on the hills provide fair information. Topographical elevations, and elevations of contacts of basalts and dolerites with the sediments were measured by the use of an altimeter from known bench marks. After these had been corrected for diurnal variations they were plotted on the base map. The Meadowbank square to the north-west has been mapped by Mr Mather of H.E.C. and two squares to the east have been mapped by Mr D. Woolley.

Physiography

The physiographic development of the area has been dominantly controlled by the structure and the complex intrusion of Jurassic (?) dolerite. The Derwent Valley is a downfaulted block with Permian and Triassic rocks with minor dolerite and Tertiary basalts and lake sediments forming the valley, whilst dolerite hills border the valley on either side. The prominent hills are formed by dolerites. Mt. Spode in the northwestern corner of the area rises to a height of 1600 ft with Triassic Knocklofty sandstones and shales forming a north south ridge flanking its eastern side. On the east side of Hollowtree road, in the Bloomfield and Allenvale area dolerite hills rise to a height of 2000 feet forming the northern extension of Black Hills. Mt. Belmont, a dolerite mass, rises to a height of 1500 feet and forms a prominent feature in the south-east corner of the Macquarie Plains sheet. The south and southwestern portions of Plenty square form a dolerite plateau 1700 ft. to 2000ft. in height. The eastern flank of this plateau is a fault scarp and extends for a distance of nearly 10 miles up to Westerway. Half a mile west of Glenora another dolerite hill forms a prominent feature. Apart from these dolerite hills bordering the area there are small hills made up of resistant Triassic sandstones and Tertiary basalts of 500 to 600 ft. average elevation. Though the elevation in the area does not exceed 2000 ft., the gradient of the hills is quite steep and deep gullies have been cut in both the resistant dolerite and the Triassic sandstones, and the physiography could be said to be in a late youthful stage.

Drainage

The area is drained by the Derwent and its tributaries - ie. Russell Falls, Styx, and Plenty rivers and smaller rivulets such as Allendale, Belmont and Dry Creek. The Derwent flows in a general south-east direction passing through three map squares. It has cut deep, narrow channels both in the Triassic sandstone formations, as at north of Glenora near Norton trig, and through Tertiary basalts as at Macquarie Plains. The course of the river is controlled for the most part by either the structure or the resistant rocks. This is discussed later under the Evolution of the Derwent Valley. The river from Norton, grid E 479000, N 750000 to Clarendon grid E480000,N 747000 flows between two faults, the Meadowbank fault on the southwest and the Norton-Clarendon fault in the northeast cutting deep channels in the Triassic sandstones. The river, flowing from the Meadowbank square enters the Glenora area flowing through a NE joint plane west of Norton, veers SSW with a sharp hairpin bend and runs in a straight course for a couple of miles until it strikes the resistant dolerite west of Glenora. It appears that the river was flowing once in a general southeasterly course parallel to and along the Norton-Clarendon fault as seen by the high level river terrace, at an elevation of 350 ft. From Glenora the Derwent river turns almost at right angles cutting a deep channel in the Tertiary lake sediments and flows in a SSE direction for over a mile to meet again the resistant basalt. From here to Bushy Park it flows through basalt, cutting a deep narrow channel with vertical cliffed valley walls. Occasional depositional flats are seen just above the river level. Fine slip-off and undercut slopes are common in this section. An early stage in the development of undercut slopes is commonly found when vertically jointed basalts overlie soft Tertiary lake sediments (Banks, 1955). The landslides are clearly seen in the cliffs facing the Dobson Highway half a mile north of Macquarie Plains railway station. After emerging from the basalt country the river travels for a mile and a half on a general southerly course and flows along the foot of the dolerite hill to meet the basalts again. Here again it has cut a deep channel with vertical cliff walls, and it finally emerges north of Plenty into the country underlain by "Feldspathic Sandstone".

The Russell Falls river drains the Mt. Field National Park area. In the NNE course at Westerway it flows along a fault, the underlying sediments being Ferntree Mudstone. The river just north of Westerway suddenly takes a right angled bend approximately along a fault scarp. The underlying rocks belong to the down faulted Triassic Knocklofty Formation. How far this E - W fault extends is not clear, on account of the cover. In the general E - W trend the river flows over the underlying Ferntree Mudstone till it strikes the dolerite hill west of Glenora. Through it the river has cut a deep narrow gorge with rapids. Emerging from this section it joins the Derwent at Glenora.

The Styx river flows from the Uxbridge area across the strike of the rocks and consequently has cut a deep narrow channel in both the dolerite and the Knocklofty Formation. This deep narrow channel continues to grid E 478000, N743300, and from there onwards the river flows as a lateral stream (Edwards, 1939, Banks 1955). The course in this part is very meandrine and has developed wide depositional flats. Two terraces can be seen, one at about 6 to 10 feet above the present level and another at least 50 feet above the second level. The slope between the two is steep and the top of the second terrace is not dissected, indicating that this terrace is quite recent.

The Plenty River flows in a northerly direction and drains portions of the Mt. Lloyd area. The section from Upper Plenty for a distance of nearly 2½ miles flows in a straight course along a Tertiary fault in the dolerite. From there onwards it flows over the Knocklofty Formation cutting deep valleys with very steep walls. The course for a distance of a mile and a half appears to be controlled by two sets of joints in the Knocklofty Formation, one set being the dip joints and the other strike joints. In the lower reaches the river has developed depositional flats, one terrace is at a height of 10 ft. above the present level; a second higher terrace at 200 ft. elevation is present. This higher terrace is developed by the Derwent river and can be recognised for 3 to 4 miles along the right bank of the Derwent from Plenty railway station up to the Mt. Lloyd road bifurcation.

The Allendale Rivulet flows from the Bloomfield area as a lateral stream, partly along the Bloomfield Jurassic fault and partly along a Tertiary fault. West of Gretna this rivulet has cut through the basalt with deep cliff faces, developing rapids before it finally reaches the Derwent southwest of Gretna. The Belmont Rivulet again flows parallel to the Belmont fault. The Dry Creek flowing from the Glenfern area flows in a strikingly straight course for nearly 4 miles along a Jurassic fault.

Thus it is seen that all drainage systems in this area are along or parallel to faults and the physiographic expression is that of the underlying structure.

Vegetation

The vegetation is generally open and consists of eucalypt, wattle, and wild cherry trees with variable amount of undergrowth, comprising ti-trees, bracken and other small shrubs. On the Westerway - Moogara dolerite plateau large eucalypt and wattle have grown which are suitable for logging. The Westerway end being in the National Park area logging is not permitted and the undergrowth of ti-trees and other shrubs is thick while on the Mooggra end it is open. On the areas of Permian rocks the vegetation consists of small eucalypt with little or no undergrowth; in the valleys thick undergrowth is common. The Triassic rocks which usually weather into a sandy soil support a thick undergrowth of ti-trees, bracken fern and sags. However, on top of the hills open eucalypt and wattle are common.

The principal occupation of the area is farming; mainly hops are grown in the river valleys. The Macquarie Plains, Glenora and Plenty areas produce nearly one third of the Tasmanian hop production. The low hills and the hill slopes have been cleared of vegetation and are used for grazing sheep. Growing wool is the second important industry of the area. In the Plenty and New Norfolk area in addition to hop growing orcharding is common.

GENERAL GEOLOGY AND STRUCTURE

The geology of the area is complicated. The marine fossiliferous sequence of Permian formations comprising conglomerates, sandstones, mudstones, siltstones, and limestones is followed by freshwater sandstones and siltstones of the Cygnet Coal Measures exposed just outside the area on the Mt. Lloyd Road, totalling nearly 1300 ft. The total thickness of the Permian in the Hobart district is 2500 ft (Banks, 1952, p. 66) This sequence in places changes to lacustrine sediments, as in the Cygnet Coal Measures, or has been subjected to erosion. This discontinuity in the sedimentation probably indicates the latter part of the period of the Hunter Bowen Orogeny, (Hills and Carey, 1949, p. 32; Banks, 1952, p 76), with elevation of land surface and consequent development of lacustrine sediments and commencement of erosion. This break in sedimentation is marked by a disconformity with the overlying Triassic rocks. The Triassic system comprising conglomerates, sandstones and shales of lacustrine origin were deposited on this eroded surface of the Permian. This disconformity was established earlier by Nye, (1921, pp. 47, 55-57; 1924, p. 22), Hills and Carey (1949, p. 32 et seq) and others in other parts of Tasmania. The basal conglomerate beds of the Triassic west of Glenora (grid E 475000 N 746400) and west of Hollowtree Road near Packham Vale (grid E 484100 N 756500) contain Permian mudstones and exhibit a slight angular unconformity. The period of sedimentation following this disconformity was terminated by two periods of epeirogenic movements, one during the Jurassic and the other during Tertiary times (Carey, 1954, pp. 189-91). During the former epeirogeny there was faulting accompanied by widespread dolerite intrusion as great discordant sills at least 1500 ft. thick away from the centres of intrusion. This epeirogeny was followed by erosion as indicated by lava flows on the deeply eroded and lateritised surface of dolerite and Triassic sandstones. During the Tertiary a second epeirogeny was superimposed on the earlier one, with widespread block faulting followed by volcanic activity pouring out olivine basalt.

The Permian rocks are exposed on the upthrown block in the southeast corner of Plenty square (Map 4) along the Moogara and Glenfern roads. In the Glenora map square (Map 2) from Karanjia to Westerway Ferntree Mudstone is exposed. Two isolated patches of Ferntree Mudstone are exposed around Packham Vale on the Hollowtree road in Mt. Spode map sheet (Map 1). Triassic sandstones and shales form the largest unit and are exposed in the valley portions. Due to the soft, friable nature of the sandstones, outcrops are poor. However fair sections are seen in the Plenty river, in the Derwent River, around Norton, Meadowbank and Gretna areas and some comparitively good sections occur west of Hollowtree road up to Mt. Spode. The Jurassic (?) dolerite forms the next largest mass and exposures are quite good owing to its hard resistant nature. Dolerite is exposed roughly east of grid E 483000 in the Mt. Spode and Macquarie Plains map sheets (Maps 1 and 3) and west of grid E 487000 in the Plenty map sheet and in the southwest corner of the Glenora sheet. Apart from these major areas smaller outcrops are seen west of Glenora, west of Gretna, half a mile north of Macquarie Plains railway station and around Norton and Mt. Spode. The Tertiary basalt with its associated tuffs occupies the valley portions from grid E 484500, N740800 to grid E 479400, N 746300 in a northwesterly trend, along the Allendale Rivulet for a distance of nearly 2½ miles and veering to northwest from the Hollowtree Road fork. The basalts flowed into and partially filled the Tertiary valley. The lateral stream developing later along the side of the basalt has left the basalt country as a flat tableland in the middle of the large valley. The cliff sections around Macquarie Plains, Glenora and Plenty are excellent. In the Macquarie Plains and Glenora areas seven flows, of which one is pillow lava, are present, (Plate 1A) separated by either tuff beds, conglomerates or lake sediments. These lake sediments and tuff beds contain silicified and calcified wood. Two more fossil wood horizons have been discovered besides those already known. Of these two newly discovered horizons, one at least in the basal conglomerate and lake sediments supported a fossil forest as seen from the upright stem and roots, (Plate 1 B) and the other is at the pillow flow level.

Underlying the Tertiary basalts are lake sediments, siltstones, claystones and sandstones, a fair development of which is seen in the Glenora area. The claystones in the exposures at the road cutting east of Glenora provide good leaf impressions.

As mentioned earlier, the structure of the area is complicated by the effects of two periods of epeirogeny being superimposed on one another. During the Jurassic time block faulting occurred accompanied by widespread dolerite intrusion, but during the other epeirogeny in the Tertiary time there was graben type faulting. This was followed by volcanic activity with outpouring of olivine basalt. Due to the superimposed epeirogeny in the area, the structure imposed by the second epeirogeny is more pronounced than the earlier one. The Derwent Valley is a structural graben valley, discussed in detail later in the thesis, bounded by the Westerway - Moogara fault with downthrow to the north-east and at least three sets of step-up faults north-east of Gretna, Magra, Black Hills, Allenvale faults, trending northwest - southeast, with downthrow to southwest. Within this fault trough are two horsts. One, the Belmont horst composed of dolerite, is bounded by the Plenty fault on the southwest and the Belmont fault on the north. The second horst is the Norton - Claredon horst composed of Ross to Knocklofty sandstones and is bounded by the Norton - Clarendon fault to the southwest and the Gretna fault to the east.

The striking Jurassic structure is the Bloomfield cauldron subsidence of dolerite. The Bloomfield fault forms approximately a 90 degree arc of a circular peripheral fault, partial ring fault, with radial faults and tension joints. The southern portion of this ring fault has been obliterated by the later Tertiary epeirogeny. The Bloomfield dolerite intrusion appears to have originated as a dyke intrusion with a general east-west to east-southeast west-northwest trend and flattening outwards, and shows advanced differentiation into acid and intermediate stages. The dolerite here has intruded into the Triassic Formations. The dolerite block southwest of the Westerway-Moogara fault and the block west of Glenora have intruded the Permian Ferntree Formation. It is doubtful whether this block also originated from the Bloomfield centre or whether there were other centres. The second alternative is more probable. The present map does not extend far enough to determine the centre of this dolerite intrusion.

The general trend of the Permian and Triassic formations varies from place to place. They are generally flat-lying, dips being accentuated near faults. The strike of the Triassic formations in the Mt. Spode map sheet trends generally north-south to north-northeast and south-southwest veering to an east-west direction in the northeast corner of the map sheet, with a zero to 10 degree dip towards northwest and south. In the Macquarie Plains and the Plenty areas the trend is roughly north to northwest with dips to west. In the Glenora area while the trend is the same the dips are towards east and northeast. The Permian rocks in the Plenty sheet trend east-west with a zero to 5 degree dip towards the south. In the Russell Falls River valley the strike of the Permian formations varies from east-west to north-south with gentle dips of the order of 2 to 3 degrees towards north and east, except near the Westerway-Moogara fault where they are of the order of 15 degrees towards southwest.

The stratigraphic sequence is given in the table below. The following chapters deal with the distribution, description and petrology of the different formations from the lowest upwards in the geologic succession.

Stratigraphic Table

System	Group	Formation	Rock Type	Thickness
Quaternary				
Recent to Pleistocene.			Land slides, scree, talus. Alluvium	
---------------------EROSION INTERVAL-------------------				
Tertiary		Volcanic	Basalts, tuffs agglomerates, etc.	340 ± ft.
		Lacustrine	conglomerates, sandstones, siltstones, claystones	150 ± ft.
EROSION INTERVAL				
-------------- STRONG EPEIROGENY AND FAULTING -----------				
PENEPLANATION AND UNCONFORMITY				
Jurassic (?)			Dolerite	1500± ft.
Triassic		"Feldspathic Sandstone"	sandstones, shales, coal seams	1900± ft. 350± ft.
		Knocklofty Formation	sandstones, shales, conglomerates	1100 ± ft.
		Ross Sandstone	conglomerate, massive sandstone	450± ft.
DISCONFORMITY				
Permian		Ferntree Mudstone	mudstones, siltstone, sandstone	1255± ft. 600 ft.

System	Group	Formation	Rock Type	Thickness
		'Woodbridge' G.F.	sandstones, mudstones, glacial material	290 ft.
	Cascades	(Grange Mudstone	mudstones, siltstone,	160 ft.
		(Berriedale	mudstone,	
		(Nassau Limestone	limestone, sandstone,	150 ft.
		(Siltstone	siltstone	15 ft.
	Faulkner		sandstone, siltstone (freshwater)	10+ ft.
		Bundella Mudstone	sandstone, siltstone mudstone	40+ ft.

THE PERMIAN SYSTEM

General

The Permian System of Tasmania is a succession of marine fossiliferous formations comprising conglomerates, sandstones, siltstones, mudstones and limestones, with a varying amount of glacial material. These include and are followed by freshwater deposits of sandstones and siltstones with coal measures. Permian rocks are exposed over a large part of Tasmania. Several workers have studied the Permian rocks of Tasmania especially around Hobart; Voisey (1938, pp. 309-333), Lewis (1946), Banks (1952, 1955), Banks and Hale (1957) have given a detailed account of the early works and the present knowledge of the Permian. As an outcome of these studies the Permian of Tasmania has been divided into several formations as previously indicated in the stratigraphic table. One characteristic feature of the Tasmanian Permian is the continuity of glaciation throughout the period with varying intensity. During the deposition of the 'Woodbridge Formation' the intensity of glaciation was at its peak. Recent work by Lane and Ahmad (unpublished) on the 'Woodbridge' and paleogeography and glaciation gives a detailed account of the nature of sedimentation and glaciation. In the area under discussion the Permian rocks from the Bundella upwards are exposed, on the upthrown side of the Glenfern fault in the Plenty map sheet and west of Glenora in that map sheet.

Bundella Mudstone

This formation is exposed where the Moogara road crosses Dry Creek at grid E 489000, N 733050, (Map 4) on the upthrown side of the Glenfern fault. Here only the top 35' to 40' of the section is exposed in the road cutting. Lateral extension of this outcrop is not traceable for long owing to poor exposure and moreover it is cut off by the Glenfern fault on the east-southeast side and is dropped down by the Dry Creek fault on the west.

The rock is an olive grey, non-fissile siltstone and consists of angular fragments of quartz, feldspar, muscovite and rock fragments. Feldspar forms a small percentage. Erratics of quartzite and phyllite are not uncommon and range in size from a fraction of an inch to a couple of inches. The section here is unfossiliferous and is easily confused with the Ferntree Mudstone. Because the overlying formation fits fairly well with the section described by Banks and Hale (1957) and

MacDougal (unpublished) in the Mt. Nassau and Mt. Dromedary areas, this outcrop is assigned to the Bundella Mudstone.

Faulkner Group

This Group is exposed overlying the Bundella Mudstone. The top of this group is not seen due to the cover of the scree material from the higher beds. This Group, according to the type section in Geiss Creek (Banks and Hale, 1957), consists of several rock types varying from sub-greywake conglomerate to siltstone. The whole sequence Banks and Hale (1957) have called a 'Group' and individual rock types 'formations'. Individual formations are thin and are not mappable units. The conglomerate of the type section is not seen here due to poor outcrops. The first member seen is a quartz rich fissile, thinly bedded sandstone noticeably micaceous and in parts cross bedded. It resembles the Knocklofty sandstone of the Triassic System. The thickness estimated is 3 feet. Overlying this is a well sorted olive grey carbonaceous siltstone, at least 6' thick exposed in the quarry at the road junction. The rock contains predominantly quartz and muscovite. The grains are sub-angular to sub-rounded and well sorted. In this place the bed is unfossiliferous except for vague traces of plant fragments. This description fits reasonably well with the description of the Rathbones of the type area. This Group is quite distinct from the underlying one in several respects. The sorting is better, mica is more abundant and is seen along the bedding planes, grains are sub-angular to sub-rounded as compared with the angular ones of the Bundella. This may indicate shallow water with strong currents favourable for re-working.

The section above this for a height of 60 to 70 feet is covered. The next outcrop seen on the SSE track up the spur is a pale yellow to orange coloured feldspathic sandstone with angular to subangular fragments of quartz, feldspar. Fossils are seen in patches; species of bryozoa and <u>Strophalosia</u> are represented. The thickness exposed is about 5 feet. This formation is correlated with the Rayner Sandstone of Banks and Hale (1957).

The correlation of all these formations from Upper Bundella to Rayner Sandstone through the Faulkner Group in this area is open to question; there are neither good sections to correlate bed by bed nor is there diagnostic fossil evidence to prove or disprove the correlation. This correlation is suggested for the simple reason that these formations underlie the Cascades Group which contains diagnostic fossils and that within this area of exposure there appears to be no structural discontinuity, unless one is inclined to put two faults of great throw, one near the correlated Rathbones and one below the unfossiliferous Bundella Formation which could be mistaken for the Ferntree. Such an explanation is highly improbable, and hence the former simpler explanation is suggested.

Cascades Group

This group of formations is exposed in the area overlying the Faulkner Group. Good sections are exposed on the spur going SSE from Glenfern and Moogara Road crossing from 450 feet to 770 feet elevation, on the lower slope of the hill west of Dry Creek and along the Lake Fenton pipe line. The Dry Creek fault throws down the section on the west side by at least 150 to 200 feet, so the lower members of the Cascade Group are not seen on that side. The Cascade Group in this locality is approximately 320 feet thick and consists of Nassau Siltstone, Berriedale Limestone and Grange Mudstone. Individual formations are not mappable as the contacts are gradational and outcrop at critical places is lacking. Thus all the three formations have been grouped together and mapped as a unit. Since the individual formations are recognisable they have been described separately.

Nassau Siltstone

This, as explained earlier, occurs only to the east of the Dry Creek fault and is cut off by the Glenfern Fault further southeast. The formation is 10 - 15 feet thick and consists of beds a couple of feet thick of white to pale yellowish white siltstones containing angular grains of quartz and a little feldspar. Numerous fossils are present especially species of <u>Strophalosia</u> and <u>Fenestella</u>. Other fossils are pectenoids, spiriferids, and fragments of pelecypods. Towards the top the formation becomes more calcareous, finally passing into the Berriedale Limestone.

Berriedale Limestone

The Berriedale Limestone here is taken as the calcareous siltstone and limestone members overlying the Nassau Siltstone. The formation attains a thickness of 150 feet. Individual beds are a few feet thick and are separated by thin bands of fissile siltstones. The limestones range from calcirudite to calcilutite. They are generally impure, the impurity being silicious and consist of clastic grains of quartz and erratics of quartzite with other metamorphic rocks forming a small percentage. The limestone beds towards the top pass into Grange Mudstone. Many fossil phyla are present. The important fossils are species of Fenestella, Stenopora, spiriferids, Aviculopecten and corals.

Grange Mudstone

This formation is exposed both on the east and west side of Dry Creek, and attains a thickness of 150 to 160 feet. On the west side of the creek the formation is exposed on the lower slope of the hill and veers with the contour of the hill to grid E 487300 N 734100. Here the formation consists of non-fissile to fissile siltstones, individual beds being of the order of a foot to a foot and a half thick. The rocks are mostly yellow to brown and rich in fossils. Erratics are common and include quartzite and other metamorphic rocks.

Another small outcrop of Grange Mudstone is exposed a mile and a half south of Westerway on the first bench of the dolerite hill at an elevation of 800 feet and continues up to about 1000 feet. Here the outcrops are poor and the dolerite floats are numerous. Fossils seen in this locality are species of Strophalosia and Stenopora.

'Woodbridge Glacial Formation'

In this thesis the formation lying above the Grange Mudstone and below the Risdon Sandstone will be called the 'Woodbridge Formation'.

The 'Woodbridge Formation' in the area is exposed above the Cascades Group in the same locality and is approximately 280' thick. The formation is composed of rhythmic alternations of sandstones and siltstones. They are grey on freshly broken surfaces and weather to yellow and yellowish brown. Erratics are more profuse than in either the lower Cascades Group or the higher Ferntree Mudstone and include quartzite, reef quartz, phyllites and schist. The erratics range up to 6 to 8 inches. In the Hobart district and elsewhere erratics up to 6 feet are known and these have led to the recognition of a glacial origin for this formation. In this area there are no tillitic beds. The base of the formation is a medium to coarse grained sandstone partly conglomeratic with erratics. Following upwards the formation becomes more fine grained and is dominantly composed of siltstones with bands of sandstone. Towards the base the formation is fossiliferous. Bryozoa are uncommon. About 50 feet from the top is a highly fossiliferous siltstone bed which forms a marker horizon. The fossils are mainly spiriferids, productids and pelecypods (specimen 8724). This bed near grid E 489900 N 731000 formsa partial cliff and is approximately 30 feet thick. This bed can be followed fairly continuously on the western side of Dry Creek from Mt Lloyd road to grid E 487200 N 733300.

Risdon Sandstone

Risdon Sandstone is here taken as the feldspathic sandstone overlying the'Woodbridge' Formation and underlying the Ferntree Mudstone and forms a marker bed in the area. The bed is 8 to 10 feet thick and consists of coarse sub-rounded quartz grains and feldspar. Fossils are absent in this sandstone.

Ferntree Mudstone

The Ferntree Mudstone lies above the Risdon sandstone and below either the Cygnet Coal Measures or where that is absent, the Ross Sandstone of the Triassic System. The thickness of the formation in the type area is 600 feet and consists of rhythmically alternating fissile and nonfissile mudstones and siltstones. Fossils are scarce and sporadically distributed.

In this area Ferntree Mudstone is exposed overlying the Risdon both on the east and west side of Dry Creek from 1000 feet and 810 feet elevation respectively. On the east side of the Dry Creek 270 feet of Ferntree Formation is exposed and is faulted against the dolerite. Similarly on the west side of the creek 400 to 450 feet is exposed and is faulted against the dolerite. Possibly the full section is exposed just outside the area on the Mt. Lloyd road where the overlying Cygnet Coal Measures are seen. In the track going west from grid E 488500 N 730900 besides the Risdon Sandstone at least three more sandstone beds are exposed higher up. These sandstone beds range from 2 to 5 feet thick. Such sandstone beds appearing higher up in the Ferntree Formation have been reported in the Great Lake area by McKellar (1957, pp. 8-9).

The next exposure of this formation is around Karanjia in the Glenora map sheet and extends up to Westerway. Along the railway line to the National Park good sections are seen. The dolerite has intruded this formation here and a certain amount of baking and hardening is noticed. (specimen 8714, 8715). From Karanjia along the old Styx valley tram line, now road, this formation is seen dipping gently at angles of 2 to 3 degrees towards NNE. This formation further along is overlain by the Knocklofty Formation and the contact appears to be a faulted one. Outcrops away from the road and railway cutting are poor, only float being seen. A good section of Ferntree Mudstone is seen in the railway cutting west of Westerway saw-mill and in the P.W.D. quarry near the Westerway police station. In the latter place the beds dip at 15 degrees towards the southwest due to drag on the Westerway-Moogara fault.

North of Russell Falls River at Karanjia 300 feet of Ferntree Mudstone is exposed overlain disconformably by the basal conglomerate bed of the Triassic system. Further west in the Westerway section nearly 600 feet of Ferntree Mudstone is seen. In the numerous timber tracks in this area 5 to 6 feet thick sandstone beds are seen. The sandstones are fine to coarse silt grade. Sporadic distribution of fossils is seen in two areas within the Ferntree Mudstone at grid locations E 472600 N 746500 and E 471500 N 747000.

TRIASSIC SYSTEM

General

Overlying the Permian System is a group of formations of Triassic to Lower Jurassic age. The relationship of these to the underlying Permian was shown to be a disconformity by Nye (1921, pp. 47,55,57, 1924, p 22). He discovered Permian rocks in the basal beds of the Triassic. The other evidence attributed to this interval of erosion is the complete break from the flora of Permian, dominated by Clossopteris, to the Triassic flora dominated by Thinnfeldia and Cladophlebis. (Hills and Carey 1949, p. 32). Similar evidence for this erosional break in other parts of Tasmania can be found in several papers referring to this period.

In the area under discussion this erosional break is seen 2 miles west of Glenora at grid E 475000, N 746400 where overlying the Ferntree Mudstone is a conglomerate bed of 3 - 4 feet thick (specimen 8708). This bed and the associated coarse gritty sandstone beds could be traced further northwest for a distance of 2 miles along this contact. The underlying Ferntree Mudstone dips north at 2 to 3 degrees whereas the overlying Triassic formationsstrike NW - SE with 5 to 7 degree dip towards NE indicating a slight angular unconformity. In yet another locality grid E 471100 N 745000 this angular unconformity is suggested. Ferntree Mudstone here strikes NNW with 12 to 15 degree dip towards WSW, while the gritty sandstone overlying it dips towards east at a shallow angle. This area too is disturbed by two periods of faulting and therefore the evidence may not be very conclusive.

This erosional break is considered to have been a prolonged period by the fact that the Triassic formation is underlain by either the Cygnet Coal Measures or the Ferntree Mudstone. Banks (personal communication) is of the opinion that where the Cygnet Coal Measures are present there appears to be no break in sedimentation and where that is absent there appears to be a break in sedimentation. This break in sedimentation and uplift is probably an indication of the Hunter Bowen Orogeny. (Hills and Carey 1949 p. 32, Banks, 1952 p. 76).

The subdivision of Triassic rocks into different formations is difficult owing to rapid facies variation and lensing out of beds over short distances. Jennings (1955 p. 175) expressed a similar opinion with regard to the Wayatinnah area, where a good correlation was not possible even with a number of diamond drills. General lithology of the members does not lend to definite correlation as individual or groups of members cannot be identified with any certainty. Correlation and subdivision on the fossil evidence is unreliable with the present state of knowledge of the plant fossils since many zones are present. However even in the absence of detailed Triassic stratigraphy two distinct formations can be recognized, the Knocklofty Sandstone and Shale and the "Feldspathic Sandstone". Towards the base of the system, the members are essentially coarse to medium quartz sandstones, massive in nature, with very minor amounts of shale beds, exhibiting pronounced cross bedding and slump structure. These where exposed form a distinct group of beds and may be recognized as a formation equivalent to the Ross Sandstone. From the Great Lake area McKeller (1957, p 4) has described 650 feet thick of massive quartz sandstone which he has grouped under Ross Sandstone. Future work on the Triassic stratigraphy can decide the stratigraphic position of these either as a separate formation or as the basal members of the Knocklofty Sandstone and Shale. In the present thesis these have been tentatively grouped as a separate formation Ross Sandstone.

The Knocklofty Formation consists of medium to fine grained sandstones with more shale beds than the Ross Formation. The sandstones in this formation are thinly bedded and flaggy, whereas in the Ross Formation they are thickly bedded and massive with minor shale beds. If this is considered a criterion three formations can be recognised, the lower one as the Ross Sandstone, the middle one the Knocklofty Formation and the upper "Feldspathic Sandstone". The thickness of the Ross Sandstone may be very variable within short distances as noticed west of Glenora, and in places may be represented by the facies variations of the Knocklofty Formation. This fact should not be ignored. Even with this rough subdivision the nature of the boundaries between them is not clearly known and are not mapped. In the area under discussion all the three formations have been recognised and where possible a gradational boundary with a (?) has been mapped.

Ross Sandstone

This formation is recognized as the basal formation of the Triassic System overlying the Ferntree Mudstone and underlying the Knocklofty Sandstone and Shale and it consists of pure quartz sandstones with very minor amounts of shale beds.

Sandstones recognized as Ross are exposed in all the three northern map squares, on the Magra Fault scarp and on the Norton Clarendon horst, around Norton trig in sheet 4874. In 4875 map sheet they are exposed on the west side of Allendale Rivulet forming a strike ridge. In the Glenora square this formation is exposed at Sugarloaf Hill and 2 miles west of Glenora.

Lithologically this formation consists of conglomerate beds towards the base and coarse to medium sandstone interbedded with minor silt and/or shale beds which are rarely exposed. The conglomerate beds are mainly quartz conglomerates containing fine to coarse pebbles set in a matrix of sandstones. The pebbles are well water-worn rounded to sub-rounded and include reef quartz and quartzite with a few pebbles of the Ferntree Mudstone. Intraformational clay pellets are also common (specimen 8708, 8712). The sandstones are for the most part white, sparkling and sugary with medium to coarse grains cemented with authigenic silica. Sandstones contain minor amounts of white mica, graphite and some iron oxide which imparts the colouration.

These sandstones exhibit sedimentary structure. They are thickly bedded and show current bedding, slump structure and intraformational mud pellets. The current bedding and slump structures are very clearly seen around Norton trig station (Plate 2A) on the Magra fault scarp and at Sugarloaf Hill. This formation usually forms cliffs. In the cliff section near the Magra Fault nearly 450 to 500 feet of this formation is seen, in the Norton cliff 200 to 250 feet is seen. West of Glenora the thickness is much less. These sections exhibit rhythmic alternation of coarse and medium grained sandstone, each major rhythm being of the order of 60 to 80 feet with minor rhythms within these major ones. A minor rhythm consists of a bed of coarse sandstone, then a bed of medium sandstone, then fine sandstone. Caving with salt efflorescence is a common feature seen in these. Current bedding is of the normal sigmoidal type with truncated tops. A northwest current direction is inferred from this. The slump structures seen near Norton trig indicate a southeast slope of the floor.

Fossils from these beds are uncommon. The shale and silt beds have some plant remains but these beds are rarely seen owing to the weathering of the sandstones and the heavy deposits of talus and scree material. These sandstones weather into white sandy soil and support a dense bracken fern vegetation.

Knocklofty Sandstone and Shale

This formation overlies the Ross Sandstone and is followed by the "Feldspathic Sandstone" and consists of coarse to fine grained conglomerates, sandstones and shales. The shale members are much more prominent than in the Ross Sandstone.

The Knocklofty Sandstone and Shale is exposed in all four map squares overlying the Ross Sandstone already described. It is also exposed on the Moogara road, in the Plenty River section and on the down faulted side of the Glenfern fault.

The sandstones consist of white to grey quartz, feldspar up to about 10%, muscovite and graphite, the latter usually occurring along bedding planes. The cementing material is generally argillaceous with varying amounts of haematite or limonite which frequently impart yellow, red, or brown colour to the rock. The matrix also contains some calcite. The sandstones are thinly bedded to flaggy and friable and show sedimentary structures such as current bedding, ripple marks, and occasional slumping. Intraformational mud pellets are not uncommon and occasionally form beds of 3 to 4 inches thick. The sedimentary structures though common do not stand out as the Ross Sandstone. Rhythmic bedding with alternating shales and sandstone is a common feature. The individual rhythms may be several tens of feet with minor rhythms included in them. Because of the shale members this formation does not normally form cliffs and salt efflorescences are not common.

A conglomerate bed, 30 to 35 feet thick, occurs in this formation in the NW trending spur half a mile NW of Packham Vale and as well on the top of the north-south running ridge west of the Allendale Rivulet, approximately at an elevation of 1100 feet. This conglomerate consists of pebbles of reef quartz set in a matrix of sand grains. Coarse gritty sandstones looking very much like Ross Sandstone are noticed in this formation. These sandstone beds are of no great thickness, being not more than 20 to 25 feet thick. Such a coarse gritty sandstone is seen on the northern slope of ESE ridge east of Rosegarland Hotel, just below the dolerite contact and in the low lying areas around the Belmont Rivulet.

The argillaceous sediments range in size from dense mudstone to silty mudstone and shales and they interdigitate with the sandstones. They vary in colour from a dirty green 'khaki' colour to purple and even white. The dirty green colour is the most common. These rocks break on weathering into cubic or rectangular pieces with sub conchoidal to uneven fracture. They are generally thinly bedded, individual beds being a couple of feet thick. The boundary between the individual beds may be either sharp or gradational. On the Moogara road at grid E 486000 N 733500 there is a very thick bed of mudstone, dark brown to purple in colour with a mottling of purple blotches. When freshly broken the mudstone is dirty green in colour. In the road cutting at least 10 - 12 feet of this is seen and the thickness is probably even more. Such thickly bedded mudstones are not frequently seen in the Triassic. It may be that this is a more common feature than is normally realised but that it is frequently masked by weathering and is not often seen. Jennings (1955, p. 178) reports a similar occurrence in one of the drill cores, where it is nearly 100 feet thick. No fossils have been found in this shale bed.

Plant fossils are common in the shaly beds. Thinnfeldia odontopteroides is found in the ridge east of Rosegarland Hotel (specimen 8704). Worm casts are also found in the shale beds and are noticed at grid 486900, 747800 (specimen 8702).

"Feldspathic Sandstone"

This formation overlies the Knocklofty Formation and is overlain unconformably by the Tertiary lacustrine sediments or basalts. It generally consists of feldspathic sandstones, mudstones, shales and coal seams.

This formation is exposed in the Plenty area around Salmon Ponds, along the Lyell Highway from Gretna School to Bluff's road, and from the 28 mile stone to the 30 mile stone.

Here the formation consists of feldspathic sandstones ranging from fine to medium grained, and are interbedded with siltstones, and shales, carbonaceous shale and inferior coal are also present. The sandstones consist of angular to sub rounded grains of quartz, feldspar, both muscovite and biotite micas, rock fragments and are set in an argillaceous to chloritic matrix. The chlorite in the matrix imparts a greenish colour to the rock. A calcareous matrix is not uncommon as shown by floats half a mile west of Salmon ponds. Feldspar is usually fresh, but when exposed on the weathered surface it is kaolinised and gives the rock a speckled appearance. Quartz sandstones, such as described from the Knocklofty Formation occur throughout this formation but they are never more than a couple of feet in thickness. Sedimentary structures such as current bedding are quite common in the sandstones and indicate a current direction from WNW or NNW.

The shaley members are fine grained and range from white to grey to black and carbonaceous. They are thinly bedded and break into rectangular slabs. The carbonaceous shales contain specks of pyrite. Those at Plenty, east of the basalt quarry contain minute crystals of gypsum. An inferior grade of coal occurs interbedded with this formation both at Plenty and near Marshall's house in the Macquarie Plains. It was reported that there were some prospecting shafts in this area. These have been covered and good sections of coal seams are not available. Plant fossils are present in the argillaceous sediments and in the siltstone and are fragmentary (specimen 8709).

Petrology

Sandstone of the Triassic Ross and Knocklofty Formations are pure quartz arenites ranging from fine to medium grain size. The grains are sub rounded to rounded. Quartz grains in the Ross sandstone (specimen 8700, 8701) are partly packed with smaller quartz grains; larger grains have a serrated margin due to authigenic silica being deposited in optical continuity round the parent grain. In addition to the authigenic silica limonite also forms a cementing material. Graphite forms a small percentage. Feldspar is absent.

Feldspathic sandstone (specimen 8707) ranges from fine to medium grained and consists of 50% subrounded to rounded grains of quartz, 20% of anhedral angular grains of feldspar, 25% of angular rock fragments, in an argillaceous matrix of 5 %. The quartz grains have a fuzzy margin due to deposition of aughigenic silica in optical continuity, while the parent grain is subrounded. Feldspar occurs as anhedral angular grains both orthoclase and plagioclase, the latter forming a small proportion. The angular rock fragments include quartzite and schist of metamorphic origin. Some basic igneous pieces appear to be volcanic but cannot be proved as the grains are very small. Flakes of mica and carbonaceous material occur in the matrix.

Environment and sedimentation

The Triassic rocks are members of the orthoquartzite suit of Pettijohn (1949) with the possible addition of volcanic sediments, all deposited under lacustrine or swampy conditions on a shallow, slowly sinking floor. The profuse sedimentary structures such as current bedding, ripple marks and slumping suggest strong currents from the northwest and a floor sloping towards the southeast. During the latter part of the Triassic - Feldspathic Sandstone possible addition of volcanic sediments is suggested by the fresh basic plagioclase. The angular rock fragments of metamorphic rocks indicate a source area of metamorphic terrain and the angularity suggests an elevation of the source lands. Lithic fragments are surprisingly rare in the Ross and Knocklofty Formations, showing thereby that epeirogenic movements were absent during that period allowing for better sorting. The presence of rock fragments in the Feldspathic Formation indicates that the earth movements or vulcanism became active during this period.

JURASSIC (?) DOLERITE

General

Extensive intrusions of dolerite which took place after the deposition of Triassic rocks form the next common rock in the region. It occurs in all the map sheets. As already stated it is seen east of grid E483000 in the Mt. Spode and Macquarie Plains map sheets, west of grid E487000 in the Plenty map sheet and also in the southwest corner of Glenora square. Apart from these large areas, outcrops occur west of Glenora and around Mt. Spode. The contacts with the pre-dolerite sediments are either sill like or have a discordant relation. The most irregular intrusions are in the Permian and in the Triassic Knocklofty Formations, particularly in the shaley members. In these rocks the dolerite frequently ramifies through the sediment. Where the thick sandstone members are encountered a concordant sill often results with some shelving contacts. Generally the base of the sill is uniform while the roof zone is quite irregular and rafts of the sediments are a common feature as seen in the Mt. Spode and Glenora map squares.

Contact metamorphism is a very minor feature. Sediments are rarely altered for more than a few feet away from the contact. A certain amount of hardening and baking very close to the contact is seen (specimens 8713, 8714, 8715, 8701, 8698). Usually no effects are visible in the dolerite 50 to 100 feet away from the contact, but at the junction the dolerite is fine-grained with phenocrysts of orthopyroxene. (Specimen 8693). At the contact the dolerite shows platy jointing. Away from the contact zone, the dolerite is medium to coarse-grained with grain size increasing towards the top of the sill. It is generally massive with crude columnar jointing which is rarely seen in surface outcrops, except in cliff sections. In addition to the cooling fractures, which result in closely spaced jointing, the dolerite sill is traversed by large scale vertical jointing which is probably related to the Tertiary epeirogeny. Near fault contacts the dolerite develops close platy jointing similar to the intrusive contact, but chilled fine grained margins are lacking.

Dolerite weathers in a spheroidal form and the extent of weathering is quite irregular. Near faults weathering may be intense and may extend to a greater depth, but generally the depth of weathering is only a few feet. Dolerite gives rise to extensive talus and scree material on steep hill slopes and accumulation of this may be very variable, but it is generally about 20 to 30 ft. thick in this area.

Age of the dolerite.

The age of the dolerite intrusion cannot be fixed with any degree of certainty. Since it has intruded into the Permian and Triassic sediments, it is post-Triassic. It is overlain on the eroded lateritised surface by Tertiary basalts and lake sediments and is therefore pre-Tertiary. Hills and Carey (1949 p.34), Banks (1952 p.83), have suggested that the epoch of intrusion is much older than the Tertiary faulting because of the evidence of prolonged erosion and peneplanation at a deep level below the original surface, all before the faulting. Edwards (1942) remarks the similarity of the Tasmanian dolerite to the Karroo dolerite of South Africa which has been considered as Lower Jurassic. The angular rock fragments and igneous rocks (?) in the Feldspathic Formation suggest that the dolerite is cognate with that formation. Lewis & Voisey (1938, p. 38) have suggested a similar relation. General agreement is that Jurassic is the most probable age of the dolerite, and the present investigation has produced no new evidence to vary this view.

Petrology.

The petrology of the Tasmanian dolerites has been described by Edwards (1942). In the present thesis the petrology of the dolerite has not been attempted in any detail or in a systematic way. The study of thin sections has been confined to the identification of doubtful specimens, a few of which are described. On specimen collected from the base of the sill has amygdules of calcite and quartz and small ovoids of mesostasis. The other notable feature in the area is the advanced differentiation of the dolerite magma to a granophyre. The granophyric differentiate is exposed on the eastern portion of Mt. Spode map sheet at grid E490000, N754500. Here the differentiation both to the granophyric phase and pegmatitic phase is noticed (specimens 8684 to 8690).

The dolerite ranges from fine grained near the contact to coarse grained away from the contact to pegmatitic in segregations. The chilled margins may be seen on both the base and the roof of the sill. The rock shows typical ophitic texture and contains plagioclase (labradorite), colinopyroxenes (augite, pigeonite), and iron oxide. Smaller amounts of orthoclase and quartz occur towards the top of the sill. A little biotite, chlorite and apatite occur in the mesostasis throughout the sill. Towards the base of the sill orthopyroxene occurs.

The plagioclase occurs as anhedral to subhedral laths of varying size depending upon the position in the sill and are fresh. Twinning is according to Albite and Carlsbad Laws and zoning is common. In composition the plagioclase ranges from andesine to labradorite, labradorite being the predominant feldspar. Towards the top andesine appears (8681). Alkali feldspar (orthoclase) and a little quartz appears towards the top of the sill. On further differentiation the proportion of orthoclase to plagioclase increases, the percentage of pyroxene decreases, quartz occurs in sufficient quantities to form a granophyre as seen in specimen 8680.

Pyroxene occurs as euhedral to subhedral grains varying in size from a fraction of a mm. to 4 mm. Augite and pigeonite are the common pyroxenes. Pigeonite has $2V = 0-5^{\circ}$, while augite has $2V = 35$ to 40 degrees. The orthopyroxenes, either hypersthene or enstatite, are found only near chilled margins, and the inversion of orthopyroxene to clinopyroxene takes place around the lower middle of the sill.

A specimen collected from the contact of dolerite and basalt opposite the Allen Vale house near grid location E 483000 N751900 is an interesting rock. The outcrop stands out as a low bench and scattered boulders and detached outcrops are seen for some distance. The rock in hand specimen (specimen 8683) is a fine grained light buff coloured rock with a granophyric texture, with streaks of greenish ferromagnesium mineral. Under the microscope the rock has a complicated textural appearance looking partly igneous and consists of 55% quartz, 35% orthoclase, with the remaining 10% as ferromagnesian mineral. The quartz grains are anhedral in shape and have rough irregular margins riddled with inclusions. The central portion of each grain is free from inclusions. The feldspar is for the most part, potash feldspar, orthoclase. While this has the same rough irregular margins, projecting outwards are lath shaped protrusions giving an amoeboid appearance. Between these grains of quartz and feldspar are randomly oriented lath shaped bodies, probably plagioclase giving an igneous looking texture like that of the dolerite. The ferromagnesium minerals are mostly mica and chlorite. No pyroxenes are found.

The texture and mineralogical composition of the rock may have been brought about in one of two ways. Firstly, the rock could be a silicified dolerite, silicified due to contact metamorphism by the heat of the overflowing Tertiary basalt, retaining remnants of igneous texture, or secondly the rock could be an extreme differentiate of the dolerite magma giving rise to a granophyre with quartz, potash feldspar and a small amount of ferromagnesian mineral. In this case the former view is suggested, since the outcrop is in contact with the Tertiary basalt and there is evidence that this area was covered by basalts. The igneous looking texture may be a remnant after replacement. Using the second alternative, explanation of the texture becomes difficult. The granophyre differentiate may well fit into similar granophyre differentiate seen at the eastern edge of the sheet. The interpretation of the dolerite block west of Allen Vale fault as the roof zone also coincides. But such a differentiated mass is not seen in other parts of the same roof block. Therefore the earlier view of replacement due to contact metamorphysm is favoured.

Specimen 8673

This specimen was collected north of the Black Hills fault near grid E 487300 N 747250. In hand specimen the rock is reddish brown in colour, highly weathered, shows minute platy jointing and is coarse to medium grained. Feldspar and pyroxene are visible to the naked eye and measure up to 2 mm across. Under the microscope the rock shows the typical ophitic to sub-ophitic texture and consists of 50% plagioclase, 35% pyroxene and 15% mesostasis.

The plagioclase, labradorite Ab 45, occurs as laths measuring up to .7 mm. in length. The crystals show zoning and twinning or combinations of the Albite and Carlsbad Laws. (Pericline being uncommon).

The pyroxene forms neutral to colourless pheocrysts up to 2 mm. across and encloses plagioclase laths. Augite ($2V = 35^{o}$) and pigeonite ($2V = 0^{o}$) are both present. Inversion textures between augite and pigeonite are common.

The mesostasis is fairly crystalline and turbid but contains recognizable granules of magnetite, needle like prisms of apatite and pale green, slightly pleochroic chlorite.

The grain size and the absence of orthopyroxene indicate a position away from the contact, probably towards the upper half of the sill. (By comparison with Edwards's (1942) series of specimens etc.

Specimen 8674

This specimen was collected from west of the Allen Vale fault near grid E 486000 N 750100. In hand specimen the rock is dark greenish grey in colour and is coarse grained with visible feldspar and pyroxene.

Under the microscope the rock shows typical ophitic texture and consists of 45% plagioclase, 35% pyroxene and 20% mesostasis.

The plagioclase, labradorite Ab 35-37, occurs as laths measuring up to a millimetre in length. The crystals show zoning and combination of Albite and Carlsbad twinning.

The pyroxene forms neutral to colourless phenocrysts of 3 mm. in length and encloses plagioclase laths. Augite (2V = 40) and pigeonite (2V = 0) are both present.

The mesostasis is fairly crystalline and turbid but recognizable granules of magnetite and needle like prisms of apatite are present.

Specimen 8675

This specimen was collected at grid E 487000 N 749500. In hand specimen the rock is dark grey in colour and very coarse with visible feldspar and pyroxene measuring up to 3 to 5 mm. across.

Under the microscope the rock shows typical ophitic texture and consists of 52% plagioclase, 30% pyroxene, and 18% mesostasis.

The plagioclase, labradorite Ab 48, occurs as laths measuring 2 mm. in length. Crystals show zoning and twinning on combinations of Albite and Carlsbad (pericline being uncommon).

Pyroxene forms colourless to neutral phenocrysts of 5 mm. across and encloses plagioclase laths. Augite (2V = 40) and pigeonite (2V =?) are both present.

The mesostasis is fairly crystalline but turbid and contains recognizable grains of orthoclase, granules of iron ore, tiny flakes of biotite and slightly pleochroic greenish chlorite.

All the three specimens were collected from portion of the same sill west of Allen Vale Fault and shows they are from the upper half of the sill. The interpretation of this on structural grounds as the roof zone is corroborated by the petrology of these.

Specimen 8681.

This specimen was collected from near grid E 489300 N 756520. In hand specimen the rock is light grey in colour and is very coarse grained with visible feldspar and pyroxene measuring several millimetres across.

Under the microscope the rock shows typical ophitic texture and consists of 55% plagioclase, 35% pyroxene, and 10% mesostasis.

The plagioclase, andesine Ab 55, occurs as large prismatic crystals measuring 2 mm in length. They show zoning and twinning on all the three laws of Albite, Carlsbad and Pericline and in combination. The Periclinal twinning is subordinate.

Pyroxene forms neutral phenocrysts measuring up to 4 mm. and encloseslaths of plagioclase. Augite (2V = 35 to 40), pigeonite (2V = 0) both occur.

The mesostasis is finely crystalline and contains anhedral grains of orthoclase, quartz, flakes of pleochroic biotite and greenish pleochroic chlorite and cubic magnetite.

This specimen was collected at a distance of 260 yards from the contact on the north side. Had the base of the sill been horizontal or nearly so, the position of this specimen would have been very close to the base of the sill. The grain size and the differentiation noticed would not have fitted into the normal picture of the differentiation of the sill. The base of the sill as marked in the geological section, deduced on other grounds, brings the position of the specimen well up to the top of the sill. The petrological evidence is in support of the same.

Specimens 8684, 8685, 8680, 8688 were collected on the southern slope of the hill at grid E 490000 N 754500, and form the different zones commencing from what was recognized as dolerite in the field to the granophyre. Specimen 8689 was collected from the northern slope of the adjacent hill. The minerological variations are represented in the triangular diagram (figure 2) with mesostasis, quartz and orthoclase, plagioclase and pyroxene occupying the three corners. Specimens 7544, 7550 and 7558 from the Mount Wellington sill are taken as the base, and the Red Hill granophyre specimen No. 3250 as the upper end. From the diagram it is seen that the percentage of pyroxene is fairly constant in 8684, 8685, 8680 and 8688, with progressively increasing percentage of quartz, orthoclase, decreasing percentage of plagioclase, towards the intermediate and acid end. The plagioclase, too, gradually changes from labradorite (Ab 48) to andesine (Ab 65). The texture of the rocks is in keeping with this minerological change. Specimen 8689 on the other hand shows an increase in the proportion of pyroxene. The proportion of pyroxene, the grain size and the ophitic

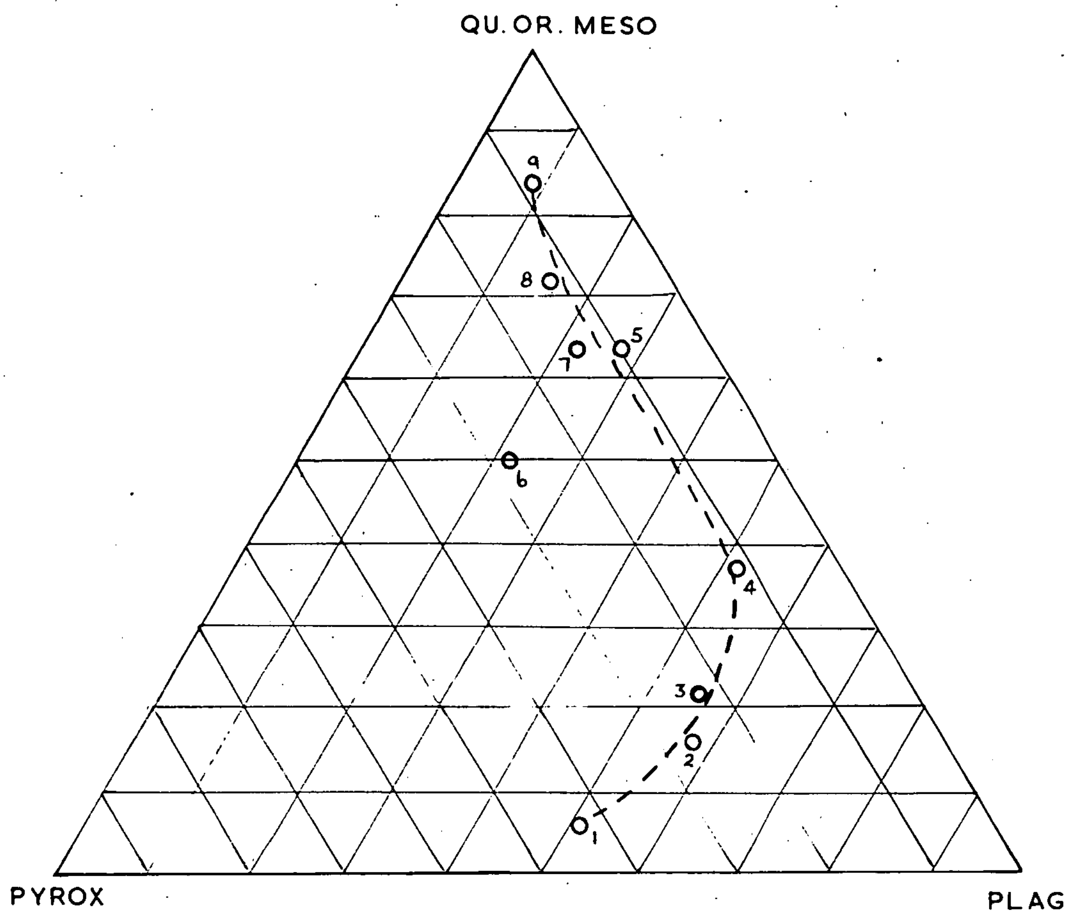


FIG. 2. VARIATION DIAGRAM OF BLOOMFIELD DOLERITE.

1.	MT. WELLINGTON SILL	BTM.	7544.
2.	,,	MIDDLE	7550.
3	,,	TOP	7558.
4-8.	BLOOMFIELD DOLERITE		8684, 8685, 8689, 8680, 8688.
9.	RED HILL GRANOPHYRE		3250

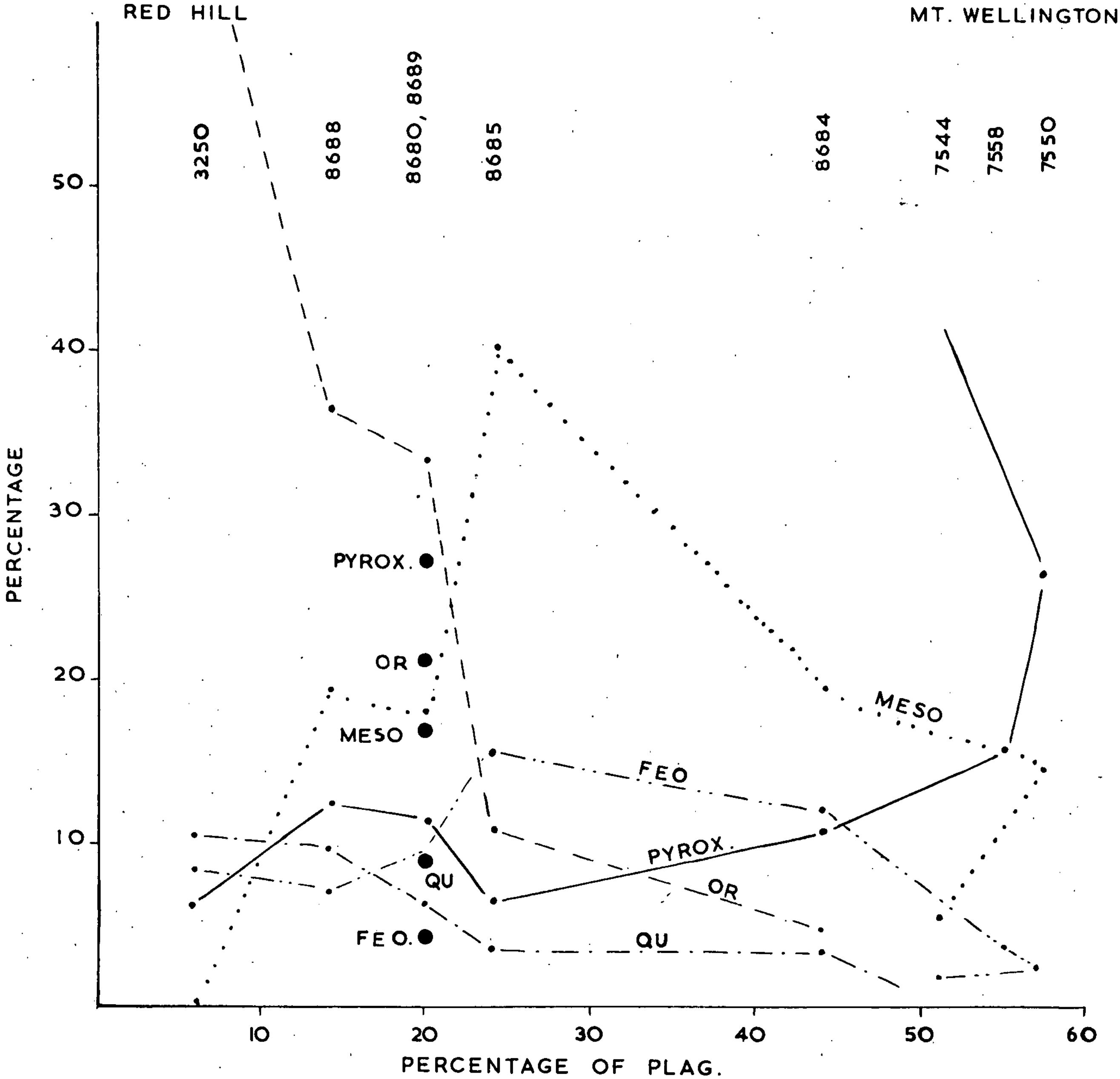


FIG. 2A VARIATION DIAGRAM OF BLOOMFIELD DOLERITE texture is taken as indicative of a pegmatitic phase.

From the variation diagram figure 2 A, variations of pyroxene, quartz, orthoclase, iron oxide and mesostasis plotted against percentage of plagioclase it is seen that

a. the percentage of pyroxene gradually decreases from coarse dolerite towards the granophyric end (specimen 8688) with slight increase in specimen 8680 and 8688;

b. corresponding with the decrease of pyroxene, the percentage of quartz and orthoclase increases;

c. the iron oxide percentage increases from coarse dolerite in specimen 7558 to a maximum in 8685 and then decreases towards the granophyric end;

d. the mesostasis increases with enrichment of lighter residues to a maximum in specimen 8685 and drops down towards the granophyre 8688 with the separation of quartz and orthoclase. From this mesostasis rich zone another trend is also noticed leading to a pegmatite specimen 8689.

With the orthodox understanding of the differentiation by crystal settling, the decrease in the percentage of pyroxene up to specimen 8685 is normal but the increase seen in specimen 8680 and 8688 is anomalous. The increase of quartz and orthoclase is quite reasonable. The reason for the iron oxide increasing up to 8685 could be that the pyroxene separating out is pigeonite low in iron. The sudden decrease in the percentage of iron could be that the excess iron goes to pyroxene and separates out as iron rich augite-ferro-augite. In the same specimen the mesostasis is also more and the lighter residue rich in K_2O, Na_2O, SiO_2 and H_2O, separates out as quartz and orthoclase in the next higher fractions. Here it is noticed that there are two trends unconnected, one separating as granophyre and the other separating as pegmatite. The granophyre separation could occur in the normal course of differentiation with enrichment of K_2O, Na_2O, SiO_2 and H_2O as stated earlier, the iron going into ferro-augite. The pegmatite could possibly separate with enrichment of water at an earlier stage with the formation of pigeonite instead of ferro augite. This divergence in trend from the mesostasis rich zone may either be due to enrichment of water at different times or due to variations in the thickness of the column of magma differentiating or possibly due to both. (Refer Plate 11 & 12 for micro-photographs)

Specimen 8684

In hand specimen the rock is dark greenish grey with visible feldspar and pyroxene. Under the microscope the rock shows typical ophitic texture and consists of 44% plagioclase, 11% pyroxene, 3% quartz, 5% orthoclase, 12% iron oxide and the rest mesostasis. The plagioclase, labradorite (Ab 48) occurs as laths measuring up to a millimetre in length. The crystals show zoning and twinning are combinations of Albite and Carlsbad (pericline being less common). Pyroxene forms neutral phenocrysts measuring up to 4 mm. and encloses laths of plagioclase and grains of magnetite. Augite (2 V = 40), pigeonite (2 V = 0) both occur. Quartz and orthoclase occur as anhedral grains measuring a fraction of a millimetre. The mesostasis is finely crystalline and turbid, but recognizable grains of iron ore in rod like form and flakes of biotite and needle-like apatite crystals occur.

Specimen 8685

In hand specimen the rock is light grey in colour and has a granular texture with visible feldspar and pyroxene. Under the microscope the rock shows subophitic to granular texture and consists of 24% plagioclase, 6% pyroxene, 11% orthoclase, 4% quartz, 15% iron ore and the rest mesostasis. Plagioclase, andesine (Ab 55) occurs as laths and prismatic crystals measuring up to 2 mm. in length. Twinning are combinations of Albite, Carlsbad and Periclinal. Pyroxene occurs as corroded phenocrysts, measuring up to 3 mm. and enclosing laths of plagioclase and magnetite. Both augite (2 V = 40) and pigeonite (2 V = 0) occur . Orthoclase and quartz occur as anhedral grains with a graphic texture. The mesostasis is fairly crystalline but dense and clouded. Magnetite grains line up as rods.

Specimen 8680

In hand specimen the rock is coarse grained light grey in colour and has a granophyric texture. Under the microscope the rock is largely composed of dense mesostasis and consists of quartz (6.4%), orthoclase (33.6%), plagioclase (20.3%), pyroxene (11.7%), iron oxide (9.6%) and mesostasis (18.1%). Quartz occurs as anhedral to subhedral prismatic laths measuring a millimetre in length. Twinning is uncommon to rare and n = balsam. Cleavages in the subhedral form are fairly well developed parallel to 001 and less perfectly to 010. Orthoclase occurs in the mesostasis as anhedral grains. Plagioclase, andesine

(Ab 55) occurs as subhedral to euhedral forms measuring up to 3 mm. Pyroxene, augite (2 V = 40 to 45), occurs as anhedral crystals with corroded outline and encloses laths of plagioclase and large subhedral grains of magnetite.

Specimen 8688

In hand specimen the rock is light grey in colour, coarse grained with a granular texture. Under the microscope the rock shows a panidiomorphic granular texture and consists of 9.8% quartz, 36.4% orthoclase, 14% plagioclase, 12.6% pyroxene, 7% iron oxide and the rest 17.2% mesostasis.

Quartz occurs as anhedral grains with a low birefringence and shows intergrowth relationship with orthoclase. Orthoclase occurs as euhedral to subhedral prismatic laths measuring up to 2 mm. in length and as anhedral grains with a granophyric texture with quartz in the mesostasis. Twinning is seen in some sections. Cleavages are developed in the subhedral forms. Plagioclase, andesine (Ab 65) occurs as subhedral to euhedral prisms measuring up to 2 mm. Pyroxene, augite (2 V = 45) occurs as subhedral embayed crystals measuring up to a [illegible] mm. Iron ore occurs as subhedral grains measuring up to a mm. across. In the mesostasis slender greenish pleochoric amphibole occurs.

Specimen 8689

The rock in hand specimen is a greenish grey in colour very coarse grained with visible pyroxene and feldspar measuring up to 3 to 4 mm. across. Under the microscope the rock consists of 9% quartz, 21.4% orthoclase, 20% plagioclase, 27.8% pyroxene, 17.2% mesostasis and 4.3% iron oxide.

Quartz occurs as anhedral grains with a low birefringence. Orthoclase occurs as subhedral prisms measuring up to 2 mm. in length, twinning being uncommon. Plagioclase occurs as euhedral prisms measuring up to 3 mm. in length and shows both Albite and Carlsbad twinning. Pyroxene both augite (2 V = 45) and pigeonite (2 V = 0) occurs as phenocrysts measuring up to 4 mm. across and encloses small prisms of plagioclase ophitically. Iron oxide occurs as small grains both in the mesostasis and bordering the pyroxene. Little biotite and apatite occurs in the mesostasis.

Specimen 8691.

This specimen was collected half a mile south east of Rosegarland Hotel on the east side of the Lyell Highway at grid 484600 N 743300. In hand specimen the rock is fine grained and dense, with a dark greenish grey colour and shows amygdules filled with calcite, quartz and dark nodules, In hand specimen it might be mistaken for an amygdaloidal basalt.

Under the microscope the rock is a fine grained dolerite with 50% plagioclase, 30% pyroxene and the rest mesostasis. The amygdules are filled with calcite and quartz. Both circular and irregular amygdules are present with sharp to irregular boundaries. On the inner side of the quartz grains in the amygdules are dark feathery growths resembling reaction structure. The dark amygdular nodules seen in the hand specimen, under the microscope appear to be of fine mesostasis, surrounded by is the normal fine grained dolerite. The edge, often sharp, is lined with tiny laths of plagioclase indicating that the nodular mesostasis rotated within the magma. (Plate 13)

This phenomenon of occurrence of distinct globules of mesostasis within the fine grained dolerite is suggestive of liquid immisibility. Direct evidence of silicate immiscibility in nature has been lacking. Roedder (1951, p. 282) found an extensive region of immiscibility in the system of FeO - K_2O - Al_2O_3 - SiO_2. A series of quenching experiments conducted by Cassidy and Segnit (1955, p.305) on an artificial mixture of soda, lime, magnesia, alumina and silica approximating in composition to iron free tektite resulted in a small sphere of one type of glass embedded in much larger quantities of a second glass. From these experiments and experiments on actual tektite they have concluded "that the so called 'lechatclierite' inclusion in tektites most probably represent a state of liquid immiscibility in a silicate melt". Therefore, it is suggested that the occurrence of distinct globules of fine mesostasis in a fine grained dolerite, is another example of liquid immiscibility in silicate melts occurring in nature.

Another similar rock occurs west of Plenty railway station at grid location E 484100 N 737900. Here also the rock occurs close to the base of the sill and the amygdules are much smaller.

TERTIARY SYSTEM

Tertiary Lake Sediments

Earlier references on the Tertiary lake sediments in this area are few in number. The earliest reference was made by Johnston (1888) who described fossiliferous lignites and clays from near the junction of the Styx and Derwent Rivers, and mentioned leaf and fruit impressions from the Glenora road cutting. Banks (1955, p) has made a brief reference to them in his report on the Tertiary fossil forest at Macquarie Plains.

The Glenora and Bushy Park area formed a lake bottom during the period immediately prior to the volcanism. Banks (1955) has called this lake"the Glenora Lake". That name may be retained. That this condition continued throughout the Tertiary period, when the region was either lakes or low marshy ground is indicated by the fact that the lake sediments and fossil forests existed in the inter-basaltic period. This lake extended from west of Glenora to at least the edge of the dolerite at Rosegarland in an easterly direction, and towards the southeast it extended at least to Plenty as shown by the conglomerate and lake sediments in the Plenty basalt quarry. The edge of this lake is marked by a conglomerate bed containing boulders and pebbles of quartzite and dolerite. Such a conglomerate bed is exposed overlying the dolerite at the road cutting on the Dobson Highway southwest of Glenora and along the Meadowbank road at locations E 477200 N 745500 and E 476900 N 747800. On the south and southeast sides, this basal conglomerate bed is not seen, but interbasaltic conglomerates occur. The basal conglomerate bed is interbedded with lenticular sandstones and clay beds. These are seen in the river cutting on the Norton property at grid E 479000 N 747000 (Plate 7). Here the conglomerate bed consists of well rounded boulders of Triassic sandstone, quartzite, dolerite and even Owen (?) Conglomerate pebbles, from half an inch to eighteen inches across and it attains a thickness of at least 30 feet. When the lakes were dry the interbedded sandstone formed a soil cover and supported vegetation and even forest as indicated by the upright petrified stems and roots (Plate 1, B). Some of the roots are calcified; thin veins of calcite run across the beds. The beds in this locality show a southerly dip of 5 to 10 degrees indicating a lake bottom gently dipping from the north side. While this was the condition on the northern edge of the lake, the western edge of the lake was probably bounded by a steep cliff face. The evidence suggesting this cliff face is firstly the conglomerate bed both in the Dobson Highway and the Meadowbank road dips easterly at 25 to 30 degrees and the pebbles are well polished and rounded; the polishing of the pebbles is very possibly due to wind action; secondly at the latter locality (on Meadowbank road) petrified wood is lying on a dip slope of 30 degrees. Post-basaltic movements are not known in this area; thirdly the thick conglomerate bed seen in the river section is not found on the eastern edge of the lake and it is suggested that this accumulated at the cliff bottom. The basal conglomerate bed at the Meadowbank locality contains pebbles of quartzite, dolerite, Precambrian (?) quartz schist, and Owen (?) Conglomerate.

The basal conglomerate bed is exposed near the Clarendon homestead and northeast of Kenmore trig. In the latter area it is overlying the Triassic Feldspathic Sandstones.

Overlying the basal conglomerate bed are sandstones and claystones at least 150 to 200 feet thick. Individual beds range in thickness from 18 inches to 6 feet. Complete measurable sections are scarce, because of pastoral lands. The road cutting east of Glenora exposes three beds below the basalts. The bed immediately below the basalt is of white claystone 6 feet thick, followed below by $5\frac{1}{2}$ feet thick yellow to orange coloured claystone. This is preceded below by sandstones. The clay beds contain many leaf impressions. One of these from the yellow bed has been identified by M. R. Banks (personal communication) as *Fagus* and *Cinnamomum*

The sandstone underlying the claystone is medium to coarse grained and is feldspathic; quartz grains are subrounded to sub- angular, feldspar makes about 20% of the rock and muscovite is common. The clay minerals in the white coloured clay bed have been identified by Bahl (personal communication) as belonging to the montmorillonite group by X-ray diffraction.

Lake sediments are also exposed on the banks of the Derwent River at various localities in the Glenora and Macquarie Plains as shown in the stratigraphic column of basalts.

At the base of section A (figure 3) is seen a 6 foot conglomerate bed containing poorly sorted, but rounded pebbles of quartzite, dolerite and basalt.

The pebbles are slightly flattened and discoidal in shape and are embedded in an argillaceous to arenaceous matrix. Overlying this is a friable yellowish brown feldspathic sandstone. The sandstone is medium to coarse grained and contains sub-angular to sub-rounded grains of quartz feldspar and flakes of mica in an argillaceous matrix. The bed is 6 feet thick, shows cross bedding and is veined by earthy calcite. The cross bedding suggests a current from the west. At the same horizon in section B (Figure 3) the conglomerate and the overlying sandstone is seen. In section C (Figure 3) and E (Figure 4) underlying the thick tuff bed is a sandstone bed of 18 inches to 2 feet thick. The sandstone is coarse silt grade. This sedimentary layer supported a forest as shown by the upright stems of petrified wood embedded in the overlying tuff. In all the stratigraphic columns of basalts this horizon is represented by either a conglomerate bed or thin sediment.

Underlying 'flow 2' in section K (Figure 5) is a conglomerate bed 7 to 8 feet thick containing boulders of quartzite, dolerite and basalt, the last mentioned predominating over others. The boulders are sub-rounded to rounded and slightly elliptical to flattish. Underlying 'flow 3' in section P, Q, R, S, and H (figure 5) is a conglomerate bed of 5 feet thick containing pebbles of dolerite and basalt only. Overlying this bed is a friable sandstone, the thickness of which varies from a foot in section Q, R, S to 5 feet in section H. In section H this sediment and the overlying tuff bed contain embedded fossil wood. In section N (Figure 6) underlying the pillow lava are lake sediments and conglomerate.

At Plenty basalt quarry overlying the Triassic Feldspathic Sandstone is a 5 to 6 feet conglomerate bed, which consists of pebbles of quartzite, dolerite and basalt. The quartzite pebbles are well rounded and slightly polished and range from a fraction of an inch to a couple of inches across. Following this is a bed of tuffaceous sandstone 6 feet in thickness gradually passing into a tuff bed. This is again followed by an inch thickness of ferruginous shale and finally by the white baked sediment underneath the basalt.

TERTIARY BASALTS

General

The Tertiary basalts cover an area of 19 square miles. The greatest development of them is seen in the Glenora, Macquarie Plains and Norton areas extending as a continuous sheet from Hamilton square through Mt. Spode map sheet to grid E 484500 N 740800 in the Macquarie Plains map sheet. Two isolated exposures occur in the Plenty map sheet north of Plenty Railway station and near the railway bridge east of Salmon ponds. In the Glenora and Bushy Park areas the basalts attain a thickness of 350 feet, and in the Plenty area the thickness is 100 to 120 feet. Looking at the areal distribution of the present exposures, it appears that the basalts are confined to the valley areas and that the exposures at Plenty and east of Salmon Ponds were once continuous with the main basalt at Bushy Park.

Edwards (1939, p 177) has classified the Tertiary basalts of this area as confined lava fields. The result of the filling, of the drainage system, he has stated, is to develop lateral streams, the pattern of which is modified depending on the basement rocks.

From the conclusions reached in chapter on the nature of the prebasaltic valley this is found to be so. From the same conclusions it is seen that these basalt-filled valleys are structural valleys -- grabens - bounded by normal faults with downthrow towards the graben. This structural valley formed the main drainage system of the pre-basaltic times with a chain of lakes and swampy low lying areas. One such lake existed at the present site of Glenora and Bushy Park and extended up to Plenty at least is explained previously. The lake and its inlet and outlet were partially filled by basalts. This resulted in the development of lateral streams. The Allendale and Belmont Rivulets and the Styx river are lateral streams of this basalt-filled valley (Plate 8,2). The Derwent which started as a lateral stream has cut through the basalt in the Bushy Park and Macquarie Plains area.

Age of the Basalts

The age of the basalts in Tasmania is not everywhere well established. Different ages have been assigned to basalts in different parts of Tasmania, commencing from Oligocene for the basalts of Midlands (Nye and Blake 1938, p. 26), to early Pleistocene for the

Central Plateau (Lewis, 1935, p. 176). In the Wynyard District they overlie and underlie "Turritella Limestone" of Oligocene (Janjukian) (Gill and Banks, 1956, p. 11) and in the vicinity of Hobart and Launceston they overlie leaf-bearing sediments of the Launceston and Derwent basins (Edwards 1949, p 99), so that these are regarded as Pliocene or younger. For the basalts of the Glenora area Johnston (1888) assigned an age of Lower Pliocene or older from the evidence of leaf impressions of Fagus and Cinnamomum. Recent studies of this flora in Victoria have indicated a time range from Oligocene to Lower Pliocene (Edwards 1938, p. 198). The basalts in the Derwent valley are overlain by gravels of pre-Malanna or younger (Lewis, 1934, pp.67-76). Edwards (1938, p. 193) says "From their appearance taken in conjunction with their situation in the path of strong rivers which are still vigorously eroding their valleys, these basalts cannot be older than late Pliocene and are in all probability Pleistocene in age". Edwards (149, p.115) showed that the Tasmanian basalts show petrological affinities with both pre and post Miocene volcanic rocks of Victoria. Thus it is seen that the basalts at the Glenora end overlie lake sediments belonging to the time range Oligocene to Pliocene, and are overlain by pre-Malanna gravels near

New Norfolk, which leaves possible a vast time range. There is room for difference of opinion as to how much time is needed to allow for the erosion of the substantial valleys which have been carved from the basalts. Perhaps Upper Miocene is the youngest age which could be accepted. Current palaeomagnetic work by Irving promises a new tool to tackle this question.

In the Glenora and Bushy Park areas seven flows have been recognized and their correlation from several measured sections has been established to a degree as a working basis. How far this correlation stands the test, future work alone can decide.

Section A (Figure 3) is located at the beginning of the Macquarie Plains cliff at grid E 482934, N 743587. A few feet away from the cliff, in the bed of the river Derwent, dolerite is exposed and hence the base of the basalt in this section is not very far below. The section commences with 5 to 6 feet of sub-basaltic conglomerate, containing quartzite, dolerite and basalt boulders and this is followed by 6 feet of friable sandstone. Then comes a covered zone of 6 feet. This section of sedimentary formation is discussed under

MACQUARIE PLAINS Cliff sections along Dobson highway SE of Derwent river

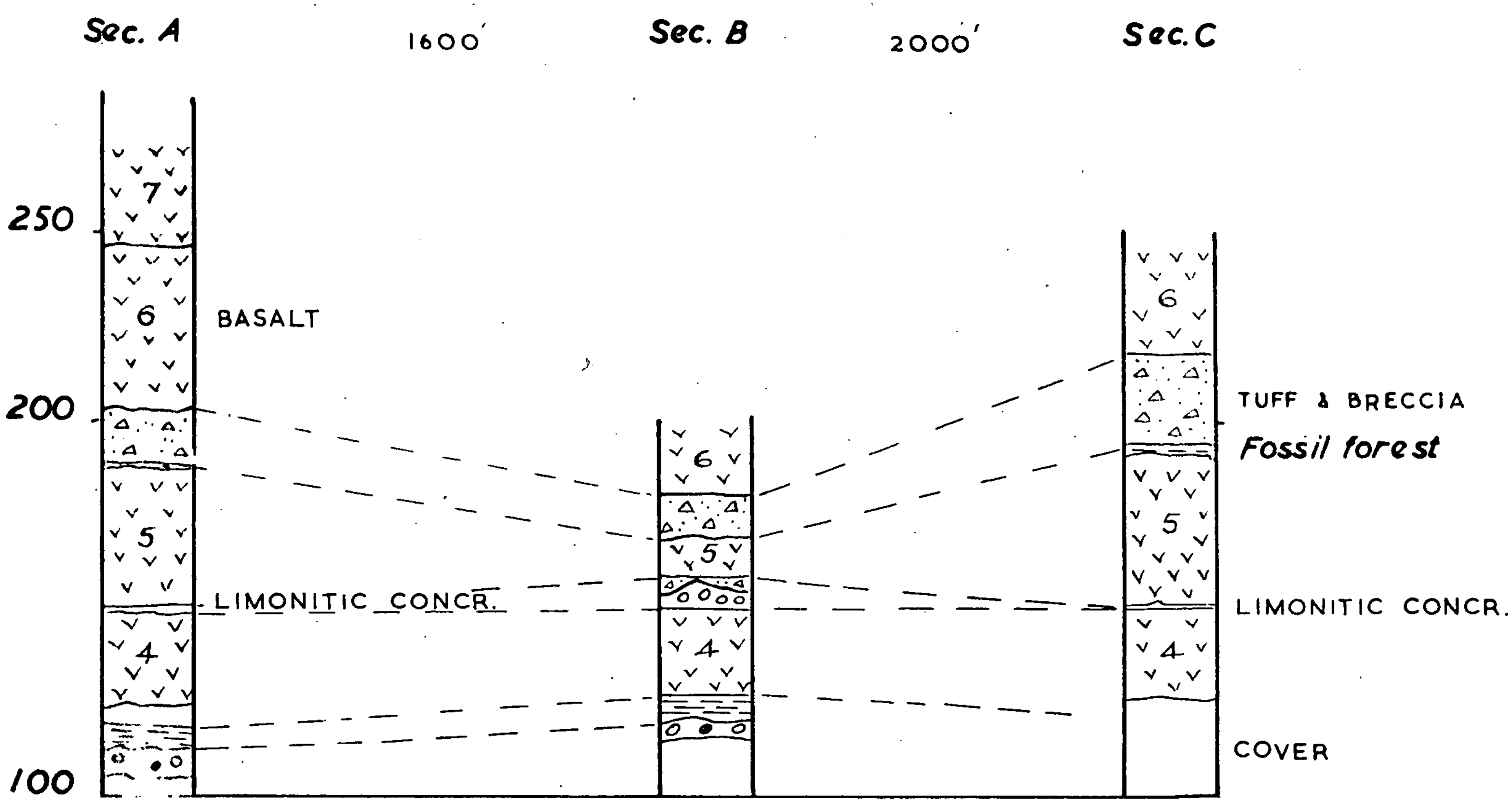


FIG. 3

lake sediments. Overlying the covered zone is a basalt flow - 'Flow 4', 25 feet thick. At the base of this flow is a half to one inch tachylytic zone followed by 6 feet of columnar jointed zone and 18 to 19 feet of hackly jointed zone. At the base tubular vesicles 18 to 20 inches long are developed. The top 6 to 8 feet of the flow is highly vesicular. Specimen 8596 collected from the columnar jointed section is dark grey in colour and is a fine grained vesicular rock. The vesicles are one to one and a half millimetres across and exhibit irregular outlines. Specimen 8597 collected from the hackly jointed portion is of the same colour and is slightly coarser. The vesicles are nearly 2 mm. across and have an irregular to elliptical outline. Overlying this flow is 6 to 8 inches of sediment separating it from the next higher flow - 'Flow 5'. This layer of sediment could possibly be a fossil soil, since further south along the cliff it becomes a concretionary layer. The sediment is yellowish to brown becoming dark grey towards the top. The overlying basalt 'Flow 5' is 35 feet thick and is highly vesicular and scoriaceous. The basal one foot has many vesicles some as large as 5 mm. across. At the base, further south, there are cavities as large as 18 to 20 inches across and 3 to 4 feet deep lined with concentrically filled limonitic concretions. The basalt appears to have overridden the objects contained in these cavities, for near the margin the basalt is finer grained and radially arranged vesicles are noticed. Banks (1956) suggests that these were originally trees knocked over and then overridden by the basalt and carbonised by the heat of the flow. The carbon was later removed by oxidation and some of the cavities filled with concretions of iron hydroxides. Specimens 8598, 8599 were collected from this flow and are dark grey in colour, highly vesicular and scoriaceous. Vesicles are irregular in outline and measure a few millimetres across.

Succeeding this flow is a 15 feet thick tachylytic breccia and tuff. The top of 'Flow 5' is very vesicular and has a wavy upper boundary. In places it seems to be covered by a thin veneer of sand and clay a few inches thick. This sandy, clayey bed could be traced further south up to the Macquarie Plains railway station to the fossil wood location. This, together with the overlying breccia and tuff, forms a marker horizon throughout the area. The tuff bed exposed in this section is at an altitude of 175 feet and contains irregular, angular, poorly sorted fragments of tachylytic basalts, vitreous black glass and fragments of Triassic Sandstone and dolerite.

Overlying the tuff bed is a hard massive, medium grained flow, 'Flow 6'. This is approximately 42 to 45 feet thick and is followed by another similar flow, 'Flow 7', on the top. The separation of these two flows is doubtful and the presence of two separate flows is assumed mainly on topographic features. Each flow makes a distinct bench and discontinuous outcrops stand out.

Section B (Figure 3) is approximately 1600 feet southeast of section A at grid E 482399 N 743505, opposite the petrol pump on the Dobson Highway. Here the section commences from a conglomerate bed 5 to 6 feet thick at an altitude of 115 feet. The conglomerate bed contains predominantly basalt boulders, subrounded to rounded, and embedded in a matrix of arenaceous to argillaceous material. This is followed by 7 feet of friable yellowish-brown sandstone. These two beds, conglomerate and the sandstone, are correlated with the conglomerate and sandstone seen at the base of the Section A. The difference in elevation between the two sections is of the order of 15 feet.

The overlying basalt flow is 25 feet thick and is correlated with 'Flow 4' of the previous section. The flow exhibits similar characteristics to the previous one.

Overlying 'Flow 4' in this section is a 6 to 8 feet thick conglomerate bed which is lenticular in nature. This is correlated with the thin sediment and limonitic concretionary layer described in the earlier section. The conglomerate bed contains predominately basalt boulders with minor amounts of dolerite boulders. Following this is the highly vesicular scoriaceous basalt 'Flow 5' but the thickness is greatly reduced to 12 to 14 feet. The top of the flow is very uneven and is somewhat more weathered than the lower one. At the base tuff intercalations are seen. Succeeding this flow on the top is a medium to coarse breccia and tuff bed 12-15 feet thick. This tuff bed is continuous with the one described in the previous section and the one to be described next. On top of this, massive 'Flow 6' is seen. The thickness of this and the next overlying flow could not be ascertained here with any degree of certainty on account of poor exposures.

Section C (Figure 3) is near the Macquarie Plains railway station about 2000 feet from section B at grid location E 482000 N 742854. Here the lower conglomerate and sedimentary bed is not exposed, being covered by river alluvium of a much later age, but the columnar jointed flow 'Flow 4', seen in the previous two sections is seen and could be traced on to the previous one. The thickness of this 'Flow 4' is fairly constant in all the three sections and there is not much variation in the elevation of the base. Succeeding this flow is the scoriaceous 'Flow 5' which here attains a thickness of 40 feet as compared with 15 feet in the previous section. The base of this flow is irregular and a thin limonitic concretionary zone is noticed. On top of this flow is 18 inches of sediment, limonitic towards the top in places, which is baked due to the heat of the hot tuffs and breccia. The sediment is white to grey in colour and contains quartz in a clay matrix. Following this is a tuff bed 25 feet thick containing opalised trees. It consists largely of irregular angular poorly sorted fragments of basalts and dolerites. Further along the road cross stratification of alternating coarse and medium breccia is noticed.

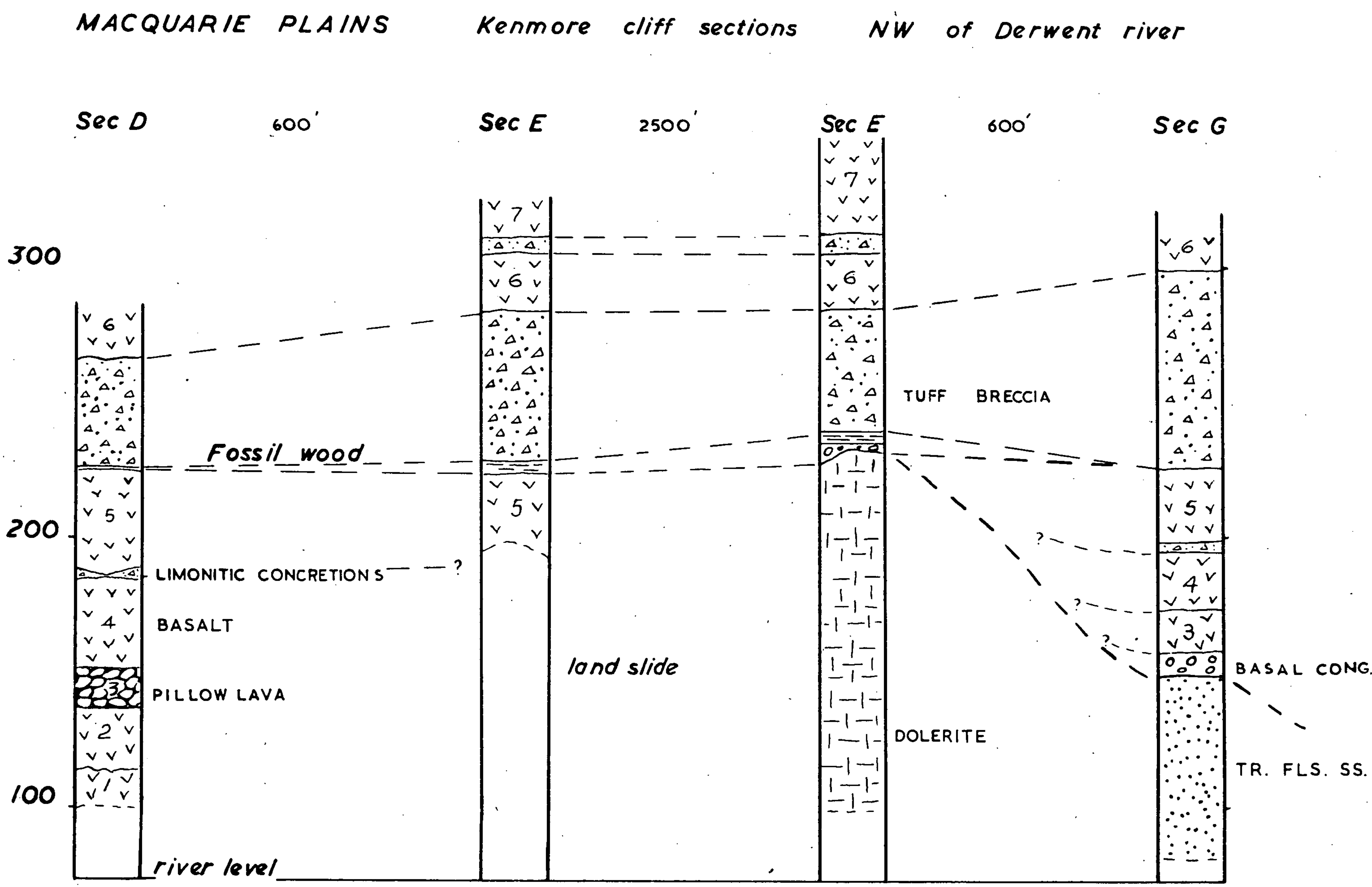
Since the breccia is not rounded or subjected to water action this cross stratification is considered to be terrestrial, perhaps due to the velocity and direction of wind, perhaps to some other cause which is not apparent. The cross stratification shows dip of 35 degrees towards south, and south southeast, suggesting a wind direction from north.

Embedded in the tuff are pieces of opalised wood in an erect position. Apparently the trees grew on the sandy clay bed underlying the tuff. The erect trees could be followed down very close to the sandy bed. The opalisation possibly took place after they were embedded in the tuff by silica solutions moving through the basaltic tuff. From this area several pieces of opalised fossil wood have been taken and more remain there. Banks (1955) states "In one case a branch was found in position on the trunk. The tallest portion of the tree yet found is about 20 feet high, but considering the diameter and angle of convergence of the sides some of the trees must have been over 60 feet in height". A tree presented by Mr Peterson to the Tasmanian Museum showed over 380 growth rings. Considering the very much larger diameter of some of the other pieces which have been found the forest could well have been growing over a thousand years before it was covered by volcanic ash. Succeeding this tuff bed the higher flow 'Flow 6' could be seen in the road cutting. The extent and thickness of this and of the following 'Flow 7' could not be ascertained. The ground to the south and east is pastoral land and no indications are forthcoming.

From these three sections A, B, C on the southeast side of the Derwent River a fair correlation can be made. The outcrops are continuous and there is no ambiguity in the correlation. There is of course doubt about the correlation of flow 6 and 7 for which no information could be found.

The following sections D, E, F, G(Figure 4) to be described are on the northwest portion of the Derwent facing the Dobson Highway and are located along the cliff face of the Kenmore hill. Fairly good continuous cliff exposures are seen from the beginning of the cliff and allow a good correlation.

Section D is located at the beginning of the cliff. The base of the section is not exposed and is covered by the river alluvium to an elevation of 100 feet. The lowest unit seen is a massive basalt whose exposed thickness is 15 feet. The top 3 feet



MACQUARIE PLAINS
Kenmore cliff sections
NW of Derwent river
Sec D
600'
Sec E
2500'
Sec E
600'
Sec G
300
200
100
Fossil wood
LIMONITIC CONCRETIONS
BASALT
PILLOW LAVA
river level
land slide
TUFF BRECCIA
DOLERITE
BASAL CONG.
TR. FLS. SS.

FIG. 4

of this is irregular to wavy. No weathering is seen. The higher flow is recognized by the vesicular zone and the irregular contact. The vesicles are quite large, some at least ¼ of an inch across and they are very irregular in shape. Some are cylindrical, measuring up to an inch in length. (specimen 8600). This lowest unit is noted as 'Flow 1' for the reasons shortly to be mentioned. The overlying flow 'Flow 2' in the section is nearly 20 to 22 feet thick, the bottom half an inch of which is tachylytic followed by a foot of cylindrical vesicles. Again the top 2 - 3 feet is highly vesicular and has a very irregular upper boundary. The limonitic nature indicates a slight amount of weathering. The flow as a unit shows very little jointing (specimen 8601).

The next layer above is a pillow lava 'Flow 3' 18 feet thick (Plate 1 A). The pillows are an average 2 - 3 feet across, some measuring 6 to 8 feet, and are oval in shape. The pillows exhibit concentric rinds, and radial vesicles and fit into one another fairly well. The void spaces in between the pillows are filled with tuffaceous material coloured yellowish brown by ferruginous material. The outer margins of the pillows show a tachylytic zone half an inch thick. This pillow flow makes another marker zone and can be traced all round the Macquarie Plainsand Glenora cliff faces (Specimen 8602). It will be recalled that Voisey (1948, Plate 3) has reported and figured a pillow lava from the Ouse River near Liawere

Following upwards two massive flows are seen separated by a thin iron concretionary zone. The lower flow of these two shows a vesicular zone at the top and tachylitic to slightly ropy bottom. The vesicles are irregular and on the outcrop measuresup to a few millimetres. The limonitic concretionary zone is only a fraction of an inch thick and the bottom surface of the higher flow is irregular. This iron concretionary zone may well be the same horizon on the opposite bank of the river between flows 4 and 5 exposed at an elevation of 175 feet. The flow on top of this limonitic layer is scoriaceous to massive. The two flows are 35 and 37 feet thick respectively. The top basalt flow is followed by a sandy clay layer of variable thickness. Further north along the cliff this sandy clay bed is 2 feet thick. Overlying this layer is 40 feet of breccia and tuff from elevation 225 to 265. The tuff is roughly stratified and crudely sorted, and contains fragments of dolerite up to

6 inches across. Embedded in this tuff bed are pieces of opalised wood lying horizontally. Open cylindrical cavities 18 inches to 2 feet across could be seen (Plate 2 B). It is by correlating this with one across the river in Section C that the other correlations have been worked out. Thus equating this tuff bed and the underlying sandy clay bed with Section C, the basalt flow immediately underlying this is denoted by 'Flow 5' and the succeeding lower ones by 'Flow 4' and 'Flow 3' etc. Therefore the pillow lava forms the 'Flow 3'. 'Flow 4' in this section and the succeeding sections has not developed the columnar jointing seen on the Dobson cliff.

Overlying this tuff bed is 'Flow 6'. The thickness of this could not be ascertained in the section because of cover.

Section E is 600 feet along the cliff. Here the lower flows up to 'Flow 5' are covered by land slide talus material and they reach up to an elevation of 200 feet. The first flow seen in this section is the one just below the tuff bed mentioned in the previous section. Underlying the tuff bed are 30 inches of sediment containing iron concretions up to 9 inches across. The top 6 to 8 inches are slightly baked. The overlying tuff bed is coarse to medium and is stratified and shows cross bedding. The latter dips at an angle of 25 degrees towards southeast. The cross bedding and stratification are marked by alternating layers of very coarse and medium tuff. The tuff bed contain lenses of breccia 6 inches to 8 inches across. The fragments are predominantly tachylytic basalt. Dolerite fragments are not uncommon. The sediments underlying the tuff bed contain poorly preserved fragments of leaf and stem impressions. Overlying the tuff bed is a 20 to 22 feet thick basalt flow 'Flow 6' of a massive nature. The basalt is hard and shows hackly jointing. This is followed by a 6 feet thick medium grained tuff bed. This is finer than the one below and shows rough stratification and does not contain big pieces of breccia. On top of this is a massive basalt 'Flow 7'. This is the top most flow seen in the whole area. The exposed thickness is at least 25 feet, but there is no knowing how much of this has been eroded out.

<u>Section F</u>. For a distance of 2500 feet from section E the landslide material forms a scree slope, except for tracing the tuff bed visually by the

vegetation no further information could be gathered until the end of the cliff near section F at grid E 482867 N 744000. Section F is opposite to Section A on the other side of the river. Here the lower 20 feet is covered by the river alluvium and from an altitude of 125 to 230 feet dolerite is seen. This is the same dolerite as that exposed in the river bed a few feet from Section A. Overlying this dolerite hill is a conglomerate bed 5 to 8 feet thick, containing dolerite and basalt boulders, followed by 6 feet of brown friable dolerite and basalt sandstone. Directly above the sandstone is the tuff bed seen in the previous sections above 'Flow 5'. The tuff bed here is at least 50 feet thick and contains dolerite boulders as much as 16 inches across. To have blown such big boulders with the tuff the volcanic centre should not be far away. A careful search around the area revealed no volcanic necks and such big boulders in the tuff will remain an anomaly. A possible source is suggested at the end of the chapter. On top of the tuff bed is a 20 feet thickness of basalt flow, 'Flow 6', followed again by the tuff and 'Flow 7' described in the last section.

The correlation of the different flows across the river is made by taking the tuff bed with the opalised trees between flows 5 and 6 as the same. Here there is a slight discrepancy between the elevations at which they are exposed. The tuff bed on the Kenmore cliff is at an altitude of 225 feet whereas in the Dobson Highway section it is at an altitude of 175 feet to 185 feet, a difference of 40 to 50 feet, in a distance of 1600 feet. This gives an angle of dip of the order of 2 to 3 degrees as worked out between Sections C and D, B and E, A and F. This inclination is not too great, the gradient is of the order of 1 in 30. This of course assumes the absence of post-basaltic tilting, a possibility which cannot be excluded.

The next section G is at a distance of 600 feet from section F at grid location E 482930 N 743292 (Figure 4). The section from the river level starts with the Triassic Feldspathic Sandstone up to an altitude of 150 feet. Overlying the Feldspathic Sandstone are the basal conglomerate beds of the Tertiary lake sediments. The thickness of this basal conglomerate bed is nearly 10 feet and consists of big boulders of dolerite and quartzite measuring 10 inches to 12 inches across. No basalt boulders are found in this. It is very similar to the basal conglomerate bed exposed near the Clarendon house. On top of this conglomerate is massive basalt 15 feet thick. The top of this flow is irregular and not much weathering is seen. Following upwards two more flows are seen, 20 feet and 25 feet separated by 5 feet tuff with a veneer of sediment underlying it. Above the basalt flow is a tuff bed corresponding to the tuff bed between flows 5 and 6. This tuff bed could be walked continuously to the other section. Therefore, working backwards the flow below the tuff bed is correlated as 'Flow 5', and the other lower ones with flows 4 and 3. In this section there is a tuff bed separating flows 4 and 5 which is not seen in the other sections hitherto described, but is represented in them by a thin veneer of sediment or a limonitic layer. Flow 3 of this section has not developed any pillows as in section D, but this flow could be traced into a flow developing pillows round the bend of the cliff. Assuming that the pillows are developed when lava flows into a water-logged area, this non development of pillows in this section could be explained as being solidification above the water level. This is also strengthened by the fact that the dolerite and the Feldspathic Sandstone form a buried hill (Plate 5A), taken from the Gretna looking into Kenmore clearly shows the swing of the higher flows and the lower ones swinging round the buried hill. The tuff bed overlying flow 5 here attains a thickness of 75 feet and contains very coarse irregular tachylytic breccia of basalt and big boulders of dolerite measuring up to a foot and a half. The tuff bed increases in thickness northwards from 40 feet in Section D to 75 feet in Section G, indicating that the material came from the north. Following upwards in the succession, flow 6 and flow 7 are met, separated by a tuff bed 4 feet thick as in the previous sections.

The next series of sections H,K, P, Q, R and S (Figure 5) are on the north-facing cliff of Kenmore hill. Section H is located 2400 feet from section G at grid E 482266 N 743133. The section commences with a covered zone, covered with river alluvium. The lowest unit seen is 12 feet of basalt, dark grey and massive. The top of the flow is irregular and no weathering is seen. This flow is correlated with 'Flow 2' as will be explained. Overlying this irregular surface is 5 feet of white to brownish-

MACQUARIE PLAINS Cliff sections NW of Kenmore

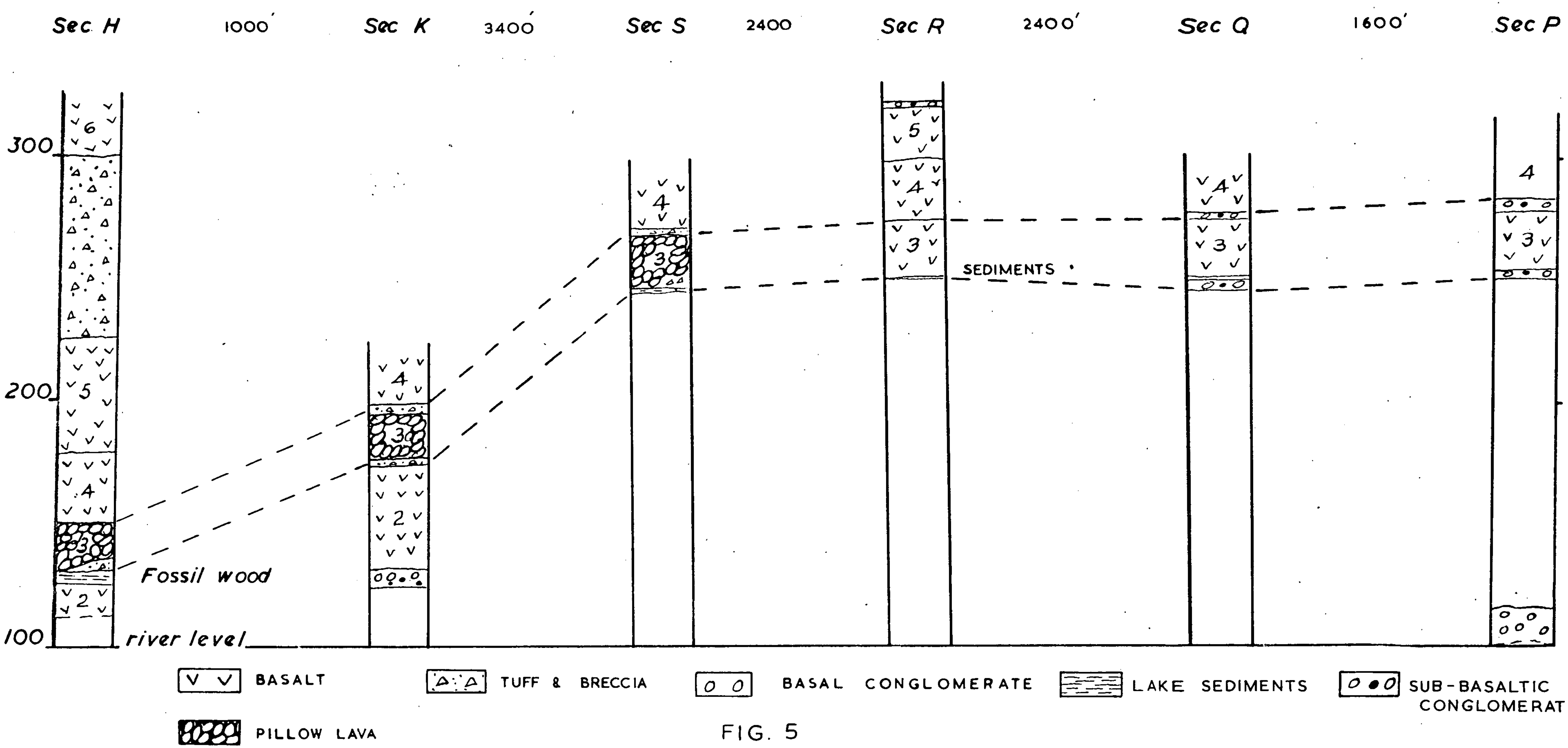


FIG. 5

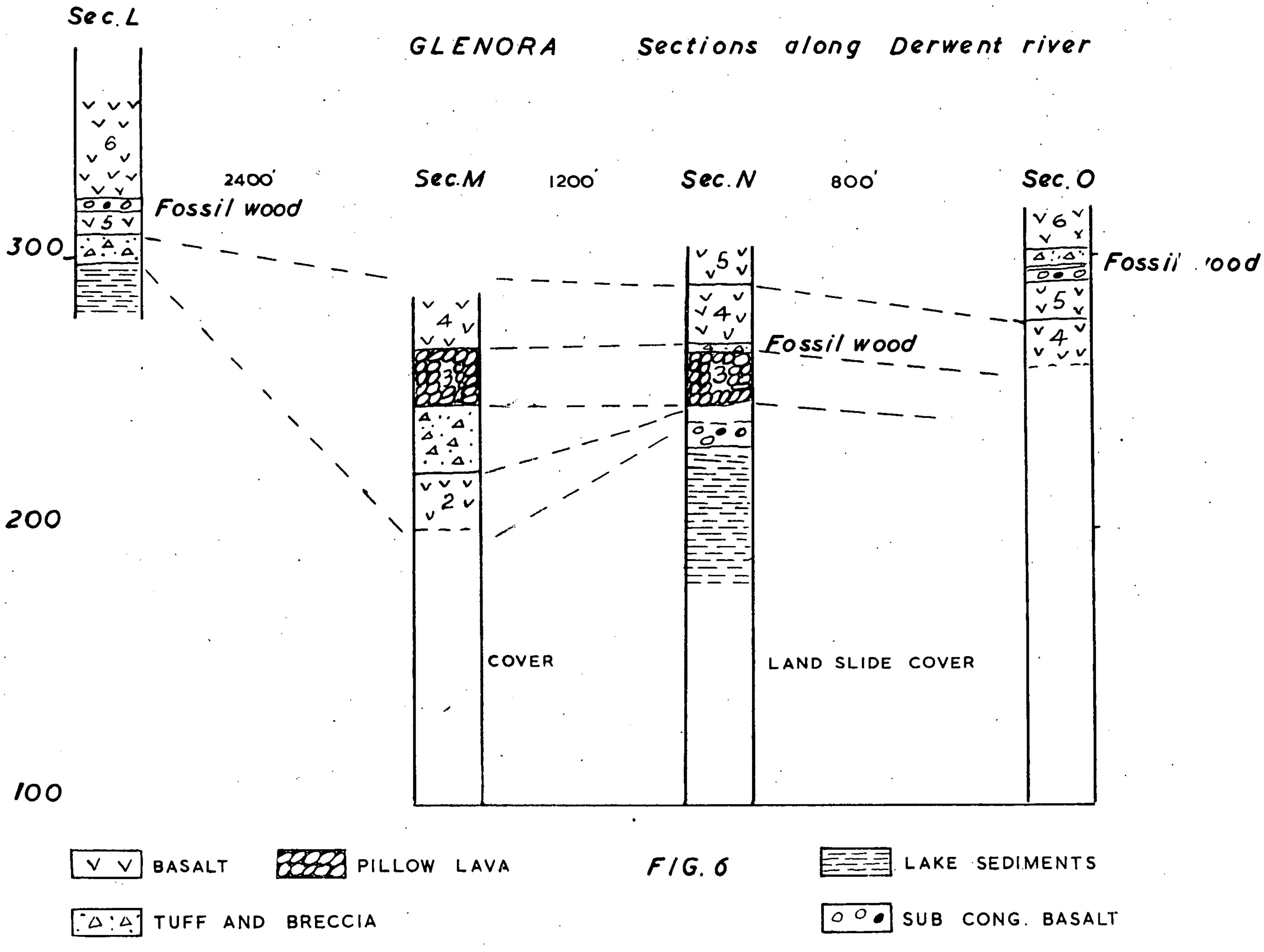
looking friable sandstone. This sandstone is slightly tuffaceous and is calcified and is traversed by veins of calcite. Following this is the pillow 'Flow 3'. Pillows are 4 to 5 feet across and they are loosely packed, the intervening spaces are filled by tuffaceous material. Individual pillows are as described in section D. Lenticular tuff material underlies the flow, in places attaining as much as 5 feet in thickness. Embedded in this tuff are opalised wood fragments. Horizontally disposed cylindrical holes a foot to 16 inches in diameter are seen. These probably were occupied by opalised fossil wood. On top of this pillow flow are flows 4 and 5 and the thick tuff bed. The description of these different horizons is very similar to the ones described earlier.

Section K is 1000 feet further west from section H. The lower portion of this section is covered by river alluvium. The lowest unit is a conglomerate bed of 8 feet thick consisting of dolerite, quartzite and basalt pebbles ranging in size from a couple of inches to 6 inches. Immediately overlying this is a massive flow 42 to 43 feet thick correlated as 'flow 2'. The base of this is tachylytic and the top 3 to 4 feet is vesicular. Following this upwards the 20 feet thick pillow 'flow 3' is encountered. The pillows are well developed but poorly packed. Overlying and underlying this pillow flow are tuff beds 4 feet and 18 inches respectively. The intervening spaces between the pillows are filled with tuff. On top of the pillow flow is flow 4 followed by 5. Between sections H and K the pillow flow is exposed at different elevations. The base of the pillow flow in section K is 42 feet above the base in section H. This within the short distance of 1000 feet indicates uneven floor.

The next section S (Figure 5) is measured at 3800 feet west along the cliff from section K. This area is a landslide zone and the talus material reaches up to 300 feet altitude. The lowest unit exposed is the pillow lave 'flow 3'. Pillows are poorly developed and measure from one foot to two feet across. Individual pillows are surrounded by tuff. Overlying and underlying this flow is tuff, the thickness of which varies considerably. Upwards in the cliff both flow 4 and 5 are exposed. The thickness of the two has varied and in this section it is probably 25 to 30 feet. The inclination of the pillow lava between the two sections is of the order of a degree and a half. It appears that between section H and K was the deepest portion of the valley during that time. The westward rise of the flow probably indicates another valley. This rising valley and the evidence to be introduced later will indicate that the basalt flowed westwards from Kenmore up to Glenora.

The next sections R, Q and P (Figure 5) progressively north-northwestwards are measured to study the behaviour of the pillow flow as an aid for correlation. Therefore those three sections are considered together here. In all the three sections the ground below 250 feet altitude is covered by talus and scree material. The 'Flow 3' with its imperfectly developed pillows in section S could be traced along to sections R, Q and P with no pillows. The thin sediment in the section S develops into a one-foot sediment underlain by 4 feet of conglomerate in section Q and this same horizon could be traced on to section P. The overlying flow in section P has isolated pillow-like structures developed but no actual pillows. In the last two sections P and Q on top of 'Flow 3' (?) a lenticular conglomerate bed is present, the thickness decreasing southwards. The thickness of the flow is fairly constant at 20 to 23 feet. This section fits fairly well with section N (to be described) which is due west and has well developed pillows and it throws light on the nature and extent of the lake at the time of this flow.

The next following four sections (Figure 6) to be described are exposed on the west-facing scarp of the Kenmore Hill facing Glenora. Section O is located at the northwestern corner of the hill at location E 479500 N 745800. Here the lower flows are not exposed being covered by talus and landslide scree material. The correlation is made from top to bottom and is strengthened by the next following section. The topmost flow exposed is flow 6. This is massive, the base being tachylytic and vesicular. Underlying this 'flow 6' is 5 feet of coarse tuff above a foot of sediment and 5 feet of conglomerate. The conglomerate bed consists of pebble-sized dolerite and basalt. The pebbles are well rounded and elliptical in shape. Embedded in the tuff bed are big pieces of opalised wood; a specimen extracted



GLENORA Sections along Derwent river
Sec. L
Sec. M
Sec. N
Sec. O
2400'
1200'
800'
Fossil wood
Fossil wood
Fossil wood
300
200
100
COVER
LAND SLIDE COVER
BASALT
PILLOW LAVA
LAKE SEDIMENTS
TUFF AND BRECCIA
SUB CONG. BASALT

FIG. 6

from that bed measured 30 inches long and 16 inches round the circumference and appears to be a portion of a big trunk. The tuff is vitric and few small fragments of angular basalt and dolerite are noticed. This is the same tuff bed as that appearing above 'flow 5' in the Kenmore cliff and forms the pastoral land on the Kenmore plateau. The thickness of this tuff bed is greatly reduced as compared with section G and it appears to thin out towards the west. Underlying this tuff bed is 15 feet of fine grained basalt with a 2 foot shattered zone at the base. The top couple of feet is vesicular and generally the flow is scoriaceous. The shattering of the base is probably due to the lava flowing over the rough consolidated surface of the earlier flow. Below this is at least 30 feet of 'flow 4'. The top 4 feet is vesicular and scoriaceous while the lower parts show hackly jointed and columnar jointed zones.

Section N is situated 800 feet along the cliff towards the south at the right-angled bend of the Derwent river. The lowest unit exposed is the Tertiary lake sediments followed by a scree covered zone up to 225 feet altitude, where a 10 ft. conglomerate bed is seen consisting of dolerite and basalt boulders. The boulders are rounded to elliptical in shape and range in size from an inch to 8 inches. Overlying this conglomerate is 6 feet of covered zone possibly occupied by lake sediments, which in turn gives place to a 18 to 20 ft. thick pillow flow 'flow 3'. The pillows are well developed and poorly packed. Individual pillows measure up to 2 ft. across and are embedded in tuffaceous material. The pillows show similar characteristics to those mentioned in section D, with a tachylytic skin and radiating vesicles. On top of the pillow flow is a foot thickness of tuff. Here the pillows are loosely packed giving the appearance of single pillows embedded in a tuff bed. Doubt arose as to whether these could be large volcanic bombs. The writer failed to ascertain from the literature any definite criteria for distinguishing between a large volcanic bomb and a pillow except by the nature of the occurrence. It is suggested that isolated pillows embedded in tuff are formed when lava flowed over underwater tuff beds. Embedded in the tuff beds are fragments of opalised and calcified wood. (Specimen 8640). This pillow flow has been correlated with the pillow flow horizon at Macquarie Plains, Kenmore cliff and the other pillow flow met with in the same horizon. Overlying 'flow 3' is a 22 ft. thickness of basalt correlated with 'flow 4'. The bottom half an inch is tachylytic followed by 4 feet of columnar jointed zone, and hackly jointed zone over it. The base is vesicular so also is the top couple of feet. Overlying this flow is 'flow 5' with a 2 ft. shattered zone at the base. The thickness of this flow in this section is not known, probably only 15 ft and it is followed by a tuff bed with fossil wood, seen in the previous section. The columnar jointed nature of flow 4 is not noticed in the Kenmore hill section except in sections A, B and C. This type of jointing is again seen in the Glenora railway cutting, but is observed in flow 6. It is suggested that this type of jointing depends not on the nature of the flow but on the environment and cooling gradient set up between it and lower flow of sediment. This is shown to be so by the fact that in Sections A, B and C the columnar jointed flow is underlain by lake sediments which probably were cold. So again in section L at Glenora railway cutting flow 6 is underlain by lake sediments. In Plenty section, too, a similar condition is seen. Thus it appears that the temperature gradient is responsible for this type of structure.

Section M is 1200 feet southeast of section N at the beginning of the Glenora cliff. The lower portion of the section is covered. The lowest unit seen is flow 2 followed by a tuff bed and a pillow flow which could be traced into the pillow flow at section N. The bottom portion of flow 2 is covered and top foot or two is vesicular. The overlying tuff is 24 ft. thick gradually thinning out in a northwest direction and consists of black glass. The next unit on top of this vitric tuff is a pillow flow correlated with flow 3 and consists of poorly developed pillows a foot to a foot and a half across. This flow appears at an altitude of 245 feet, and if this is projected to the pillow flow at section D in the Kenmore cliff it results in an overall fall of 30 ft. only. On top of flow 3 is flow 4, only the bottom few feet of which is seen. Here the flow has not developed the columnar jointing.

Section L is located at the Glenora railway cutting and it runs across the road section. Here only two flows are seen, flow 5 and 6 separated by a conglomerate bed. This conglomerate bed is 5 ft. thick and consists of predominantly basalt and dolerite boulders ranging from a couple of inches to 8 inches across. Small fragments of opalised and calcified roots and stems are seen. Further east along the railway cutting and road junction this conglomerate bed is represented by a tuff bed with opalised fossil wood. This tuff bed could be traced right along the top of the hill to Kenmore cliff and corresponds to the tuff horizon above flow 5. Underlying this conglomerate bed in the railway cutting, a massive basalt with a vesicular top is exposed (flow 5). The full thickness of this is not seen. The roof is very irregular as seen from photo 6, (Plate 3 A). Overlying the conglomerate bed is flow 6 with development of 4 feet of columnar jointing followed by a hackly jointed zone. The lower half to one inch is tachylytic and a foot is shattered due to overriding on the uneven lower surface. The shattered zone with a thin veneer of sediment underlying it could be traced further west to the mouth of the railway cutting where it is represented by a 5 ft. tuff bed. (Plate 3 B). This shows that the tuffs were deposited on a steep vertical side of the lake sediment and flow 6 flowed from the eastern end overriding. The columnar jointing is developed nearly perpendicular to the cooling surface faithfully following it. It appears that some time before flow 6 the lake sediments were warped up as seen from the western end of the railway cutting and west facing road cutting. In the former locality the lake sediment is generally horizontal and truncated by the overlying tuff; in the road cutting they dip south and southeastwards at 25 to 30 degrees and again flatten out. Here the very irregular surface prior to flow 6 is seen (plate 4) and the relative local difference in elevation has been as much as 40 feet. A diagrammatic north-south section across the railway cutting and road cutting shown in figure 7 illustrates the probable base of flow 6.

In between Glenora road cutting and Kenmore section D there are no good exposures and no sections were measured. The road leading from the Dobson Highway on to the top of Kenmore hill, exposes the tuff bed between flow 5 and 6 with the overlying and underlying basalt flows. This tuff bed with discontinuous patches over the pastoral lands could be traced either way to Glenora and Kenmore.

The correlation of the basalts across the river on the north side to the Clarendon area is not easy as will be seen from the sections measured. The

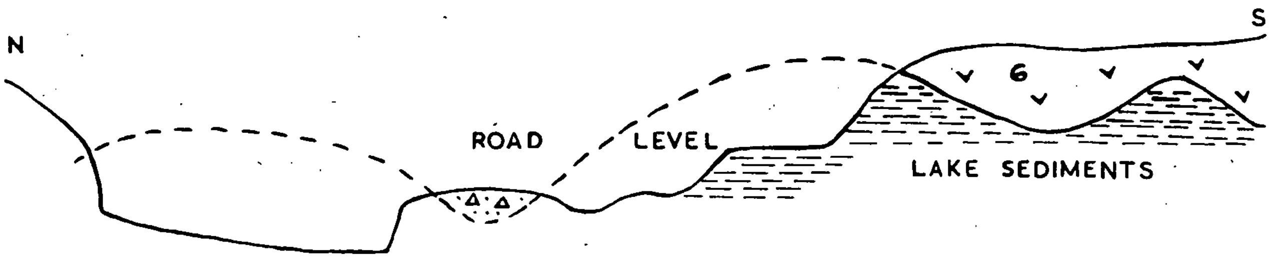


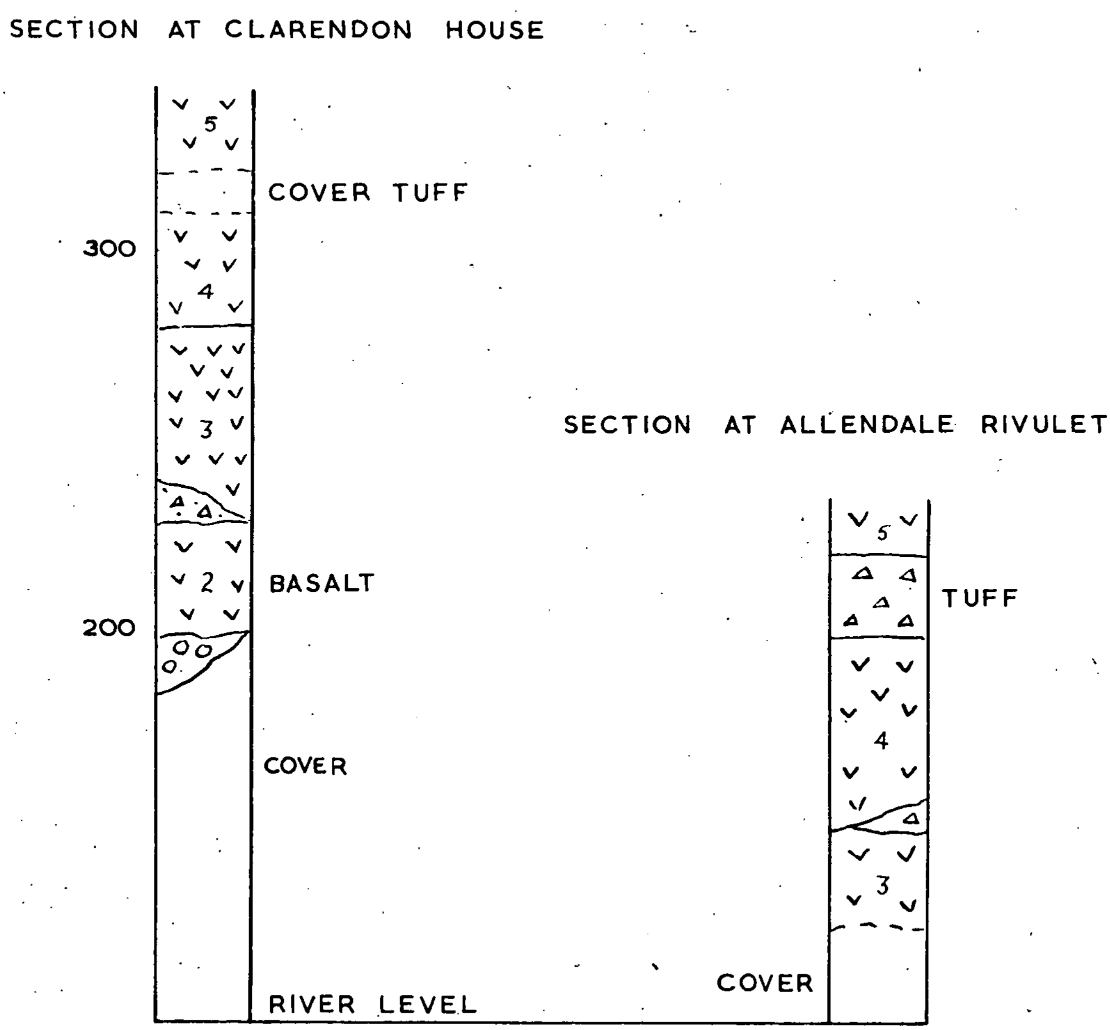
FIG. 7. DIAGRAMATIC SECTION ACROSS RAILWAY & ROAD CUTTING EAST OF GLENORA

SCALE 1" = 100'

pillow flow 'flow 3' as already seen in sections P, Q, and R has not developed pillows and this is also the case on the Clarendon side. The tuff bed in between flows 5 and 6 is not seen owing to poor outcrops and pastoral land. The only bed that could be correlated with some certainty is the tuff horizon between flow 4 and 5 which on the Clarendon side becomes thicker. Two sections were measured on the Clarendon side, one a ¼ mile southeast of Clarendon house and the other at the Ellendale Rivulet west of Gretna (figure 8).

The section at the Ellendale Rivulet starts with a massive compact flow, the top portion of which is slightly ropy and vesicular. Only the top of this flow is exposed. Overlying this on the right side of the rivulet is lenticular pyroclastic material, the maximum thickness seen being 20 ft. The same is not seen on the left bank of the rivulet. Overlying this on the right bank is a massive flow 35 feet thick. The bottom ½ to 1 inch is tachylytic followed by columnar jointed zones. This in succession is followed by a hackly jointed zone. The top few feet are vesicular. Overlying this is a tuff bed,

FIG. 8 SECTIONS ALONG THE NORTH BANK OF THE DERWENT RIVER AT MACQUARIE PLAINS



not very coarse and 18 ft. thick. The base of this is at an altitude of 200 ft. which corresponds with the tuff bed in section G on the opposite bank of the river. Correlating on this meagre evidence the underlying flow is taken as 'flow 4' and the one below as 'flow 3' (the lowest in this section). Already it has been observed that pillows are not developed in the section G. This could very well be the same horizon. But there is no definite evidence at present to prove or disprove it. When further evidence is available this correlation may have to be modified. Overlying the tuff bed is flow 5 according to this correlation. On the left side of the Ellendale Rivulet, both flow 4 and 5 have developed a columnar jointed zone followed by a hackly jointed zone. Flow 5 on this side is scoriaceous. The several flows on the left hand side of the rivulet show a dip of 4 degrees towards the east.

In the Clarendon section the basal unit seen is a conglomerate bed which thins out in the south-easterly direction. This basal unit contains boulders of dolerite and quartzite which range in size from 4 inches to 8 inches across. A search for basalt boulders was fruitless. Therefore this conglomerate bed is taken as the basal lake sediments and has been correlated with the basal conglomerates seen on the other bank. Following this is 30 ft. thick massive basalt correlated as 'flow 2' with the top 3 feet being vesicular and scoriaceous. The vesicles are irregular in shape and size and measure up to 5 to 10 mm. across. Overlying this is the lenticular pyroclastic agglomerate consisting of angular fragments of basalt and tuff with fragments of dolerite. The maximum thickness attained is 10 feet. On top of this is a 35 to 40 ft. thick flow here correlated as 'flow 3'. The bottom is slightly ropy and tachylytic and the higher part of the flow is hackly jointed, medium grained with small vesicles. The differential weathering has resulted in plug-like protrusion standing out of the general surface (Plate 10). Following this on the top is 30 ft. of another massive flow, 'flow 4' followed by 12 feet of tuff. The correlation of these flows is based on the correlation of this tuff bed which could be traced right along the face of the cliff to the one in the section at Ellendale previously described. The evidence for correlation across the river to the Kenmore hill is very inadequate. The farther one goes from the type area the correlation becomes even more difficult and unreliable.

Basalt outcrops are poor in the area between grid E 482900 N 746200 and E 480000 N 753500, and only floats are seen on the paddocks. On the Lyell Highway northwest of Hollow tree road junction outcrops are fair but not good enough to differentiate the flows or to draw any correlation. In the area between Hollow tree road and Norton homestead four flows could be identified. The lowest is a tuff bed, exposures of which are seen on the bank of the Ellendale Rivulet and in the small quarry opposite the P.W.D. quarry. Two flows could be seen in the P.W.D. quarry at an altitude of 385 ft. Separating the two flows is a thin irregular layer of limonitic material. The top of the lower flow is uneven, a foot and a half is highly vesicular. The underlying tuff is medium grained, weathering to brown; crude stratification is noticed. These flows could not be traced either east or west due to poor outcrops.

In another P.W.D. quarry ½ of a mile north of Gleneg Wool Farm two flows could be recognized, one of which, the lower one, is a pillow flow. Underlying the pillow flow is a tuff bed. The top 4 ft. of this is exposed and contains angular fragments of volcanic glass and tachylytic basalt. It also contains pieces of fossil wood (specimen 8632). The pillow flow is of the order of 50 ft. thick, individual pillows are 3 to 4 ft. across with tachylytic margin and radiating vesicles. Intercalated with the pillows is tuffaceous material. Overlying the pillow flow is another flow, the thickness of which is around 50 to 60 ft. followed by another tuff bed of 10 ft. thickness. The base of this flow is uneven and the top 2 ft. is vesicular. The flow is massive and hackly jointed. The top tuff bed could be traced over a distance of 300 yards. Opposite the main P.W.D. quarry on the south of the road is a small road cutting exposing basalt. This is at the road level and is probably below the tuff underlying the pillow flow. This suggestion is made for the reason that during excavations for house building at the Gleneg property large pieces of fossil wood were found; Mr R. Downie showed a fossil tree specimen measuring 20 inches in length and 8 inches in diameter; since these excavations are above the basalt in the quarry under discussion the fossil wood horizon may correspond to the fossil wood found below the pillow flow.

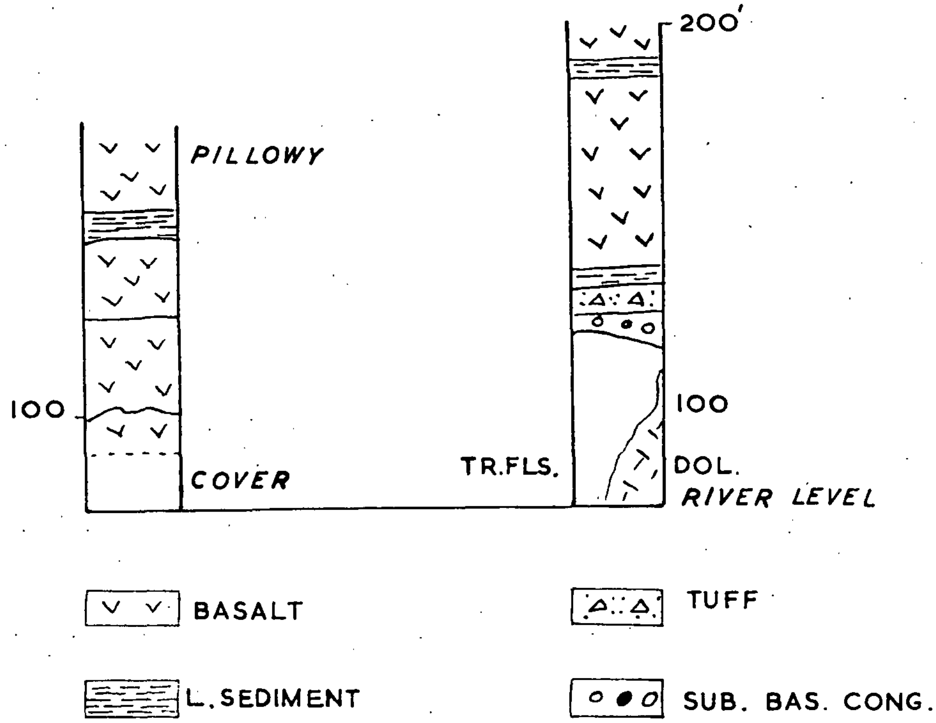
On the east side of the Hollow tree road floats of scoriaceous basalt on dolerite are seen. The basalt at one time covered this side of the valley but has now been eroded out.

At grid E 483050 N 741100 in the creek tuff and agglomerate are exposed underlain by sub-basaltic conglomerate containing pebbles of dolerite and basalt. The thickness of the conglomerate bed is 20 ft. but the base is not exposed. The overlying tuff is compact and consists of angular fragments of tachylytic basalt and volcanic glass. This is probably equivalent to the tuff bed noticed in the Macquarie Plains railway station section between flows 5 and 6. Overlying this tuff bed is a very highly scoriaceous flow. The vesicles are irregular and measure up to an inch across. This flow may correspond to 'flow 6'.

The next basaltic section is at grid E 484000 N 740700 along the railway line figure 9. Here the section is covered from river level to a

SEC. AT 484740 SEC. AT PLENTY

FIG. 9



height of 20 feet. The lowest unit exposed is a hackly jointed basalt. The top of this flow is irregular. The flow is massive, compact and vesicles are filled by calcite. On the top 8 feet is exposed. Overlying this is a flow 25 feet thick; the lower half an inch is tachylytic followed by an 18 inch vesicular zone. Vesicles are tubular and irregular in shape. The lower portion of the flow shows rough columnar jointing. The top 2 to 3 feet is an irregular zone again vesicular and scoriaceous. On top of this is another flow 18 feet thick with a tachylytic base followed by a vesicular zone. The flow is massive and fine-grained. Following this is 6 feet of sediment, friable sandstone, tuffaceous in nature with thin $\frac{1}{4}$ to $\frac{1}{2}$ inch limonitic layers. On top this is a fine-grained glassy tachylytic flow slightly pillowy; good pillows are not seen. The correlation with the previous section and that of Macquarie Plains is unreliable. Assuming that the tuff bed between flows 5 and 6 is getting thinner towards southeast and is here represented by the tuffaceous sandstone the flows below become 5, 4 and 3 respectively downwards and the higher flow becomes 'flow 6' with slight pillowy nature.

The next section is at the Plenty quarry on the Lyell Highway near the old Plenty bridge. Here the lowest unit is dolerite in the bed of the river; on the east side of the quarry Triassic Feldspathic Sandstone dips under the basalts at 35 degrees. The section as seen in the quarry from the east and to the top is as follows figure 9 (Plate 6 A). Overlying the Feldspathic Sandstone is a 4 ft. thick sub-basaltic conglomerate with pebbles of quartzite and vesicular basalt. Towards the top the conglomerate becomes finer and passes into a 4-5 ft. thick tuff bed containing angular pieces of basalt and volcanic glass an inch across, in a fine tuff matrix. Overlying this is 2 feet of white to brown coloured sandy clay with tuff intercalations with an inch of ferruginous shale. This sandy clay bed has been overridden by a basalt flow from the west and is squeezed up. The top half an inch has been baked and is hardened. Overlying the lake sediments are nearly 50 ft. of basalt. The bottom half on an inch is tachylytic followed by two columnar jointed zones each zone being approximately 4 ft. high, the next 35 to 37 feet is hackly jointed and is again followed by columnar jointing. On account of the great thickness two cooling surfaces developed and columns developed at nearly right angles to the two cooling surfaces. The lower column is seen to curve round the underlying sediment. On top of this flow is 3 ft. of lake sediment, white sandy clay followed by 3 ft. of scoriaceous flow, which is only a remnant of a much thicker flow.

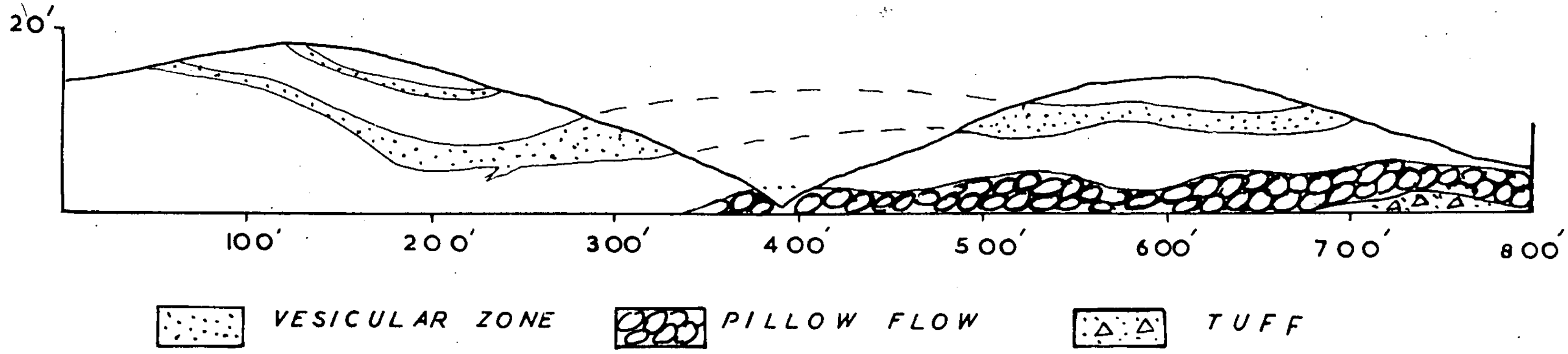
In a section further south along the road the lowest unit seen is a highly vesicular amygdaloidal flow, with amygdules of calcite $\frac{1}{8}$ to $\frac{1}{4}$ inch across. This is followed by a thin conglomerate bed ranging from 1 inch to 18 inches thick and consisting of polished quartzite pebbles and basalts, fairly well rounded. This is overlain by another flow. The topmost flow is correlated with the top most flow in the quarry and the tuff bed and the underlying conglomerate horizon are correlated with the sub-basaltic lake sediment seen at the top of the quarry. This conglomerate bed can be traced on to the lake sediment by detached outcrops. The conglomerate bed dips towards south at a gentle angle.

The ground between the Plenty basalt outcrop and the southeast end of Macquarie Plains basalts, a distance of $\frac{3}{4}$ mile, is covered by brown, sandy Quaternary river gravel. Towards the Plenty end floats of tuff could be seen. Therefore, it could be assumed that these two basalt outcrops were once continuous.

There is another small basalt-covered area 2 miles southeast of Plenty. The Derwent river has cut through this exposure, rapidly eroding it, and has left a small area of it. This basalt is in the dolerite country bordered by 2 or 3 prebasalt faults. In the railway cutting four flows could be seen in a very irregular way (sketch section figure 10). Each succeeding flow moved forward over the lower ones. The lowest units are towards the northwest and the higher units are towards the southeast. The lowest unit is a tuff bed followed by a pillow flow of 4 to 6 feet thick. The pillows are a foot to a foot and a half across with tachylytic concentric rings and radiating vesicles. Overlying this is a flow 6 to 8 feet thick, massive with an 18 inch vesicular zone at the top. Following this is a scoriaceous flow 10 to 12 feet thick or probably thicker.

SECTION ALONG THE RAILWAY CUTTING EAST OF SALMON PONDS

FIG. 10



It is seen from the description of the several sections that while correlation of different flows could be accomplished to a degree in the Glenora and Macquarie Plains areas the same is not possible on present information outside the type area.

A summarised sequence of the Tertiary volcanic history is presented in figure 11. The tuff horizons have been interpreted as the explosive phase, and the sub-basaltic conglomerate and lake sediments have been interpreted as the quiescent period. There have been five periods of volcanic activity, in each case an explosive phase followed soon after by a flow except in the case of flow 2. The periods of quiescene were possibly of a great length, sufficient to cool the lava field and to support vegetation and forest of at least a thousand year standing. Flow 7 may not have been the final flow. The Derwent river flowing over the Kenmore hill has eroded the upper surface; to what extent, and how much has been eroded away, it is hard to say.

The view expressed by Edwards (1939)

GENERALIZED SEQUENCE OF TERTIARY BASALTS AND LAKE SEDIMENTS IN GLENORA AND MACQUARIE PLAINS

Indicating fossil wood horizon & volcanic phases

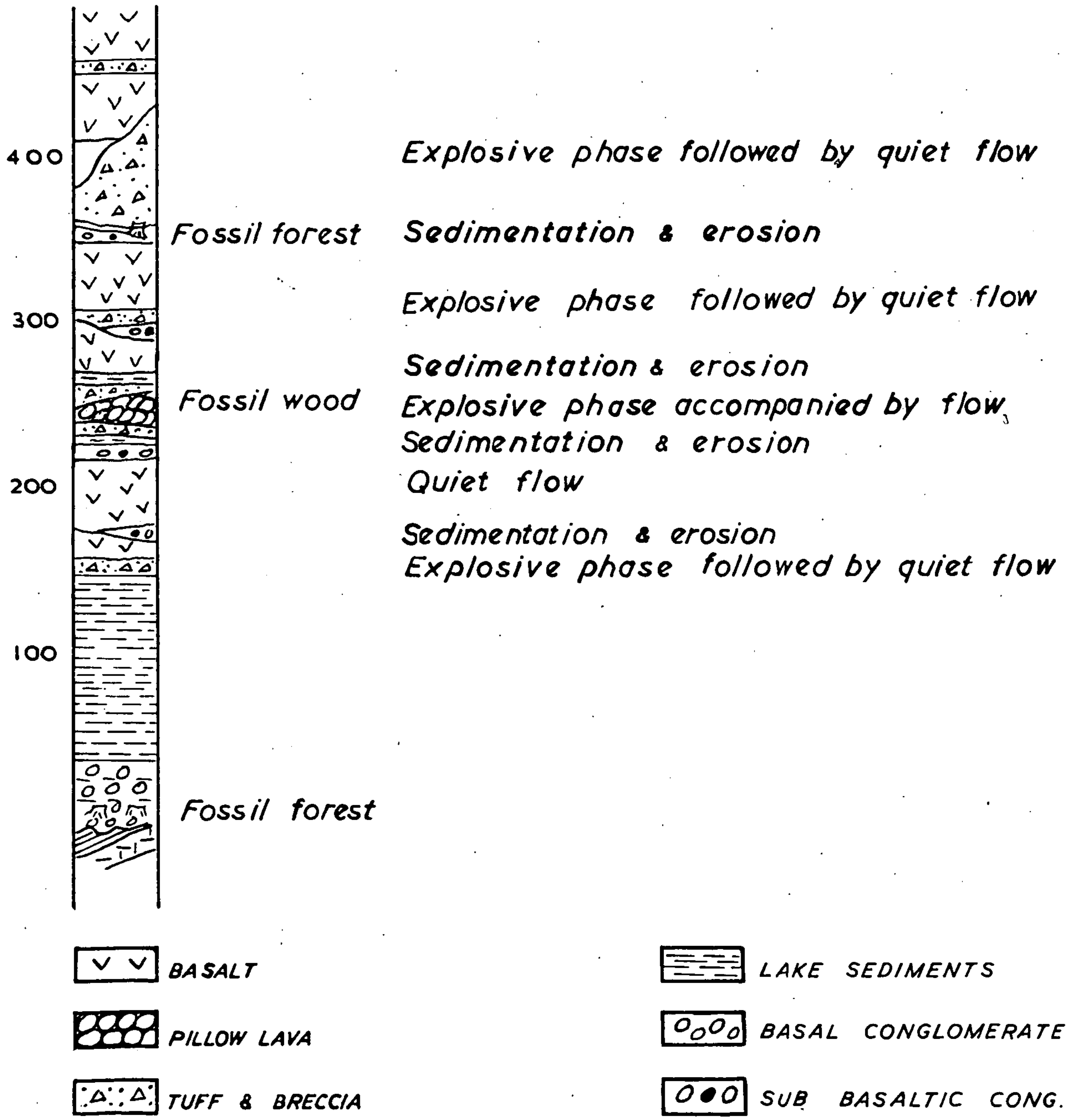


FIG. 11

that the Tertiary basalts flowed down the valley from the Plateau areas is hard to accept wholly. The pattern of the basalt outcrops from Ouse downwards is suggostive, that the basalt flowed down the valley. In addition there appears to have existed a chain of centres along the graben valley tapping portions of the same magma chamber, thus having very close resemblance in chemical and mineralogical composition. A volcanic vent has been known for many years at Sandy Bay, recognized by Professor Carey (personal communication) and recently described by Spry (1955), and McDougall (1957) has reported rocks from the Bridgewater area. There is some indication of a centre between Ellendale Rivulet and Clarendon trig station. The evidence for this is : -

1. The tuff bed between flows 5 and 6 north of Kenmore trig attains a thickness of 75 feet and contains big boulders of dolerite; therefore the source is not far off.

2. The thickness of this bed gradually thins out towards the Glenora end and shows a tendency of thinning towards the Macquarie Plains railway station and beyond.

3. The flows east of Ellendale Rivulet show

a dip of 4 degrees towards east.

The intersection of all these three directions points to a possible centre west of Ellendale Rivulet and east of Clarendon trig.

Petrography of the Basalts

Ulrich (1888) made the first petrological study of the basalts of Tasmania. He recognised olvine basalts and nepheline bearing rocks. This early work was followed by Twelvetrees (1908), Tilley (1928) Edwards (1949), Spry (1955) and a few others. Edwards made a study of the basalts of Tasmania on a regional scale and has classified the basalts on petrographic grounds into different types - Ouse type, Bridgewater type, Midlands type, etc. His basis of classification was threefold depending on the type of pyroxene, texture of groundmass, nature of glass and lastly nature and proportion of phenocrysts.

The present observations on the basalts are the results of the study of 30 to 35 thin sections from the Macquarie Plains, Glenora and Plenty areas. Specimens were collected from different flows from the stratigraphic sections A, C, D, L, M, N, Ellendale, Plenty and a few other places. The object was twofold. Firstly to classify these according to Edwards' (1949) classification and secondly to see if any difference exists petrologically to recognise the several flows. While the first part has been accomplished to a degree the second part has not been a success.

The basalts fall into two types according to Edwards' classification scheme, namely - Ouse Type and Bridgewater Type, but some sections are intermediate between these two. But differences are so minute, classification is not possible. This classification is purely textural and relates therefore to the cooling history. In the same flow specimens collected from near the base of the flow and middle of the flow fall under different types (specimens 8644, 8643, 8648-8605, 8609); such differences are also noticed along the flow (specimens 8599, 8604, 8611, 8649, 8650). This suggests that it is not the difference in basalts, but the pattern of cooling that controls the types. Where the thickness of the flow is considerable, rapid change is seen across the thickness as shown by MacDougal in the Bridgewater area. Along the same flow this change in type is markedly slow and depends on the position of the specimen, but it is noticeable e.g. in flow 5 from Glenora, Macquarie Plains area (specimens 8611 - 8599). As the thickness of individual flows in the area is not great (the maximum thickness is 40 feet) variations of type across the flow is not marked.

The Glenora and Macquarie Plains basalts consist of some olivine (5% to 25%) either as phenocrysts or granules, but commonly as phenocrysts; moderate amount of plagioclase constituting between 20 % and 45%; pyroxene which comprises between a few percent and 15% of the rock, variable amount of mesostasis as glass, several percent of introduced silica and calcite. The rocks are olivine basalts according to the use of the term by Hatch, Wells and Wells (1949, p. 299).

Olivine occurs as colourless, euhedral to anhedral crystals ranging downwards from 2 mm.; irregular fractures so typical of olivine are common, but cleavage is very poorly developed. The figure is biaxial negative with a very large axial angle. The negative sign indicates that the ferrous oxide content of the mineral is greater than 13%. Alteration of olivine to serpentine or carbonate is not very common. In a few slides olivine altering to calcite could be seen.

Plagioclase is usually present in the form of slender lath-shaped crystals ranging up to 1 mm. in length. Twinning is very well developed, the Albite twinning being most common, and Carlsbad and Pericline twinning being uncommon to rare. The composition of the plagioclase varies from Ab 30 to Ab 50 (labradorite). Normal zoning is seen in a few cases.

Pyroxene occurs generally as anhedral crystals and as feathery aggregates and ranges in size up to less than .1 mm. It is often found in the mesostasis, rarely as large crystals. It is colourless to pale grey or neutral in colour and exhibits the typical properties of clinopyroxenes. In most sections only augite was found, with moderate axial angle.

Iron ore occurs as minute anhedral to euhedral grains and in rod like crystals.

Mesostasis is formed completely of dark brownish black to black glass with occasional green glass in very minor amounts. It is isotropic and has a refractive index less than that of balsam.

Silica occurs mainly as opal with minor amounts of chalcedony. In addition to the colourless variety of opal deep brown opal occurs in many sections (8600, 8601, 8602, 8604, 8610, 8611, 8625, 8628, 8629, 8648, 8653, 8660). This has the usual crustification and banding structure but abnormally has a refractive index higher than that of balsam. The refractive index ranges from 1.58 to 1.60 as determined by separating a few grains from the basalt and comparing them with standard R.I. liquids. Calcite occurs in small quantities in the amygdules.

On the basis of the proportion and grain size of the various constituents and hence the texture, it has been possible to recognise two different types of basalts, Ouse Type and Bridgewater Type. These have been described by Edwards (1950, p 102 - 103). In the following pages one from each type has been described and reference to other sections of similar type has been recorded.

The following sections have been grouped into Ouse Type and Bridgewater Type.

Ouse Type	Bridgewater Type
8599, 8600, 8601, 8602,	8698, 8596, 8597, 8604,
8603, 8607, 8617, 8618,	8605, 8609, 8610, 8611,
8625, 8626, 8628, 8644,	8616, 8619, 8620, 8629,
8645, 8648, 8656, 8661.	8630, 8643, 8649, 8650,
	8651, 8652, 8653, 8657,
	8660.

Ouse Type (Specimen 8599). (Plate 14 A)

The rock in hand specimen is fine grained and highly vesicular. Under the microscope it shows a hyalophitic texture and consists of 40% plagioclase, 8% olivine, 3% opal and the rest as mesostasis.

Plagioclase, labradorite Ab 48 - 52 occurs as subhedral phenocrysts measuring up to 0.2 mm. in length in a random orientation. Twinning according to Albite and Carlsbad laws is common, the Albite twinning being more predominant.

Olivine occurs as subhedral to euhedral phenocrysts measuring up to 0.1 mm. across.

Mesostasis consists of black glass and contains feathery aggregates of pyroxene (augite). The feathery aggregates are sometimes bent.

Secondary silica occurs as colourless opal filling vesicles.

Bridgewater Type (Specimen 8596). (Plate 14 B)

The rock in hand specimen is grey and fine grained. Under the microscope the rock shows a hyalophitic texture and consists of 45% plagioclase, 15% pyroxene, and 15% olivine, with the remainder as mesostasis of black to brown glass.

Plagioclase (labradorite, Ab 37) occurs as subhedral phenocrysts measuring up to 0.1 mm. in length and exhibits twinning according to Albite and Carlsbad laws. The Albite type twinning is more common.

Pyroxene, augite (2V = 45) occurs as anhedral grains and aggregates and shows typical characteristics of clinopyroxene.

Olivine occurs as subhedral phenocrysts of 0.2 mm. across and shows slight alteration towards the edges.

The mesostasis consists of essentially black to brown glass with feathery crystallites. A small percentage of green glass is also present.

Specimens 8607, 8618, 8644, 8648 show characters of both Ouse Type and Bridgewater Type. Considering the granular aggregates of pyroxene present in the slides they could be grouped under Bridgewater Type but the amount of black glass appears to predominate and on that score they could be grouped under Ouse Type or as an intermediate type. Since the differences are very minute they have been grouped under the Ouse Type.

QUATERNARY RIVER GRAVELS

The post-Tertiary has been a period of erosion and deposition along river courses. Rocks of this epoch include superficial deposits of rock slides, scree, talus, and river gravels of boulder, sand and silt grades. Of these the rock slides, scree and talus are exposed around the basalt cliffs of Macquarie Plains and Glenora. The breakdown of dolerite cliffs south of Mt. Belmont, east of Gretna and other dolerite cliffs has produced extensive deposits on the slopes. These attain a thickness of 20 to 30 feet, at places even more.

Of the river gravels, boulders to pebble size, are deposited along the Derwent course at different elevations. Three terraces have developed, one at an altitude of 500 feet, the second at an elevation of 350 to 400 feet and the third at an elevation of 200 feet, the present terrace being at 75 to 100 feet. The 500 ft. terrace is seen in the Norton property and west of it and contains boulder- to pebble-size fragments of quartzite and dolerite. The second terrace at 350 to 400 ft. is seen north of Clarendon house, on the right bank of the river Derwent at the Norton bend, and extends over the Kenmore basalt table-land. Further downstream this terrace is observed in the New Norfolk area. The 200 ft. terrace is more extensive and is seen south of Styx river in the Glenora and Macquarie plains area, and extends south-easterly into the Plenty sheet and is seen up to Mt. Lloyd road. This terrace in addition to boulders and pebbles contains sand and silt grade deposits; the latter predominates. The sand grade deposits range from white yellowish to brown sand sub-angular to sub-rounded and are equant. The deposits contain fragments of plant remains and attain a thickness of 75 to 100 feet.

The next terrace between 75 to 100 feet forms the present terrace and is predominently silt to sand grade alluvium.

PART II

STRUCTURE

As mentioned, in brief, previously, the structure of the area is dominated by the effects of two periods of epeirogeny; one during the Jurassic time and the other during the Tertiary, as established by Carey (1954, pp. 189-191). During the Jurassic widespread block faulting occurred as well as some of the cauldron subsidence type. This was followed by intrusion of tholeiitic magma as dolerite which spread over a great area as concordant to discordant intrusions. This uplifted topography was subjected to a long period of erosion and peneplanation lasting several millions of years producing a mature peneplain, Carey (1946, pp. 31-46). Owing to this long peneplanation isostatic dis equilibrium was set up and the climax of this resulted in strong epeirogeny during the Tertiary times. The nature of this epeirogeny has resulted in graben faulting and was followed by volcanic activity with outpouring of olivine basalt. Due to the two superimposed epeirogenies the structure caused by the latter epeirogeny is more prominent than that of the former and has even obliterated the earlier one to some extent.

(A) Jurassic Structure

Bloomfield fault.

The prominent Jurassic structure is the Bloomfield cauldron subsidence in the Mt. Spode map sheet. The Bloomfield fault which forms the ring fault of the cauldron extends in a general east-west direction from grid E 490000 N 757200 to grid E 487200 N 757200 and swings in a southwesterly direction up to Allen Vale homestead forming a 90 degree arc. This is a partial ring fault with a stratigraphic throw of 1000 ± ft. towards south and east. The Permian Ferntree Formation is faulted against the Triassic Knocklofty Formation. The Permian on the upthrown block has a 35 degree dip towards the west, while the Knocklofty on the downthrown side has a moderate dip of 8 to 10 degrees. Apart from the drag dip and stratigraphic juxtaposition no brecciation or later silicification if seen. In the middle of this are a mile and a half north of Allen Vale house is a dyke-like body bounded by straight dyke contacts. This, Professor Carey suggests (personal communication), acted like a feeder dyke to the main intrusion. The Bloomfield ring fault has been cut off on the south-east side by Black Hills fault of Tertiary age.

To relieve the strain radial tensional faults and joints have developed. One such radial fault extends in a NW - SE direction half a mile NNE of Packham Vale house. The throw on this fault is difficult to estimate. The evidence for this radial fault is partially physiographical and partly structural. Physiographically the upthrown block is nearly 500 ft. above the down-faulted block. The strike of the Triassic beds on the upthrown side is N 10°W while on the downthrown side it is north-west-southeast. Further NE along this fault, dolerite has intruded along this fault. The physiographic expression of this Bloomfield structure is that on the south-southeast side of the Bloomfield house is a flat-lying area with a Triassic raft at an elevation of 1100 ft., and bordering on the inside of the peripheral fault dolerite forms a ridge all round with an average relief of 300 to 500 ft. above the surrounding country (geological section). Through this ridge deep gullies have been cut along the tensional radial joints leaving steep-sided hills circular in cross section.

The northwest-southeast trending fault east of the Allen Vale fault runs for over 2 miles from grid location E 488500 N 748100 and a strong linear is visible on the aerial photos. The order of displacement is hard to judge. A rough estimation from the relationship of Ross and Knocklofty formations may be of the order of 300 to 400 ft. (?). On the west side, the upthrown block, pure quartz sandstone, coarse grained and with no shale members, similar to the Ross Sandstone occur, as against Knocklofty sandstone and shale on the east, downthrown side. The general strike of beds on the west side is NNW while on the east of the fault it is roughly east - west. The age of this fault is open to doubt. The pattern of dolerite outcrops suggest a post-dolerite or Tertiary age, but at grid location E 488050 N 749050 baked Triassic shales and sandstones of Feldspathic formation are seen, which places the age of this fault as pre-dolerite and therefore, Jurassic. It is suggested that the age of this fault be taken as Jurassic. Therefore this fault forms one of the radial faults coeval with the Bloomfield structure.

There is another similar fault at the eastern end of Mt. Spode map sheet just outside the area, which is radial to the Bloomfield ring fault. The age of this appears to be coeval but since it is outside the map sheet it is not considered.

The next Jurassic fault is across the Black Hills road a mile and a half east of the Dobson and Lyell Highway junction. The fault runs in a general N 10^{o} W direction with very steep dips of 85^{o} towards the west. This fault when traced southwards suddenly stops at the dolerite-Triassic contact, which runs across it and hence the age of this fault is pre-dolerite. Along this pre-dolerite fault, dolerite has intruded as a dyke about 15 ft. thick. There is ample evidence of post-dolerite movements along this dyke. In the quarry in this dyke, shattering and brecciation with secondary calcite deposition in the fracture planes can be seen.

The other Jurassic structures are seen in the Glenora map square. West-northwest of Glenora on the north side of Russell Falls river, is an east-west trending Jurassic fault with downthrow to the south. The throw is hard to estimate but may be of the order of several hundred feet. This fault acted like a feeder to the dolerite intrusion, which has spread as a concordant sill on either side. The evidence for this Jurassic fault is that on the south side, the down-faulted block, dolerite has intruded into the Permian Ferntree Formation as a transgressive sheet rising towards the east, while on the upthrown side the intrusion is in the Triassic Ross Formation as a sheet rising westwards. In the former area the dolerite forms the roof zone while in the latter area it forms the base of the sill. On this base and roof relation of the sill, assuming that the dolerite is about 1500 ft. thick the throw on the fault would be of the same order.

The next Jurassic fault is half a mile south of Karanjia and trends in a general WNW direction to Westerway, with the downthrow side to the south. On the upthrown side the Permian Ferntree Formations is exposed in juxtaposition with the Triassic Ross to Knocklofty Formation which forms a topographical high. The Triassic Formation on the downthrow side indicates slight drag dip.

In the Westerway area there are four Jurassic faults one trending roughly 305° along the rivulet flowing from the Ellendale side, the other trending east-west just north of the Westerway bridge. These two faults with a downthrow to the southwest and north have brought down the Triassic Knocklofty Formation in a wedge-shaped outline. Just east of Westerway railway station is a NNW - SSE trending fault with downthrow to the WSW, bringing the Permian Ferntree Formation and the Triassic Knocklofty Formation in juxtaposition. This fault and the one mentioned south of Karanjia have been cut off by the Westerway-Moogara fault of Tertiary age. There is possibly a minor fault in the Ferntree Formation running roughly along the Russell Falls River in this section.

Roughly along the Russell Falls River, between Westerway and Karanjia a fault is suspected on the grounds that west of Karanjia is an exposure of Permian rocks of probable 'Woodbridge' age, while north of the Russell Falls River Ferntree Mudstone occurs. The Permian beds south of the Russell Falls River dip towards east at 3 to 4 degrees while on the north side they dip at 2 to 3 degrees towards north. As the area is covered by alluvium no positive conclusions could be made.

A summarised picture of Jurassic structure in the Glenora map sheet is that there are two roughly parallel faults with a wedge-shaped downfaulted Triassic block. The last Jurassic fault is in the Plenty map sheet, running north-south along the Dry Creek. The fault is in the Permian formations with downthrow of 150 to 200 ft. to the west bringing down stratigraphically the Permian formations. This Dry Creek fault is cut off by the Glenfern fault on the north side.

To visualise the Jurassic structure in the presence of later Tertiary epeirogeny is difficult. However an attempt is made here and the following pattern is suggested.

1. The Bloomfield area formed a centre of dolerite intrusion. The Bloomfield fault formed a partial ring fault with a cauldron subsidence.

2. The strain on this ring fault was relieved by radial and peripheral faults and radial tensional joints.

3. The two sub-parallel faults in the Glenora and Westerway area possibly formed tangential faults

of this major Bloomfield structure.

4. Dolerite has intruded in these structural weaknesses and the intrusion of the dolerite is wholly or partially controlled by these faults.

From the Jurassic structural pattern described, the Gretna fault, described later, may be of Jurassic age forming a tangential fault to the Bloomfield structure. But the dolerite at E 482800 N 748000 is also involved in the fault being on the upthrown side in relation to the dolerite block at the Hollow tree road crossing. This is also supported by the dolerite structure contours. To explain both the facts, it is suggested that Tertiary movement occurred along a Jurassic linear, and hence that it is described under the Tertiary structure.

(B) Tertiary Faults

The Tertiary epeirogeny resulted in great block faulting of graben type generally trending 300° with secondary faults trending north and northeast. In the area there are several major Tertiary faults and also a few minor ones. The overall Tertiary structure will be summarised at the end of this chapter.

Glenfern Fault.

A major fault runs in a general 300° direction from the eastern edge of the Plenty map sheet for a distance of a mile and a half and extends to the south-east into the New Norfolk square where it has been mapped by Woolley. The fault is clearly seen in a cutting on the Mt. Lloyd road about 2 furlongs east of the Glenfern and Moogara road bifurcation and forms a strong linear on the air photos. At the road cutting the drag dip in the Triassic Knocklofty Formation is 40° to the northeast and this indicates the direction of movement along the fault with the south block up. The stratigraphic throw on the Glenfern fault is at least 1800ft. bringing the top of the Bundella Mudstone in juxtaposition with the Triassic Knocklofty Formation. The upthrown block forms hills capped by dolerite and the downthrown block forms the low-lying Derwent valley. The Glenfern fault cuts off the Dry Creek fault which is Jurassic in age. The throw of the Glenfern fault is taken by the north-south running fault at grid E 487200 N 734000 with downthrow to the west of the same order as the Glenfern fault, bringing Cascades Group rocks against the Knocklofty Formation at the northern end, and against dolerite and Ferntree Formation at the southern end. The age of this N-S fault is open to doubt for the following reasons:-

1. The fault is generally parallel to the Jurassic Dry Creek fault.

2. The throw is in the same sense as the Dry Creek fault.

3. There is slight suggestion of baking of the Permian Ferntree Formation.

These observations suggest a Jurassic age. Assuming a Jurassic age for this fault the structure becomes complicated and there is no way of explaining the sudden break of the major Glenfern fault with a throw of 1800+ ft. Therefore on the grounds of making the structure comprehensible a Tertiary age is assumed. In that case the throw on this fault is comparable to the Glenfern fault and explanation of structure becomes possible.

Upper Plenty Fault.

This fault runs along the upper Plenty River and is for the most part in the dolerite. The throw on this fault is not ascertainable and may be distributed with the other faults around it.

Westerway-Moogara Fault.

This fault has a profound geographical expression, when viewed from the NE, with the dolerite plateau extending from Moogara to Westerway through Uxbridge. The area to the northeast of this fault is occupied by either the Knocklofty Formation or downfaulted dolerite. This fault extends from the Plenty River to the Russell Falls River at Westerway for a distance of nearly 10 miles and probably extends further west. The fault is clearly seen south of Westerway railway station, across the Styx valley road, and Styx River to the Bushy Park Uxbridge road in the Glenora map sheet. In the Plenty map sheet since the fault is in the dolerite itself field evidence is not clear, but on the aerial photos a strong linear is observed. In the Glenora map sheet across the Styx Valley road, the Triassic Knocklofty Formation which normally has a gentle dip of 5 to 7 degrees towards the northeast, suddenly changes to 15 to 20 degrees towards southeast near the fault. Again this drag dip is seen in the Styx river near grid E 474900 N 741600. The Triassic Ross and Ferntree Formation boundary is chopped off by this fault near grid E 471100 N 744950. In the section between Styx river and Westerway, creeks flowing from the top of the plateau flow straight down the scarp face and turn northwesterly at the foot of the scarp along the fault zone. This is very conspicuous on the aerial photos Ellendale Run 8, Number 24145. At the Westerway end still further evidence of faulting is seen. The dolerite has intruded the Grange Mudstone Formation of the Permian on the upthrown side, while on the downthrown side the dolerite is in contact with the Ferntree Formation and Triassic rocks, indicating a stratigraphic throw of at least 1100'. The Westerway-Moogara fault and Glenfern fault appear to be the same in an en echelon relation and form the southwestern boundary of the Derwent Graben.

Lawitta Fault.

This fault is better seen in the New Norfolk area since only its northwestern extension is seen in the southeast of the Plenty sheet. Further northwest it is covered by Pleistocene to Recent gravels. This fault has a downthrow to the northeast again, of the order of a few hundred feet.

On the downthrown side near grid E 490000 N 736000 Feldspathic Sandstone is exposed, while on the upthrown side lower Knocklofty similar to Ross (?) Sandstone is exposed forming a topographical high. Assuming the correlation as correct the throw would be of the order of 900 to 1000 ft. Even assuming that the Triassic rocks belong to the Knocklofty Formation there appears to be a few hundred feet of throw. This fault has a throw in the New Norfolk area of the order of 300 - 400 ft. as estimated by Woolley, (1957).

If the Lawitta fault is continuous under the Pleistocene gravel in the Plenty area, it may join up with the fault mapped ½ a mile west of Plenty railway station and in the 'Ivanhoe' property, which has the same sense of throw, but the amount of throw is probably less. Seen on the map, the projection of this fault into the Macquarie plains and Glenora sheets marks the southwestern limit of the basalt. Whether this fault is continuous under the Pleistocene to Recent gravel and river alluvium is a matter of conjecture. If it is continuous, it joins with the Meadowbank fault.

Plenty Fault.

This fault is best seen just north of the Plenty basalt quarry near old Plenty bridge, and it trends 300° with a downthrow to the southwest. The evidence for this fault is that the Feldspathic Sandstone, underlying the basalt and lake sediments dip towards the southwest at a steep angle of 30 degrees marking the drag dip; at the bed of the Derwent river dolerite outcrops in what happens to be the downfaulted portion of the Belmont dolerite block. The throw as estimated is of the order of a couple of hundred feet. The northwesterly extension of the Plenty fault is covered by the later basalts or is taken by a NNW trending fault under the basalt country. A slight suggestion of this fault is seen near grid E 484100 N 740800 where the contact of Tertiary basalt and Feldspathic Sandstone runs straight across on top of the ridge and the underlying Feldspathic Sandstone shows a drag dip of 20 degrees towards SSW.

Belmont Fault.

The Belmont fault runs in a general 295° direction on the north side of Mt. Belmont, roughly along the Black Hills road and veers southeasterly into Black Hills and New Norfolk map sheets. It has a downthrow of 700 feet in a NNE direction. The evidence for this fault is as follows:-

1. On the north facing ridge east of Rosegarland Hotel, just below the dolerite, the Triassic Knocklofty Formation is a very quartzose sandstone bed about 25 feet thick. This bed has a southerly dip of 7 to 10 degrees, and is seen all over the valley area to the north, having been down-faulted.

2. From the correlation of the structure of the Belmont dolerite block, which is a portion of a transgressive sheet rising northeasterly and the dolerite block southwest of the Magra fault, it is seen that the Belmont block is upthrown about 700 ft.

3. The Knocklofty Sandstone and shale are successively cut off by this fault in the eastern end of the map sheet.

4. At the extreme end of the map sheet the dolerite is highly shattered with later secondary calcite deposition in the fracture planes so that the rock in the quarry appears to be a fault breccia.

Magra Fault.

This fault is better seen 2 miles northeast of Gretna near Mr Gould's house. Associated with this fault in this area is a complicated system of secondary faults. The Magra fault itself trends roughly 300° and brings Ross Formation against Knocklofty and dolerite. The secondary strain-releasing faults trend generally 340° bringing small blocks of Knocklofty and dolerite together. Severe brecciation and later secondary calcite deposition are amply seen along these fault planes. On the fault scarp the irregular roof of the dolerite intrusion is seen. This fault could be traced for over 3 miles up to the Ellendale Rivulet. From there on it is covered by Tertiary basalt. About 20 yards from the junction of the Lyell Highway and Bluff road the drag dip of about 25 degrees in the Knocklofty Formation indicates the sense of movement on the fault. Here the Ross (?) and Knocklofty formations are in juxtaposition indicating a throw of ±500 ft. The secondary faults generally have a downthrow to the northeast of variable amounts.
The probable disposition of dolerite and Knocklofty Formation and their subsurface projections are indic-

ated in the geological sections.

The Magra Fault extends southeasterly into the Black Hills square and veers southerly into the New Norfolk square, thus extending several miles. The throw in this area as estimated by Woolley is of the order of 500 feet.

Black Hills Fault.

This is situated roughly 660 yards north of the Magra fault and trends in the same direction as it. This fault could be traced from the Ellendale Rivulet to a point a mile southeast of Black Hills trig station, over a distance of seven miles. In the northwestern end of this fault the Ross sandstone is brought in contact with the dolerite and in the southeastern end the fault is in the dolerite itself. Nearly a mile from the Lyell Highway and Bluff road crossing on the Bluff road drag dips in the Triassic rocks indicate the presence of this fault and the direction of throw. The downthrow ($\pm$ 500) is towards the southwest and its magnitude was determined from the roof relation of the dolerite. The throw on this fault in the Black Hills area is estimated to be of the order of 250 feet.

Allen Vale Fault.

This fault has a sinuous trace on the map commencing from near grid E 486200 N 750000 and running in a roughly NNW direction to Ellendale creek. The field evidence for this fault is not very conclusive and its presence has been deduced by the structure of the dolerite base. The estimation of throw depends upon the assumed thickness of the dolerite sill. In the Bloomfield area the dolerite is at least 1500 ft. Assuming the thickness to be 1500 + the estimated throw on this fault would be around the same order.

It is seen that the three faults Magra, Black Hills and Allen Vale, trend in a general NW direction with successive downthrow to the south-west forming parallel step faults with a cumulative throw of the order of 2800 feet. The same order of throw is observed on the Glenfern, Lawitta and Belmont faults.

Gretna Fault.

Along the Ellendale Rivulet west of Gretna a fault is suspected underneath the basalt country running in a north-south direction from the Derwent

River to the Hollow Tree road fork or a little beyond this. This fault is suspected on the grounds that around the Gretna area and up to Bluff road Triassic Feldspathic sandstone is exposed while on the Clarendon and Norton area Ross formations are exposed forming an upthrown block (Plate 9). The presence of this fault is again suspected from the structural map of the dolerite base. Just at the Hollow tree road fork and north of it the dolerite and the Triassic sandstone, which form small hillocks, abruptly terminate in this valley; the Triassic sandstone shows a steep dip of 30° towards southeast. This drag dip is a result of both the Black Hills fault and this one. On the upthrown block a small patch of dolerite is exposed at an elevation of 500 ft. as compared to the dolerite at 375 on the east side.

Norton Clarendon Fault.

The evidence for this fault is best seen in the Derwent river at the Norton bend, where the Ross sandstone forming steep cliffs is exposed lying horizontally, while ½ a mile south of Norton trig on the cliff the Knocklofty Formation has a higher dip of 25 degrees to the southwest indicating a drag on the downthrown side. This fault has a strike of 325° and when projected southeastwards it meets the Gretna fault. Just west of Clarendon house in the bed of the Derwent River Knocklofty Formation is exposed, while ½ a mile north of the Clarendon house coarse quartzose sandstone, Ross, is seen. NW of Clarendon house is a high level river terrace at an elevation of 300 to 350 feet. Though the ground in this area is fairly even at that elevation, this river terrace is not seen immediately on the north of the creek. Therefore it is suspected that while this river terrace was being formed the area to the NE of it was still a higher ground, probably a fault scarp.

Meadowbank Fault.

This fault runs roughly parallel to the Meadowbank road and it throws down the dolerite to the ENE (Plate 8 A). This probably formed a fault scarp prior to the deposition of basalts and lake sediments, from the fact that the basal conglomerate of the Tertiary lake sediments lie on a dip slope of nearly 30° and petrified wood lies at this angle in the conglomerate bed. In a quarry just west of the bridge over Russell Falls River shattering in the dolerite is seen with secondary calcite deposited in the fracture planes. The dolerite on the Dobson highway shows intense brecciation and weathering. Further evidence for this fault is that the Sugar Loaf hill is composed of Ross Sandstone, and an isolated outcrop of Knocklofty to Feldspathic Sandstone occurs in the Styx river at the Dobson highway. Thus, if the Lawitta fault extended under the Pleistocene gravel of the Styx valley it would probably connect with this fault.

Apart from these major NW-SE trending faults, there are a couple of NE trending faults south of Salmon Ponds in the Plenty area bringing down a rectangular block of dolerite between the Knocklofty and Feldspathic sandstones. The dolerite is bounded by two parallel faults with downthrow to the northwest.

In addition to these major and minor faults, towards the end of the Tertiary Period there appears to be some movement of a very minor nature, as indicated by the buckling and upwarping of lacustrine sediments underlying Flow 6 in the Glenora area. These sediments roughly suggest a westerly plunge. Such disturbance may be very local and may possibly be due to the explosive phase of volcanism.

This is also supported by the thick tuff bed underlying Flow 6.

From the description of the major and minor Tertiary faults so far made, it is seen that the Tertiary structure is dominated by NW trending normal faults with downthrow to either northeast or southwest. These major faults lie on either side of an imaginary line extending from New Norfolk to Glenora and from Bluff road to east of Hamilton. Faults on the southwestern side of this line have a throw to the northeast, while those to the north of that line have a throw to the southwest resulting in a structural valley graben. The axis of this graben roughly coincides with the imaginary line mentioned above. The Glenfern and Westerway-Moogara fault extending over 15 miles with a downthrow of 1800 ' to the northeast forms the southwestern boundary of this Derwent graben. The Lawitta fault with its probable continuation with the Meadowbank fault with a downthrow of the order of 500' again to the northeast forms the inner boundary of this graben. These two sub-parallel faults have a cumulative throw of 2300 ' . The Plenty and Belmont fault together add up another 500 feet or so. The deepest portion of the graben in that case will not be on the supposed axis. But if the throw on the Lawitta fault is more than the estimated one, which is not very unlikely, the deepest portion of the graben will be between the Lawitta and Plenty faults. The throw on the Lawitta fault becomes less towards the New Norfolk end.

On the northeastern side of this axis are again three sub-parallel step faults, the Magra, Black-Hills, and Allen Vale faults, with a total throw of 2800 feet to the southwest. The Gretna and Norton-Clarendon faults with an upthrow to the west and north-east respectively form a horst in the Derwent graben. So also the Plenty and Belmont faults with throws to north and south form another horst in this graben. As the combined throw on the Black Hills fault and Magra fault in the New Norfolk area is of the order of 600 feet only it is seen that the throw gradually becomes less towards south. From the mapping of these faults in the New Norfolk area it is noted that all the three faults, Belmont, Magra and Black Hills close on the Lawitta fault leaving Mt. Belmont as a horst extending in a NW direction roughly parallel to the graben axis. These two horsts lie on the opposite sides of the graben axis, the Belmont horst being to the NE while the Norton - Clarendon horst is in between the northern and southern axis. Thus it is seen that the axis of the graben in this part runs in northwesterly direction in an en echelon fashion.

As all the major faults are normal gravity faults, the easiest relief is vertical and down. The major trend being 300^{o} the obvious stress field is at right angles to it, i.e. 30^{o} and is tensional. A secondary minor stres field was probably present which might account for the other faults in the 340 direction and NE direction.

(C) Nature of the dolerite intrusion

To understand the nature and form of the dolerite intrusion an attempt has been made to construct a structural contour map from the elevation of dolerite contacts with the pre-dolerite sediments and the behaviour of the contact as found in the field (Map 5). The constructed structure map is thought to be fairly reasonable by first approximation. The structure of the dolerite deduced from it fits into the known field evidence, and gives reasonable cross-sections.

From the structure map it is seen that the dolerite intrusion of the Bloomfield area originated as an east-west trending dyke extending over several miles distance and spread over as a sill on either side. This dyke intrusion was accompanied by the Bloomfield cauldron subsidence. This inference from the structure map is corroborated by the field evidence. Firstly, the contact of the dolerite running in a general WNW direction for 2 miles from E 490000 N 756800 veering southwesterly in an arc to a point $\frac{3}{4}$ of a mile south of Packham Vale house is either dyke-like or steeply shelving. The dolerite near the contact is fine-grained and chilled but some distance away from the contact, it is very coarse grained (specimen 8681) and has undergone advanced differentiation comparable to the top of the Mt. Wellington sill. The southern contact running east from grid E 487500 N 751700 to the end of map sheet is conformable with the underlying Knocklofty Formation, dipping gently towards the north and forms the base of the sill. Secondly the dyke origin is again suspected by the steepsided outcrop with a dyke contact

E 483000 N 754500, which protrudes from the general outline of the exposure.

Thirdly the final granophyric differentiation of the dolerite magma is seen along the interpreted dyke position. The granophyre differentiation only appears to take place when the column of magma is of sufficient thickness. This can happen in two ways in the area; (a) the intrusion if it is sill-like should be of sufficient thickness or (b) the granophyre occurs near the top of the root zone of intrusion. The first probability of a sill of sufficient thickness does not corroborate the steep shelving contact seen on the north side. Hence the latter second view is suggested. From the structure map and field evidence the probable nature of the intrusion is reconstructed (figure 12) and is interpreted as a small lopolith, dyke-like in its root zone.

The dolerite block southwest of Allen Vale fault is the roof zone of the down-faulted sill rising towards the east northeast. The eastern margin is marked by the post-dolerite Allen Vale fault and the western margin is along the Allendale Rivulet. The contact is obscured by the alluvial cover and soil. The southwestern contact of this block is running in a wavy southeasterly direction from E 483600 N 750500

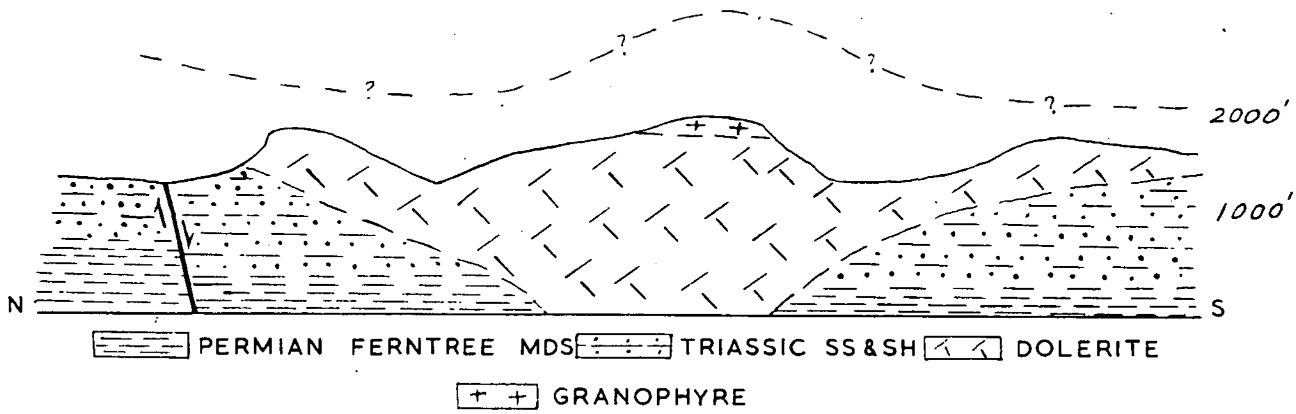


FIG.12 DIAGRAMATIC SECTION ACROSS BLOOMFIELD INTRUSION

and is a concordant shelving contact from an approximate elevation of 400 ft. to 600 ft. in the Triassic Ross Sandstone. The boundary veers southwards from E 485000 N 750100 for a distance of $\frac{1}{2}$ a mile and turns back towards the Allen Vale fault with a strongly discordant relation. This discordant relation is clearly seen south of photo centre Allendale Run 6 - 083 where the dolerite cuts through three successive higher beds of the Knocklofty sandstone and shale, from quartz sandstone through yellowish buff coloured shale to white quartz sandstone. Similarly the triangular block of dolerite at the Lyell Highway and Hollow Tree road junction forms the down-faulted roof zone of the same sill. The northeastern margin is a fault contact with the Black Hills fault, the downthrown side being to the southwest. The southern and southeastern contact of this triangular block is transgressive with a strongly discordant relation at the road level and concordant higher up with the Ross Sandstone.

The dolerite block east of grid E 486000 and north of the Black Hills fault in sheet 4874 forms a complex intrusion in the Triassic Knocklofty Formation. The dolerite contact from E 489000 N 749000 runs in approximately NNE direction and its nature is obscured by the scree slope. The dolerite block between photo centres Allendale run 6 - 85 and 86 forms a flat area with the Knocklofty Formation on the north side; the contact running just at the edge of the flat. The dolerite has a concordant relation with the underlying sediment and forms the base of the sill which originated from the Bloomfield centre. The contact, which has a concordant relation up to photo centre 85, veers towards the northwest with a dyke-like relation to the sediments on the east side along the Jurassic fault, and turns west with a concordant relation up to the Allen Vale fault.

The southern contact of the dolerite block, tetween the Allen Vale fault and the Jurassic fault has a transgressive discordant relation with the underlying Knocklofty as seen by the relative elevation of the base of the sill from 1000 ft. at grid E 488000 N748700 to 1100 ft. at grid E 487000 N 749000. The Knocklofty members overlying this dolerite block form a raft block.

The dolerite contact from grid E 488300

N 748800 runs in a southeast direction with a dyke-like relation along the pre-dolerite fault for a distance of 700 yards and after turns west up to grid E 488000 N 748000; it again swings southwest and follows a creek bed for a distance of nearly 1000 yards. From there on it extends as a tongue northwestwards for nearly a mile. This portion of the dolerite has a dyke-like relation to the sediments. This block, between the Black Hills fault on the south and the Allen Vale fault on the north and bounded on the east side by a probable post-dolerite fault running southwest from grid 489000 747000 is interpreted as the roof zone of the sill, while the block lying to the east and northeast is considered the base of the sill. The dolerite exposure seen in the cliff north of Mr. Gould's house is the roof portion of the sill with a discordant relation to the rocks overlying it.

The northwest-southeast trending rectangular block of dolerite from photo centre run 7 - 97 8 - 42 is the basal portion of the sill. This block has been faulted in a complicated way by the post-dolerite Tertiary fault system. While the northeastern boundary is in contact with the Magra fault the southeastern boundary has a fairly concordant relation. The contact is mostly obscured by the scree material along this line. The southeastern part if this block is faulted against the Belmont fault.

The dolerite south of grid N 743000 and east of E 484000 forms the upthrown block of the same sill described up till now. The base of the sill in this section is rising towards the northeast. The contact with the Triassic Feldspathic Sandstone seen in the quarry 100 yards from the Dobson Highway crossing runs along the north-facing slope of the hill in a general ESE direction to the end of the map sheet where it is faulted against the Belmont fault. This contact is apparently concordant. The sill rises stratigraphically from the Knocklofty Formation in the east to Feldspathic Formation in the west and southwest while the base of the sill itself rises towards northeast. Therefore it is seen that the sill in this part is discordant both stratigraphically and structurally.

The small elliptical outcrop of dolerite a mile NE of Macquarie Plains railway station is an outlier of that portion of the sill explained above.

The ear-shaped outcrop of dolerite 1000 yards west of Gretna is an outlier of the portion of the sill south of Magra fault. The contact with the underlying Feldspathic Sandstone is conformable. This outcrop with the main portion of the sill, again has both stratigraphic and structural discordance.

The elliptical outcrop of dolerite around Mt. Spode is the northwestern extension of the main sill at Bloomfield explained earlier in this chapter. The eastern margin of this outcrop has a concordant relation to the underlying Triassic rocks while the southern contact has a discordant relation. The base of the sill dips westwards. The outcrops on the north-east of Mt. Spode has a concordant contact on the north and east side but has a dyke-like contact on its south-west side.

The dolerite block west of Glenora is portion of a sill rising to the east. It has intruded the Permian Ferntree Formation and the Ross Formation along a predolerite fault. The portion of the dolerite mass south of grid N 746000 forms the roof zone of a sill. Small roof rafts of Triassic sandstone are seen in the railway cutting at location E 476000 N 745100 and further west along the railway line the dolerite peeps up through the Ferntree Formation. The

Sugarloaf Hill forms the roof of the sill. The roof contact could be said to have a slightly discordant relation to the sediment both stratigraphically and structurally. Stratigraphically and structurally the sill is rising eastwards. While this is the case with the block south of the fault, on the north side, the dolerite has intruded the Triassic Ross Sandstone and the base rises westwards. The base of the sill runs roughly northwards just west of grid E 476000. The eastern margin of this ear-shaped outcrop is unconformably overlain by Tertiary lake sediments and is cut off by the Meadowbank fault.

The dolerite outcrop west of Plenty and Salmon Ponds in sheet 4873 has intruded Triassic Feldspathic Sandstone. The contact runs in a general NNW direction and is conformable. In the north near Grid E 483600 N 740000 portion of this sill is cut off by the Tertiary fault. The sill is rising generally towards the east. This portion of the sill is probably the same sill described west of Glenora. If this is so the sill is rising stratigraphically from Ross Sandstone to Feldspathic Sandstone and is stratigraphically discordant.

The dolerite between the Plenty River and the N-S Tertiary fault is a down-faulted block intruding into the Knocklofty Sandstone at its northern end. The contact is generally concordant. However slight stratigraphic discordance is noticed in the fact that the underlying Knocklofty formation strikes NW and dips towards the southeast. This portion of the sill rises towards the east.

The main mass of dolerite occurring southwest of the Westerway-Moogara fault extending from west of the Plenty River to Westerway has intruded into the Grange Mudstone, as shown by the raft a mile and a half south of Westerway. This sill is bounded on the NE by the major Westerway-Moogara fault. It is suspected that this sill too rises eastwards, but no evidence for this is available. The relation of this block and that described west of Glenora is not clear. They may form part of the same sill or there may be two sills in this area.

Apart from these large dolerite exposures, there are a few smaller ones. The small dolerite outcrop in the bed of the River Derwent near the Plenty basalt quarry forms a downfaulted portion of the Mt. Belmont dolerite slab. The linearly extending outcrop just west of Plenty railway station forms another down-faulted portion of the dolerite just west of that exposure.

EVOLUTION OF THE MIDDLE DERWENT VALLEY

The history of the Middle Derwent Valley commences after the Tertiary epeirogeny. As mentioned under structure the Tertiary epeirogeny gave rise to block faulting resulting in a graben valley the axis of which was roughly NW - SE direction in an en echelon fashion. This graben valley was the main drainage channel during the post-epeirogenic and pre-basaltic times and initiated the pre-basaltic Derwent.

The pre-basaltic valley with 100 ft. contour intervals has been reconstructed from the elevation of basalts with Triassic and Jurassic rocks (Map 6) and by first approximation appears to be in keeping with the ideas. These contours show the present altitudes of the topographic surface on which the basalts were extended. In the discussion which follows it is assumed that there has not been any differential movement since the extrusion of the basalt. No evidence of post-basaltic faulting or warping has been found, or suspected, but it is a different propositon to prove that it has not occurred. The following discussion should be read with the proviso that post-basaltic movements, if subsequently proved, could affect the interpretations given. From the contour map it is seen that the graben floor was very uneven and the contours bring out the steep scarp face of the Tertiary faults and the elevated horsts, the presence of which was inferred from the structure and nature of throw on the faults. The Norton-Clarendon horst was roughly 600 ft. high and the Belmont horst was 1500 ft. high, plus that amount which has been eroded out during the post basaltic times. The graben valley sides were at least 2000 ft. high.

A mile north northwest of Norton trig the basalts cut 300 ft. contours and do not intersect the lower ones showing there by that the valley did not extend southwest of Norton horst and that the area formed a saddle between the 'Glenora Low' and the Gleneg Low'. Similarly on the Lyell Highway the contact of basalts with the Triassic and Jurassic rocks progressively rises towards the north from 300 ft. upwards. Hence the 300 ft. contour could not have extended beyond the contour shown on the map, indicating that the valley floor rose northwestwards. Therefore the 300 ft. and 400 ft. contour in the Hamilton square formed a low with no connection to the outside at that elevation. For this low area 'Gleneg Low' has been suggested. Similarly the Glenora area formed another low with 100 ft. and lower contour with a narrow channel through Plenty. To this low area in which lacustrine sediments accumulated the name of Glenora Lake has been suggested. This name was earlier suggested by Banks (1955) and may be retained.

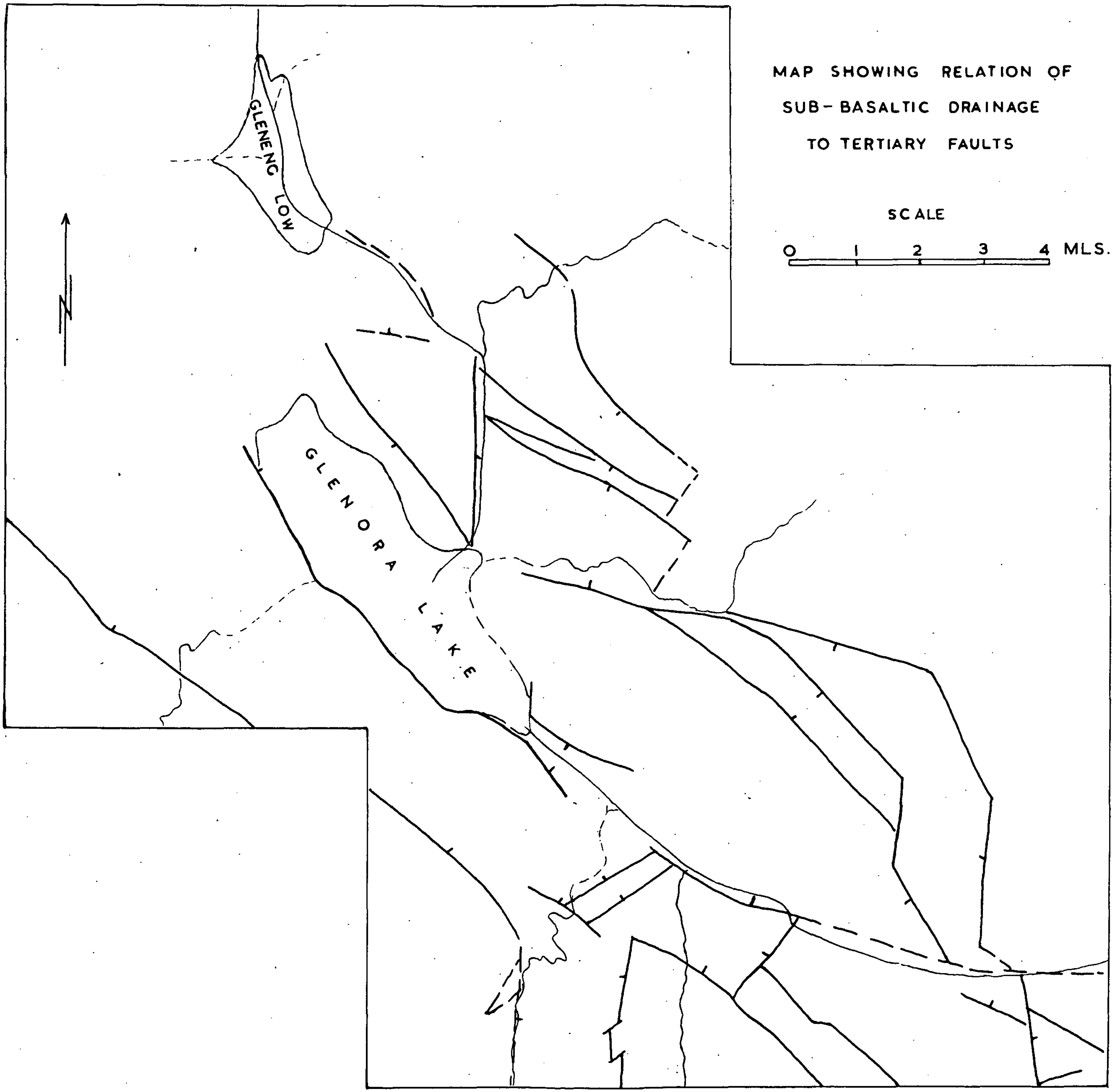
Therefore it is inferred that the graben floor was very uneven with lakes and low-lying areas. The pre-basaltic Derwent was flowing through these low-lying areas and lakes connecting them through a series of cascades and rapids. Into the 'Gleneg Low' flowed the pre-basaltic Derwent and two streams, one from the Mt. Spode area in the northeast and the other from the west, as shown by the contour intersections. To the Glenora lake flowed the Russell Falls river over a scarp from the west and the Styx river from the southwest. These two lakes were connected by the pre-basaltic Derwent flowing roughly parallel to the present Lyell Highway under the area which is now basalt-filled. This ancestral Derwent was joined by the Allendale Rivulet from Bloomfield area and Belmont

Rivulet from the east.

The drainage pattern immediately after an epeirogeny is normally understood to be controlled by the structure. In this respect the pre-basaltic Derwent was no exception and its course was controlled by the Tertiary faults as seen in the map (Map 7). The pre-basaltic Derwent was flowing in a general north-south direction before it joined the Gleneg low. From there it flowed round the Norton-Clarendon horst on the north and east side and joined the Glenora lake keeping the Belmont horst to the left. The outlet from the Glenora lake was in the southeast corner of the present basalt outcrop, through the Plenty area.

In these lakes, Glenora and possibly Gleneg, lacustrine sediments accumulated, brought down by the various rivers, such as Styx, Russell Falls, Belmont Rivulet and Derwent River of pre-basaltic times. These prebasaltic lakes and valleys were filled by basalts from Miocene to Pliocene time onwards.

Attention is drawn to the fact revealed by the contours shown on Map 6 that the basalt on the Gleneg basin goes down to below 300 feet above sea level whereas the 300 ft. contour on the Glenora basin


MAP SHOWING RELATION OF
SUB-BASALTIC DRAINAGE
TO TERTIARY FAULTS
SCALE
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GLENENG LOW
GLENORA LAKE

is shown closing off three or four miles downstream. The floor of the basalt in the intervening valley seems to have been 100 to 200 feet higher than in the Gleneg basin. There are four possible interpretations of these facts:-

1. The basalts may have followed so soon after the block faulting that there had not been sufficient time for the Gleneg Lake to silt up completely to its lip overflow level. In view of the upstream catchment the silting of such a depression would have been quite rapid.

2. The block faulting may have been protracted, commencing well before the basalts but continuing almost contemporaneously with the basalts, so that a newly formed unfilled depression existed at the time of the outpouring of the basalts.

3. The block faulting is substantially older than the basalt, and the Gleneg basin was completely filled with lake sediment to spill point well before the time of the basalts. However the overflow river followed the shatter zone of the Black ills fault, along which it was able to erode a deep narrow defile to a depth of below 300 feet above present sea level.

With this new base-level the soft silts of the Gleneg basin suffered rapid erosion and were largely re-excavated and removed down the defile. The basalt in due course completely filled the Gleneg depression as well as the narrow defile connecting it with Glenora Basin. Under this interpretation this basalt-filled gorge would still exist down to below 300 ft. altitude within the continuous strip of basalt which connects the two depressions. There is no way of proving or disproving this hypothesis short of drilling across this basalt shoestring.

4. There has been depression of the Gleneg basin with respect to the Glenora basin by post-basaltic movement.

Of these four possibilities perhaps the third is the most probable. Nothing has been found in the area to suggest post-basaltic differential movements. All the faults which have been found in the area which meet the basalt, pass under it without disturbance of the basalt. Systematic jointing common to the Permian and Triassic sediments and the dolerite, and which is believed to be associated with the early Tertiary epeirogeny, is completely lacking from the basalt which shows only cooling joints.

Professor Carey advises me that in the borings for the new Hobart Bridge there is evidence of very substantial erosion of the lake sediments before the out pouring of the basalts.

After each basalt flow, there were inevitably shallow undrained depressions caused by irregularities of the basalt surface. These rapidly filled up with lacustrine silts and cobbles of basalt and dolerite along the stream beds. Soils developed and forests grew before destruction by tuff showers or the next flow, which spread to still wider areas as the valley floor filled. The higher sides of the graben were however never reached.

Basalts flowing into the lakes are inferred by the occurrence of pillow lava both in the Glenora and Macquarie Plains area and in the Gleneg area, described earlier. The successive filling of the lakes and the valley by basalt dislocated the drainage system with consequent development of new systems of drainage. The new courses tended to be along either side of the basalt field as lateral streams, presumably owing to the fact that the basalt flows were a little higher in the centre. The diversion of the Derwent took place beyond Ouse. The river flowed on the southwest side of the basalt field as a lateral stream and joined the Glenora area which was still comparatively a broad low area. While cutting its course the Derwent meandered at 500 feet elevation; the remnant high level river terrace at 500 ft. in the Norton property indicates this part of its history. A later stage in the history of the development of the valley is recorded in the Norton area by the second river terrace at an elevation of 350 to 400 ft. altitude. The river at this elevation meandered over the Kenmore basalt tableland. Possibly at this time the narrow gap between Sugarloaf Hill and the southwestern edge of basalt at Glenora was closed either by the basalts or dolerite or the northwestern extension of Lawitta fault formed a still higher scarp. Therefore the Derwent could not flow as a lateral stream in this part and was forced to cut a channel in the basalt itself. The Russell Falls River which was not affected by the basalts assisted in this work.

The filling of the Glenora lake diverted the Styx River to flow at a higher level as a lateral stream between the dolerite hill to the southwest and basalt to the northeast. The Styx River vigorously carved a course roughly parallel to its present course and everytime pushed northwards by its own depositional flats until it was captured by the Derwent. (Plate 8 B)

The Allendale Rivulet during the post-basaltic period occupied a position roughly parallel to it's present course further east and progressively migrated to its present position. In this work it was assisted by the various creeks flowing from the high ground along the Magra and Black Hills fault. The Belmont Rivulet assisted in this work of modelling the drainage slope.

The course of the Plenty River and the Dry creek was not affected to any degree by the basalt floods. These flowing from the Moogara and Glenfern plateau came down through cascades and rapids bringing with them a lot of sediments and deposited them in the valley. These rivers joined the Derwent roughly near their present position. The Derwent River assisted by all these rivers rapidly eroded the basalt floor in the New Norfolk area and has left remnants of basalt at a higher elevation flowing again as a lateral stream this time on the north side of the basalt-filled valley.

The Derwent and its tributaries in the present history are controlled by the Tertiary faults (Map 8). The Derwent River flowing as a lateral stream in the Hamilton square enters the Glenora area through a joint plane and strikes the Norton-Clarendon fault and rebounds in a southwesterly course partly in the Triassic rocks and partly in the lacustrine sediments till it meets the resistant dolerite at the Meadowbank fault. In this section it flows between two Tertiary faults on the southwest side of the Norton horst instead of the north and east side as it did before the basalts. As mentioned earlier the narrow gap between Sugarloaf Hill and the edge of the basalt at Glenora being closed it carved a course in the basalts and emerged at the lower tip of the Norton horst. Here there were two possibilities open, either to cut a course through the basalts again or to capture the Belmont Rivulet and flow eastwards on the north side of the Belmont horst. As the Belmont Rivulet had already carved a course sloping westwards the Derwent again cut through the basalt to emerge out on the south side where it is joined by the Styx river, and captured the latter's course. In doing so it crosses over the graben and

MAP SHOWING RELATION OF PRESENT DRAINAGE TO TERTIARY FAULTS

SCALE

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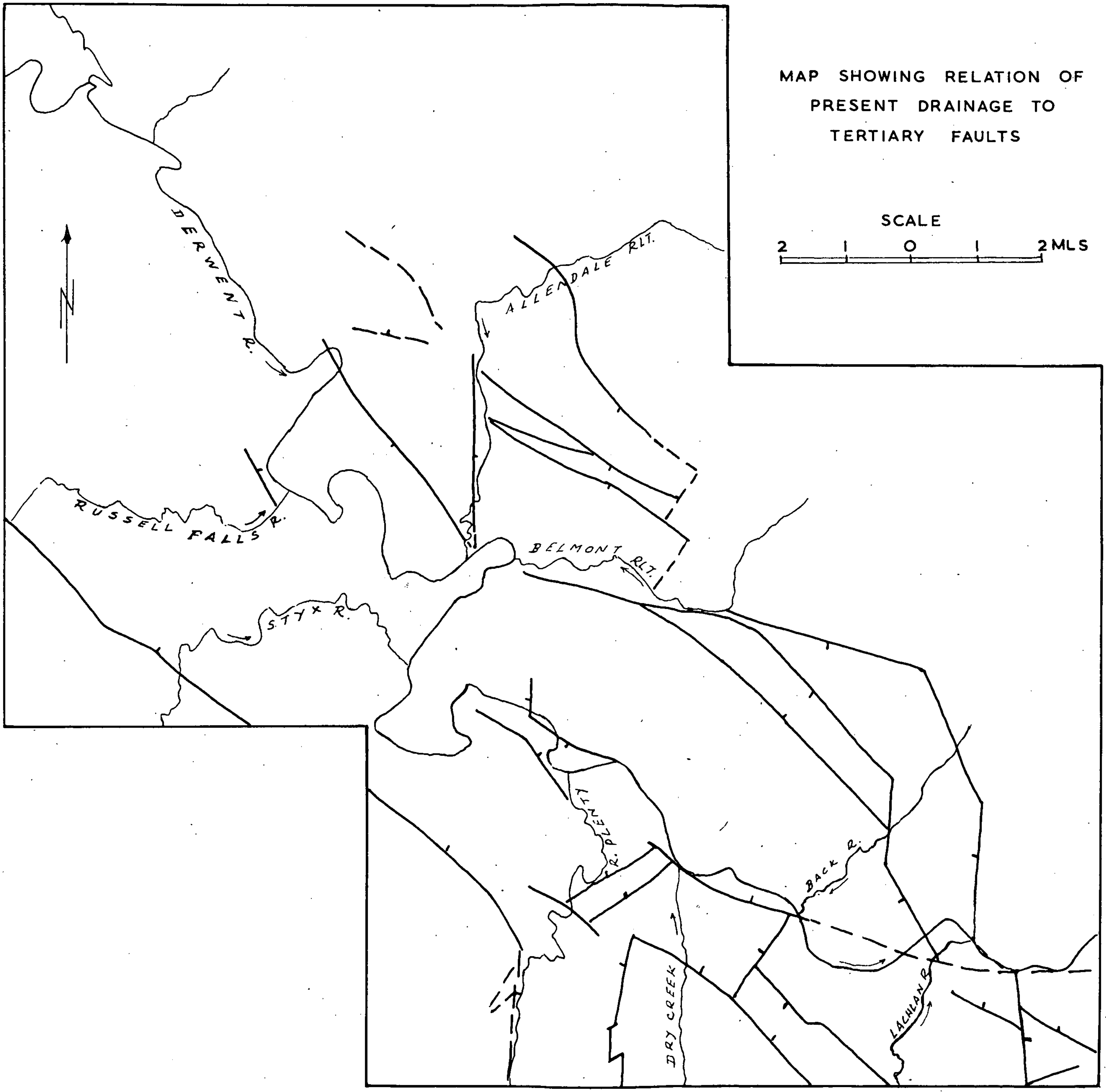

again comes into the graben north of Ivanhoe property and emerges north of Plenty and flows between the Plenty fault and the Lawitta fault on the southwest side of Belmont horst. The river flows on the north-east side of the Lawitta fault until New Norfolk and east of New Norfolk it finally flows out of the graben.

Thus it is seen that the Middle Derwent River is a structurally controlled river during both the pre-basaltic time and post-basaltic time.

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A. Pillow lava in Kenmore cliff at Macquarie Plains

B. Silicified wood portion of a trunk in upright position at grid 479747

PLATE 2

A. Triassic Ross sandstone showing slump structure and current bedding south of Norton trig.

B. Tuff bed in Kenmore cliff showing crude stratification with cylendrical cavities indicating position of fossil wood lying in a horizantal position. Underlying the tuff bed is lake sediments followed by Flow 5.

PLATE 3

A. Looking north at Glenora railway cutting. Shows irregular roof of Flow 5 overlain by lake sediment.

B. Begining of Glenora railway cutting looking south.

PLATE 4

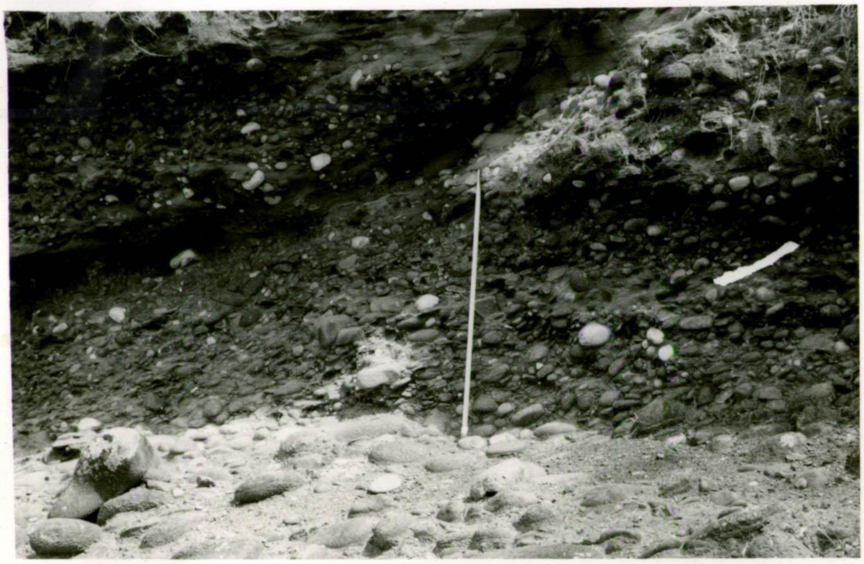
Looking east at Glenora road cutting. Shows uneven floor of Flow 6 underlain by lake sediment.

Looking SW from Gretna at the Kenmore hill showing the burried hill with lower flows swining back of it.

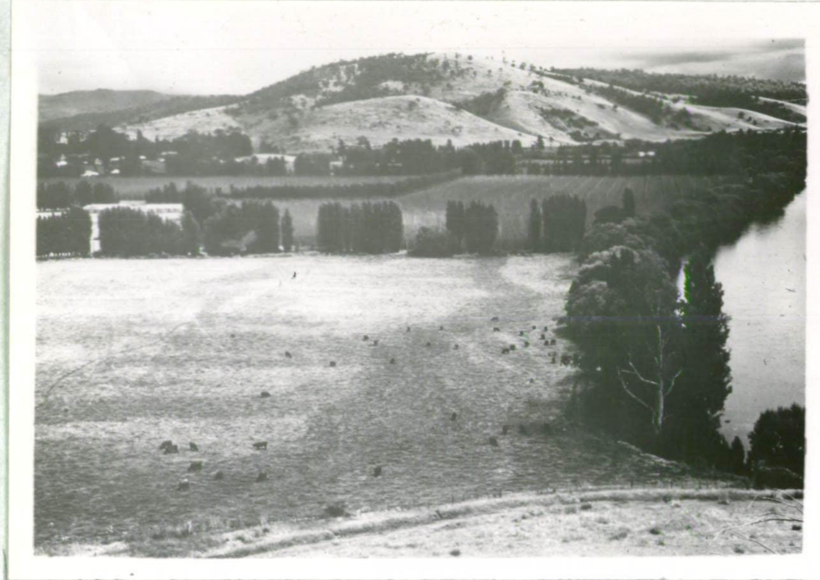
A. Basalt quarry at Plenty. In the lower left corner Tr.Feldspathic SS is seen overlain unconformably by conglomerate and tuff. Basalt has overridden the sediment from the right.

B. Basalt quarry at Plenty.

PLATE 7



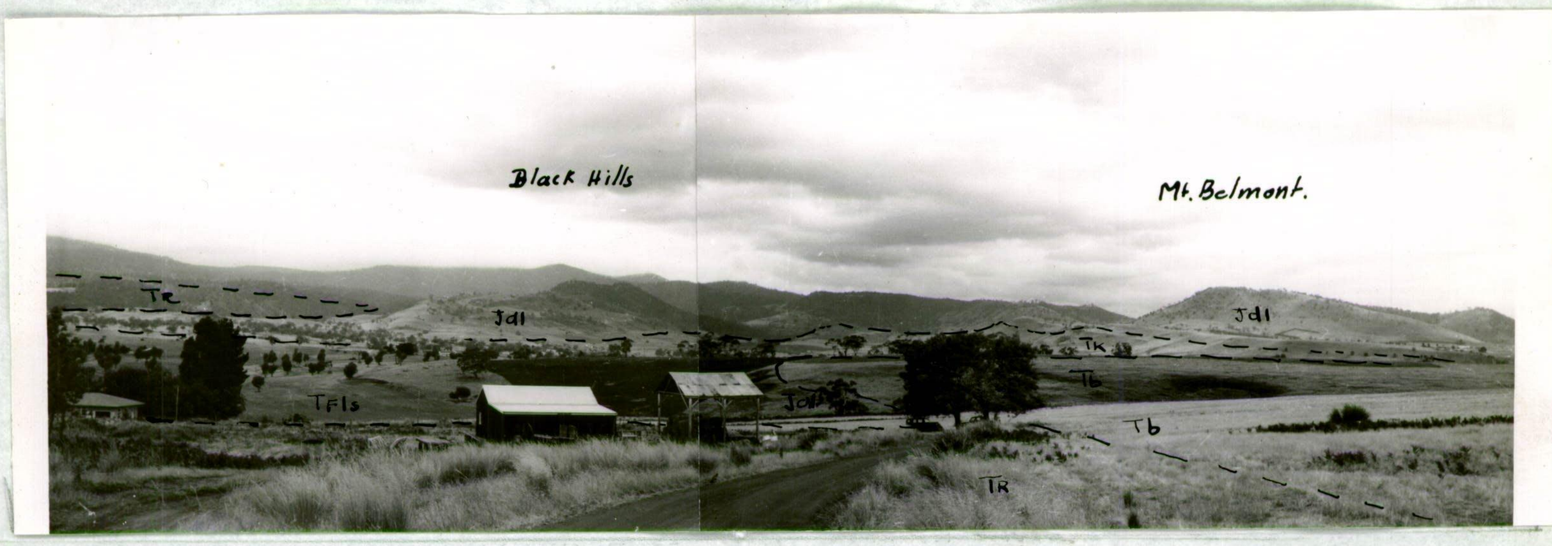
Basal conglomerate of Tertiary lake sediments exposed in the Derwent River.



A. View looking west from Kenmore. In the centre is the dolerite hill with the Meadowbank fault running in front of it

B. View from Macquarie Plains railway stn. looking SW. Development of Styx river as a lateral stream. Kenmore hill is to the right.

PLATE 9



Panaromic view looking east from Claredon property showing the rock distribution and the Gretna fault running from left to right in the foreground

PLATE 10

Differntial weathering of basalt.

A. Sp. 7558. Dolerite from top of Mt. Wellington sill under X nicols.

B. Sp. 8681. Dolerite from Bloomfield area under X nicols.

A. Sp. 3250. Red Hill granophyre under X nicols.

B. Sp. 8680. Granophyre from Bloomfield area under X nicols.

Sp. 8691. Amygdular dolerite.
Under ordinary light.

A. Sp. 8599. Ouse Type basalt under ordinary light.

B. Sp. 8596. Bridgewater Type basalt under ordinary light.