PAP. AND PROC. ROY. SOC. TASMANIA, 1947 (1ST AUGUST, 1948)

The Geology of the Country Around Tarraleah, Tasmania

By

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PLATES VII, VIII

Abstract. The regional geology of an area of 260 square miles in the vicinity of Tarraleah on the central plateau of Tasmania is described. The most extensive formation is the Jurassic dolerite. Smaller inliers of Permian marine and Triassic freshwater sediments are of sporadic occurrence. A reclassification of the Permian into the Marlborough Series at the base, Woodbridge Formation and Ferntree Formation at the top is suggested. Extensive areas are covered by Tertiary basalts and smaller areas by Pleistocene glacial till. The structure in the pre-Tertiary rocks shows a gentle regional dip to the east which is interrupted by several strike faults with large downthrows to the west.

I. INTRODUCTION

This paper is the result of a geological reconnaissance of the country in the vicinity of Tarraleah (42° 18′ S.Lat., 146° 26′ E.Long.) made in January-February, 1947, on behalf of the Hydro-Electric Commission of Tasmania and is published through the courtesy of the Commission.

The area examined, which is shown on the accompanying geological map, is somewhat irregular in shape, covering an area of approximately 260 square miles. It is the stretch of country north and east of the River Derwent, extending from Derwent Bridge on the west to the hamlet of Dee on the east, with an extension to the north along the valley of the River Nive as far north as its confluence with the Pine River. The village of Tarraleah is situated to the south-east of the centre of the mapped area.

The mapping was effected by stereoscopic interpretation of aerial photographs, supported by traverses on the ground. All of the roads, tracks, transmission lines, and main streams in the area have been traversed, in addition to numerous other cross country traverses, so that, with the exception of areas specifically indicated on the map as untraversed, the geologic boundaries can be regarded as of fairly high reliability.

The western margin of this area receives an average annual rainfall of 60 inches, which falls off rapidly to 35 inches per annum along the eastern margin. The entire area, except for scattered marshes, is thickly covered by Eucalypt forest with very dense undergrowth, which, however, becomes less dense in the lower rainfall areas to the east. The dense vegetation makes traversing on foot very slow and obscures the geology, both on the ground and in the air photos. With the exception of some of the basalt-covered plains in the vicinity of Bronte which have been cleared for sheep grazing purposes, the area is almost entirely in its virgin state.

II. Physiography

The area examined is part of the high dolerite plateau of Tasmania standing at an average elevation of approximately 2500 feet above sea-level, above which rise some isolated hills such as Brady's Sugarloaf (3361 feet) and the Wentworth Hills scarp. The plateau is a somewhat undulating surface with broad N.W.-S.E. trending depressions, and on its surface are many high-level marshes. Small marshes occur throughout the area, but more extensive marshes (Brady's Marsh, Big Marsh, Father of Marshes) are developed at an approximate elevation of 2150 feet to 2200 feet in the belt of country extending south from Bronte. All of these marshes are somewhat elongated in shape in a general N.W.-S.E. direction and their development, as will be shown later, has been controlled largely by the geologic structure.

The plateau is deeply incised by the Rivers Derwent, Nive, and Dee, and their tributaries. All the main rivers drain in a general southerly direction and in this area, for the most part, pursue parallel courses.

The *Derwent*, rising in Lake St. Clair to the north of Derwent Bridge, flows almost due south through a wide U-shaped (glacial) valley for 10 miles south of Derwent Bridge to Butler's Gorge, where it changes its course abruptly to flow through a rather mature valley for approximately two miles in an E.N.E. direction before again resuming its more or less normal south-easterly trend through a very immature valley in the dolerite. There are no important tributaries to the Derwent in this area, except the Nive, which joins it near the southern margin of the map—it appears here that the Nive is actually the master stream and the Derwent is its tributary.

The *Nive*, with the exception of minor bends, pursues a north-south course throughout the mapped area. North of its junction with the Pine River the Nive flows in a south-easterly direction in an immature valley deeply incised in the dolerite plateau. At approximately one mile south of its confluence with the Pine the Nive valley becomes much wider and more mature, the river flowing through a flood plain approximately half a mile wide for a distance of one mile, where it is joined by the Serpentine Creek entering on the east bank. South of this it flows through a narrow gorge in the dolerite, and downstream from this gorge it enters the basalt area where the nature of the valley again changes markedly. It is here incised only 250 feet in the basalt-covered plains and is characterised by broad sweeping curves, meandering at will and not controlled in any way by the geological structure—the bed has a braided character with many boulder accumulations, and it receives tributaries from both east and west. This is its nature where it crosses the Lyell Highway (Plate VIII, fig. A). At a short distance downstream from the Lyell Highway the Nive leaves the basalt area and again suffers a marked change in character—the valley becomes narrower and the river is incised approximately 1000 feet. This immature nature persists as far south as its crossing with the Tarraleah-Ouse Highway, where it enters an area of Triassic shales and its valley becomes more mature. Other than the Pine and Derwent, which have already been mentioned, the main tributary of the Nive in this area is the Clarence River entering from the west at approximately eight miles north from the Tarraleah power house; other west bank tributaries being Wentworth Creek, Horne's Creek, and Wilson's Creek. All of these west bank tributaries have very steep grades where they enter the Nive and in the lower parts of their courses are characterised by many waterfalls. On previously published maps (e.g., the 4-mile State map No. 3 of Tasmania, 1944), Wentworth Creek is shown as entering the Nive at two miles north of Horne's Creek. Actually, the Wentworth flows into Horne's Creek and the single stream enters the Nive at three and a quarter miles upstream from the Tarraleah power house.

The *River Dee* is the third main drainage channel. It also flows in a general southerly direction. In the area shown in this map (Plate VII) it has similar characteristics to the Nive between the Pine River and Bronte Gorge, i.e., after entering the mapped area in an immature valley it flows through a wide flat area for several miles to where it crosses the Lyell Highway. Downstream from this point its valley again becomes immature like that of the Nive near Tarraleah, although it is not so deeply incised as the Nive.

III. Geology

1. General Outline.

By far the most extensive formation developed in this area is the Jurassic dolerite. Smaller inliers of Permian and Triassic sediments are of sporadic occurrence. Extensive areas are covered by Tertiary basalts and in places there is a thin veneer of Pleistocene glacial deposits. The general geological structure of the pre-Tertiary rocks shows a gentle regional dip to the east, which is interrupted by several strike faults with large downthrows to the west. Owing to the extensive areas of dolerite in which the geologic structure is indeterminable it is difficult to obtain a complete picture of the regional structure and it is very difficult to correlate the various isolated occurrences of Triassic sediments throughout the area. The regional easterly dip was responsible for the pre-basalt topography which has been to some extent drowned by the extensive outpourings of basalt which are now dissected by the River Nive. Except in the westernmost part of the area in the valley of the River Derwent the Pleistocene glaciation appears to have left very little trace of its activity.

2. Stratigraphy.

A. *Permian Sediments.*—Rocks of Permian age occur in one part of the area only—in the section (which for convenience may be called the Marlborough inlier) extending from London Marsh Farm in a north-westerly direction to the Marlborough Highway, which runs from Bronte to Great Lake. The best outcrops of these rocks are to be seen along the valley walls of Serpentine Creek in the vicinity of 814N., 447E.* The only previous examination of this Permian section was made by Strzelecki, who collected a number of fossils from this locality which were described by Lonsdale and these descriptions have been referred to in the literature

* Co-ordinates are units of 1000 yards and refer to the grid on the accompanying geological map (Plate VII), which is the same as the military grid on the 4-mile State map of Tasmania, published in 1944. Co-ordinate references given elsewhere in this paper refer to the grid on the accompanying geological map.

since. Strzelecki's account of these rocks, published in his 'Physical Description of New South Wales and Van Dieman's Land' (1845) is so brief that it may be repeated here in full—

'8th. *The sources of the river Nive, in the Upper Country, and the locality east of Marlborough,* exhibit perhaps the most complete section of this group that is to be seen. Here a massy fossiliferous limestone abuts against a very inclined argillaceous and siliceous slate: upon this limestone rests a slaty fragmentary rock without fossils; a fossiliferous, arenaceous, and argillaceous massive rock, with somewhat of a slaty fracture, follows. This is crowned by a sedimentary deposit of mud and fine sand, which reaches an elevation of 5200 feet. The series in this locality contains the following fossils:—

Crinoidal columns
Productus brachythoerus
Spirifer subradiatus and *S. Stokesii*
Fenestella internata and *F. ampla.*'.

Johnson (1888, p. 128) only gives a brief reference to Marlborough, which he quotes directly from Strzelecki's earlier description and it is apparent that Johnson himself did not visit the area.

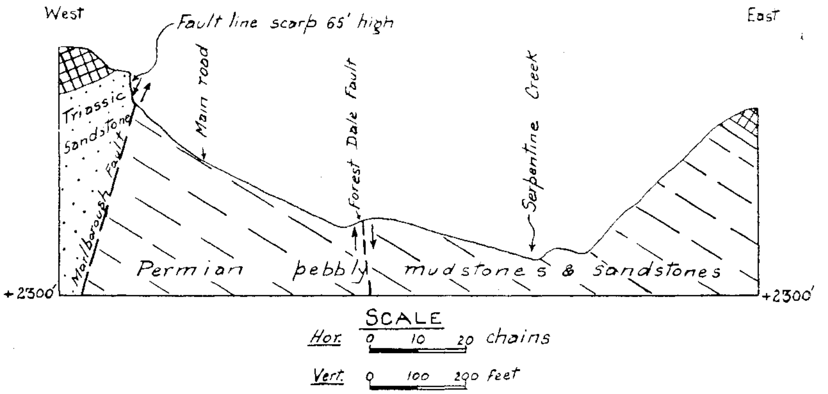

FIG. 1.—Diagrammatic east-west section at co-ordinate line 818 N. across the Marlborough and Forest Dale faults showing the fault line scarp along the Marlborough fault. The cross-hatched areas at the east and west ends of the section are of dolerite.

In this area the Permian rocks form a belt from one to one and one-half miles wide trending in a north-south direction (fig. 2). To the west this Permian inlier is truncated abruptly by the Marlborough Fault, which has thrown down Triassic rocks and associated dolerite sills to the west, and we find here Triassic sandstones in contact with the lower members of the Permian sequence. The contact crosses the main road at 814N., 446·3E., and here the Permian is in juxtaposition to the dolerite. Further north (due west of Forest Dale Farm) the contact is between Triassic quartz sandstones and Permian pebbly mudstones (fig. 1). It is interesting to note here that, although the west is the downthrown side of the fault, the scarp along the fault line is facing east, due to the Triassic sandstones being more resistant to erosion than the Permian pebbly mudstones and sandstones, and this occurrence indicates that topography is not an infallible indicator of faulting in this region.

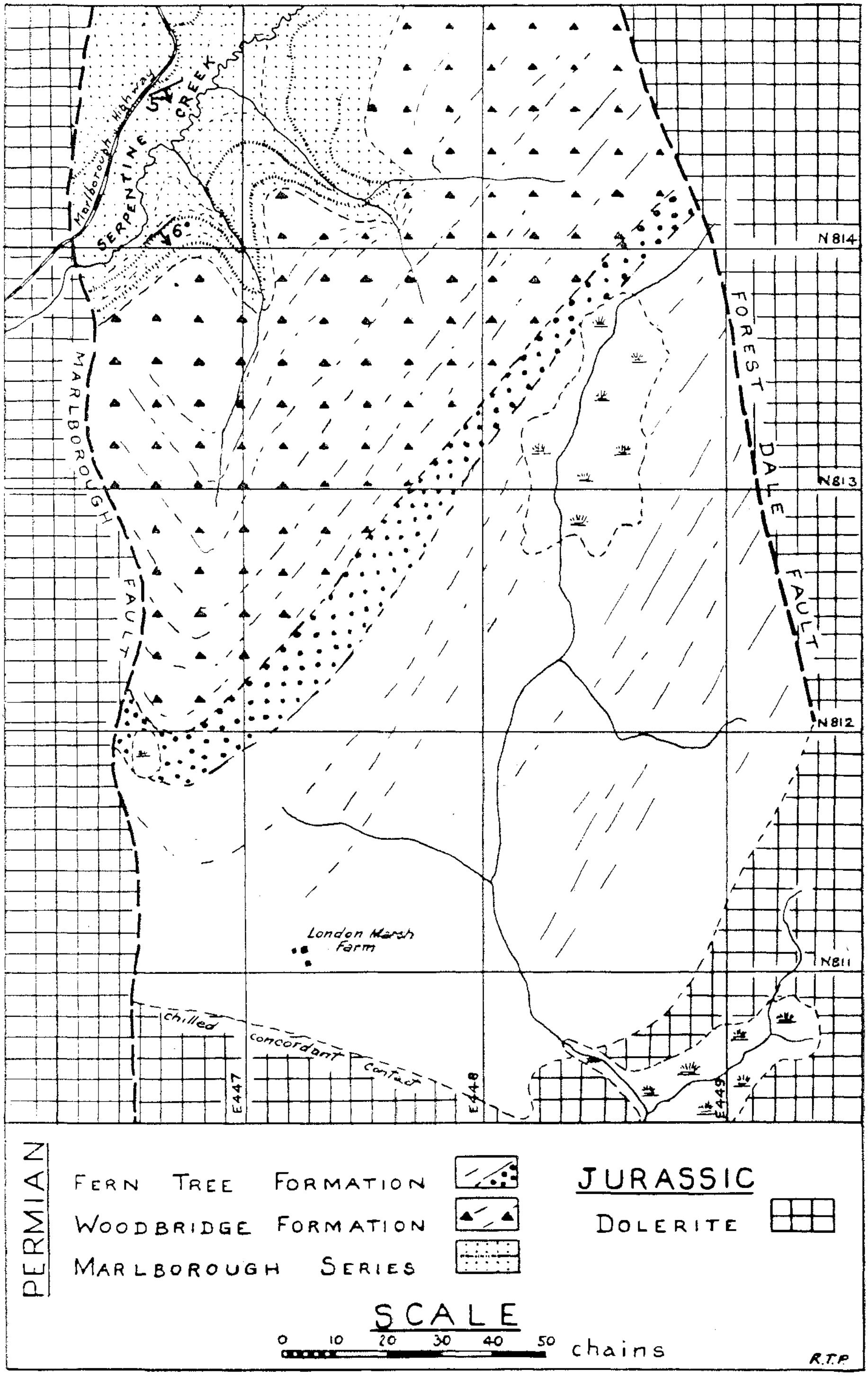

FIG. 2.—Geological map of the Marlborough Permian inlier showing subdivision of the Permian. The dotted section at the base of the Fern Tree Formation is a sandstone which may be the Risdon Sandstone of the Hobart District. Within the Marlborough Series exposed in Serpentine Creek the dotted areas are the Bronte Sandstone Facies and the hatchured bands are the Granton-Grange calcareous mudstone Facies. Grid lines refer to the grid on the Geological Map (Plate VII).

The eastern margin of the Permian belt is in part a concordant intrusive contact with dolerite and in part a faulted contact. To the east of Forest Dale Farm the Permian dips flatly to the east under the dolerite forming the higher country, the contact being here a concordant intrusive one. Again to the south and east of London Marsh Farm the Permian mudstones dip conformably under the dolerite, but there is considerable doubt as to whether this horizon of the Permian is the same as that of the contact east of Forest Dale Farm. Elsewhere the eastern contact of the Permian with the dolerite is a discordant one—on the air photos the bedding of the Permian sediments can be seen to be sharply truncated by the dolerite to the east. This contact is considered to be a fault (the Forest Dale Fault) which was either slightly older than or contemporaneous with the Jurassic dolerite intrusions, along which the dolerite has arisen in the form of a dyke (fault intrusion) and spread out at different stratigraphic horizons in the Permian to the east and west.

The strike of the Permian sediments in the part of the Permian belt lying between the Marlborough and Forest Dale Faults is north-east with a uniform gentle south-easterly dip of 5°, while in the section to the east of the Forest Dale Fault the general strike is north to N.N.W. with an easterly dip of 5° to 10°. There is no apparent distortion of the Permian beds at the Marlborough Fault.

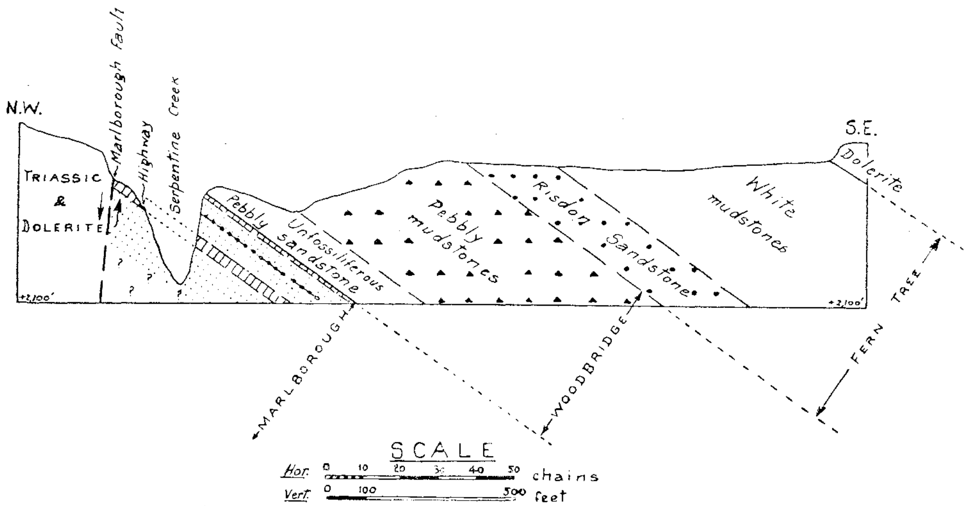

FIG. 3.—Geological cross-section of the Marlborough Permian inlier showing proposed subdivision into the Marlborough Series, Woodbridge Formation, and Fern Tree Formation (with the basal sandstone member which is probably the Risdon Sandstone of the Hobart District). Within the Marlborough the dotted sections are the Bronte Sandstone Facies, and the hatchured strata are the Granton-Grange Mudstone Facies. There is a well-defined stratum, 10 feet thick, of richly fossiliferous conglomerate between the two prominent mudstones and is indicated on the section by small circles.

Permian Lithology.—The Permian sediments grade from calcareous mudstones through pebbly mudstones to sandstones and pebbly sandstones. The most complete section available is that running in a south-easterly direction from a point on the Marlborough Highway at four and a half miles north from Bronte. The Permian section exposed here is estimated to have a stratigraphical thickness of 1250 feet (fig. 3) and it can be conveniently subdivided into three main formations, which can be correlated with the Permian rocks of the Hobart District described by Lewis (1946) and Voisey (1938), as follows:—

1. *The Marlborough Series.*—The lowest part of the section consists of interbedded white fossiliferous conglomeratic sandstones, yellow fossiliferous mudstones (lithologically similar to Lewis' Grange Stage of the Hobart District), and dense bluish-grey fossiliferous calcareous mudstones (lithologically similar to Lewis' Granton Stage of the Hobart District). The base of the Permian rocks is not exposed in this area. The name *Marlborough Series* is here proposed for this fossiliferous section of the Permian, in which there are three distinct facies thus:—

(*a*) *Bronte Facies.*—A pebbly fluvio-glacial sandstone facies which is richly fossiliferous in places. The fauna is dominated by large Spirifers, including *S. avicula*, *S. vespertilio*, and *Martiniopsis* sp. Other fossils present are *Conularia*, *Platyschisma*, *Aviculopecten*, *Eurydesma* (rare), various *Fenestellidae*, *Stenopora*, and crinoid stems. The typical rock of this facies is a creamy white pebbly fossiliferous sandstone. It carries angular boulders up to six inches diameter of various rock types of which quartzite is the most abundant, set in a sandy matrix. This sandy matrix (from a microscopic examination) is composed of poorly graded detrital material ranging from clay to coarse sand, the sand grains being angular and consisting predominantly of quartz with minor amounts of clear fresh felspar (both microcline and plagioclase) and muscovite. There can be little doubt that the poorly graded material forming the rocks of this facies is of glacial origin. A variant of these pebbly sandstones (from a small roadside quarry five miles north from Bronte along the Marlborough Highway) is a cream coloured silty mudstone containing abundant crinoid stems along with *Fenestellidae*, *Stenopora*, and *Mytilus*—this rock contains a considerable proportion of fine silt in which quartz, fresh felspar, and muscovite were identified.

The Bronte facies forms the greater part of the Marlborough Series exposed by Serpentine Creek. It does not appear to be developed in the Hobart District.

(*b*) *Grange Facies.*—A richly fossiliferous yellow mudstone facies in which the fauna is dominated by *Fenestellidae* and *Stenopora (Batstomella)* with abundant *Strophalosia*, *Spirifer*, and *Aviculopecten*, and also *Productus* and *Mytilus*. The yellow mudstones of this facies are practically free of calcareous material and the fossils are casts only. Lithologically these rocks are identical with Lewis' Grange Stage mudstones of the Hobart District.

(*c*) *Granton Facies.*—A richly fossiliferous bluish-grey calcareous mudstone facies with the same fauna as the Grange facies. The rock is essentially a mudstone, the only calcareous material being present in the actual shell remains, and it differs from the Grange facies only in colour and the presence of the actual shell remains rather than casts. It is lithologically similar to Lewis' Granton Limestone Stage of the Hobart District.

2. *The Woodbridge Formation.*—This consists of unfossiliferous pebbly mudstones with occasional erratics up to several feet in diameter. This formation conformably overlies the Marlborough Series (fig. 2) and extends in a southerly and south-easterly direction from the crestline of the southern side of Serpentine Creek. Throughout this area the bedding can be distinctly seen on the air-photos in the lines of vegetation which grows mostly along the lines of the almost imperceptible escarpments and not on the dip slopes. For the most part the

lithology of this section of the Permian is white pebbly mudstones with thin interbedded pebbly sandstones and it may be correlated with Voisey's Woodbridge Stage of the Hobart District (Voisey, 1938, p. 314).* In places grey to white mudstone fragments in a clayey soil predominate, elsewhere accumulations of pebbles and boulders weathered out of the mudstones are the only materials exposed—these boulders are up to 20 inches in diameter and include a variety of rock types such as granite, porphyry, phyllite, quartz, quartzite, West Coast Range conglomerate, chlorite schist, &c. No fossils were found here. This stage is undoubtedly of glacial origin.

The Woodbridge Formation developed in the Marlborough Permian inlier has a stratigraphical thickness of 360 feet and is overlain conformably by a well-defined sandstone which is here considered to be the basal member of the Ferntree Formation now to be described.

3. *The Ferntree Formation.*—The pebbly mudstones of the Woodbridge Formation pass abruptly up into a sandstone band, which, from the air photos, is conformable with the underlying pebbly mudstones. The sandstone is a yellowish-grey, fine even-grained rock, which under the microscope consists of angular grains of quartz and clear unaltered plagioclase in approximately equal amounts. Fossils may occasionally be found near the base of this sandstone. It is overlain by white unfossiliferous mudstones which extend to the south of the London Marsh homestead. It is probable that this sandstone horizon represents the *Risdon Sandstone* (Carey & Henderson, 1945), which is considered by Carey and Henderson to lie at the base of the Ferntree Mudstone Formation as defined by Lewis (1946, p. 34). Above this sandstone the white mudstones are comparatively free of pebbles and the rocks are lithologically similar to the Ferntree Mudstones of the Hobart District.

The above is a description of the section of the Permian lying to the west of the Forest Dale Fault. To the east of this fault the rocks are interbedded pebbly mudstones and sandstones which I have not been able to correlate with the sequence to the west of the fault. The only fossiliferous horizon found was a narrow band of dark grey shaley mudstone with *Spirifer* and rare *Fenestellidae* exposed in the bed of the Serpentine Creek at 50 chains south-east of the Forest Dale homestead. This appears to be a poorly fossiliferous equivalent of the Granton facies of the Marlborough Series.

B. *Triassic Sediments.*—Triassic sediments, consisting in the main of quartz sandstones with minor amounts of micaceous shales containing *Phyllotheca* occur in a number of places in the mapped area. The most general occurrence is in the form of elongated strips generally with a meridional trend, flanked to east and west by dolerite, and the regional dip is always to the east. These Triassic strips are separated by wide expanses of dolerite in which the structure is not determinable with certainty, and this, together with the paucity of fossil remains makes the matter of correlation of the Triassic from place to place in this area

* *Permian Nomenclature.*—Voisey (1938, p. 314) has called the unfossiliferous glacial pebbly mudstones which overlie the fossiliferous Granton-Grange limestones the Woodbridge Glacial Stage, whereas Lewis (1946, p. 32) refers to the same group as the Lindisfarne Stage. The overlying non-pebbly mudstones have been called the Lindisfarne Stage by Voisey (1938, p. 314), and Ferntree Stage by Lewis (1946, p. 34). In order that these anomalies in nomenclature be cleared up it is suggested here (with the concurrence of Drs. A. H. Voisey and S. W. Carey) that:—

1. Voisey's name *Woodbridge* be retained for the pebbly mudstone formation overlying the fossiliferous Grange-Granton limestones.
2. Lewis' name *Ferntree* be retained for the overlying non-pebbly mudstone formation.
3. The name *Lindisfarne* about which there is some ambiguity in both Lewis' and Voisey's classifications be allowed to lapse.

very difficult. There are six main occurrences of Triassic sediments together with a number of small inliers which appear to be xenolithic bodies in the dolerite. The Triassic rocks to the east of the Marlborough fault will be dealt with first because their relationships to the Permian rocks are more evident.

(i) *The London Marsh-Seven Mile Creek Belt.*—At 15 chains south of London Marsh homestead (811N., 447E.) the white Permian mudstones pass under the flat-lying dolerite sill, the contact here being a concordant intrusive one. At 56 chains south along the London Marsh track from this contact the dolerite is overlain by a dark-grey to black flinty hornfels which extends for approximately one mile further south and to London Marsh on the east. This area of approximately 300 acres of flat country sloping gently down to the east is covered with a veneer of this flinty rock. The dolerite around the margin of this hornfels sheet is very fine-grained and closely jointed and the hornfels area is considered to represent a veneer of hornfelsed mudstone overlying a dolerite sill. The hornfels is a very fine-grained dark-grey to black flint-like rock with a thin weathered skin of earthy, yellowish-grey clayey material. Under the microscope the original clastic nature is evident in the presence of innumerable minute quartz and clear unaltered plagioclase grains of silt grade and an occasional larger quartz grain to 0·3 mm. diameter embedded in a very fine-grained indeterminable groundmass representing reconstituted clay.

Similar dark-coloured hornfelses occur at the junction of quartz sandstones with dolerite at 806N., 450E. These sandstones are lithologically similar to the Triassic sandstones to the west of the Marlborough fault and because of this occurrence of hornfels associated with quartz sandstones the London Marsh hornfelses are considered to be at the base of the Triassic or the extreme top of the Permian Ferntree Mudstone Formation.

White quartz sandstones outcrop to the south-east of the London Marsh hornfels area and are exposed along the Lyell Highway between 793N., 449½E., and 798½N., 450½E. This sandstone belt has a meridional trend with a concordant contact with the dolerite to the east. In addition, it contains several dolerite sills and the sequence of sandstones and dolerite sills is truncated along the western margin of this belt by dolerite.

This sandstone is a white even medium-grained rock consisting almost entirely of detrital quartz, which, on exposed surfaces has a sparkling appearance. Microscopic examination of similar "sparkling" sandstones from west of the Marlborough fault indicates that the original detrital quartz grains were rounded, but have suffered secondary enlargement, the secondary quartz being in crystalline continuity with the detrital quartz and developing actual crystal faces which are responsible for the "Sparkling" lustre of the rock surface. These sandstones are completely barren of fossils and are considered to be Triassic on lithology (similar sandstones overlie Triassic *Phyllotheca*-bearing shales in the Triassic belt north of Bronte) and its position with respect to the undoubted Permian rocks near London Marsh farm.

(ii) *Duck Creek Belt.*—This is a narrow belt, 15 chains wide, of white unfossiliferous quartz sandstone, occurring along the Lake Echo road north of its junction with the Lyell Highway. This belt also trends north and south parallel to the strike of the sandstones which dip flatly (3° to 6°) to the east. This sandstone, which is lithologically similar to those of the Seven Mile Creek belt is overlain both to the east and west by dolerite so that its top only is exposed. South of the Lake Echo turn-off the Tertiary basalts cover the sandstones and dolerite unconformably, but the older rocks re-appear from below the basalt at 2·4 miles due south of the road junction, and here again the sandstone is overlain by dolerite. The sandstone immediately below the basalt is contact metamorphosed to a dense greyish quartzite.

(iii) *Bronte (Upper Nive) Belt.*—There is a well-defined belt of Triassic sediments running due north from Bronte to the northern margin of the mapped area. The belt is very narrow at Bronte, but widens to one and a quarter miles near the junction of the Nive and Pine rivers. The general strike within the belt is again north-south with an easterly dip of 10°, but near the northern edge of the mapped area the Triassic forms an elongated synclinal basin, truncated along its eastern margin by the Marlborough fault—the westerly dip on the eastern limb of this fold probably being a drag effect, reversing the regional easterly dip, on the Marlborough fault.

There are two distinct facies of the Triassic represented in this belt, the stratigraphically lower part being a clayey facies, the stratigraphically higher part being arenaceous.

(*a*) The clayey facies:—consists of white to dark-grey and black shales with a minor development of pale greenish shales and light coloured sandy shales with fine-scale current bedding and ripple marking. The shales in places are very micaceous and occasionally carry remains of *Phyllotheca.* Towards the top of this argillaceous formation the shales becomes very dark-coloured, with abundant very poorly preserved plant remains (not determined) and contain a thin coal seam. This coal is exposed in a small borrow pit on the west side of the road at 812·8N., 444·6E.

The Triassic shales of this belt are intruded by a number of thin dolerite sills and the alternation of soft shales and resistant dolerite has led to the development of dip-slope topography. This shale belt is overlain conformably by dolerite, the dolerite at the contact being fine-grained microporphyritic and, therefore, clearly the chilled base of a dolerite sill. This dolerite sill is approximately 400 feet thick and is overlain conformably by the arenaceous facies of the Triassic now to be described.

(*b*) The arenaceous facies:—the rocks of this group are very uniform lithologically, being white "sparkling" current-bedded quartz sandstones which in places show evidence of contemporaneous slumping. The sparkling lustre of these rocks is due to the secondary growth to euhedral crystals of the rounded detrital quartz grains as has been described above. These sandstones are estimated to have a stratigraphic thickness of approximately 500 feet. The contacts with the dolerite both above and below are concordant intrusive as evidenced by the occurrence of microporphyritic dolerite at the contacts. In addition, discordant dolerite dykes connecting the dolerite sills above and below the sandstones occur in this locality. These sandstones are truncated to the east by the Marlborough fault and, due west from Forest Dale Farm, are in direct contact with the Permian sediments (fig. 1).

In the bed of the Nive River from its confluence with Serpentine Creek for a distance of 30 chains to the north we find quartz sandstones associated with the shales. This is a very disturbed zone in which the sediments dip at angles up to 55°. In this zone the sandstones (on the west) which appear to overlie *Phyllotheca*-bearing shales (on the east) are probably part of a downfaulted block from the quartz sandstones higher in the succession. Nowhere else in the area examined has this arenaceous facies been seen associated with the *Phyllotheca* shales. The sequence of rocks here is:—

'Sparkling' quartz sandstone.

?Fault — — — — — — — —

Dark-gray *Phyllotheca* shales.

Pale greenish sandy limestone ('Fontainebleau' sandstone).

Interbedded white and dark-grey *Phyllotheca*-bearing shales and ripple-marked siltstones or sandy shales showing also fine-scale cross-bedded structure.

The occurrence of sandy limestone associated with the *Phyllotheca* shales here is of interest because it is the only place in the area surveyed where calcareous rocks occur associated with the Triassic shales (except in the detrital materials underlying Big Marsh, which are described below). This sandy limestone is a light greyish colour, fine-grained and massive, and the Fontainebleau structure can be faintly distinguished on the freshly broken surfaces. The sand grains of this rock are angular and consist predominantly of quartz with a little fresh plagioclase and muscovite.

Discontinuous outcrops of Triassic sediments occur along the southerly extension of this belt. The country to the south of Bronte is flat-lying and in places marshy—the Bronte marshes, Brady's Marsh, and Big Marsh are situated in this belt. There are a few sporadic outcrops of well-lithified sandstone along the eastern margin of the Bronte marshes between distances of two and two and a half miles south of Bronte. The sandstones occur only in the form of scattered boulders but in one place an outcrop of sandstone, overlain by dolerite, was found. These sandstones are coarse gritty consisting predominantly of quartz with minor amounts of turbid felspar and rare flakes of muscovite and biotite. Whether these sandstones are merely isolated xenoliths in the dolerite or form part of a stratum underlying the dolerite is not apparent from the occurrence examined.

The nature of the rock underlying Brady's Marsh is unknown, but boulders of sandstone and dark-coloured hornfels found approximately half a mile south-east from the southern end of the marsh indicate that these rocks may underlie Brady's Marsh. Big Marsh, situated to the south-west of Brady's Marsh appears to be underlain by the Triassic sediments. The perimeter of Big Marsh is entirely of dolerite, but several shallow holes sunk with a post-hole digger in the floor of the marsh discloses well-lithified mudstone and clayey sand which may be of Triassic age. Since these bores are of some significance in connection with the origin of the marsh the results are given here—

Bore A. (near the southern end of the marsh):

From surface to 1′ 6″: Black peaty clay.

1′ 6″ to 2′ 3″: White clay of uniform texture.

2′ 3″ to 3′ 0″: Yellow clay with some iron-stained sandy material.

3′ 0″ to 4′ 0″: Grey clay with uniform texture.

4′ 0″ to 4′ 10″: Grey clay with shale (mudstone) fragments.

At 4′ 0″ this hole entered the solid floor of the marsh as it was found very difficult to get the digger down the next 10 inches, the spoil from which was mainly grey mudstone fragments. This rock was a dense, grey, non-calcareous, non-sandy well-lithified mudstone containing muscovite flakes and a few obscure plant fossils which may possibly be *Phyllotheca*. It is most probably Triassic, but in view of the obscurity of the fossils this is by no means certain.

Bore B. (centre of Big Marsh):

From surface to 1′ 6″: Black peaty clay.
1′ 6″ to 7′ 6″: Greyish clayey sand.

A laboratory examination of the material from the bottom of this hole indicates that it is a slightly calcareous sandy clay in which there is approximately 50 per cent of fine sand grade material. These sand grains are angular, but strongly frosted there being very few grains with unworn surfaces. Turbid felspar is the predominant mineral and quartz is next most abundant. Some contorted mica flakes are present. The heavy minerals were separated in order that they could be compared with those of an undoubted Tertiary sand interbedded with the basalts to the west of the River Nive. The heavy mineral index was low and contained a very small proportion of slightly magnetic ilmenite (as compared with the high ilmenite content of the Tertiary sand). In view of its low ilmenite content and absence of pyroxene it appears to be pre-dolerite and, therefore, not of Tertiary age. The other heavy minerals in the sample are:—

(i) Opaque, non-magnetic, very turbid, unidentified.
(ii) Zircon, perfect euhedral unworn crystals, slightly yellow in colour.
(iii) Garnet, colourless isotropic, chunky, unworn.
(iv) Biotite—rare worn flakes.

This examination of the materials from the floor of Big Marsh indicates that it is underlain by Triassic sediments rather than by dolerite (the only rocks exposed around its margin) or by Pleistocene till. More detailed work, however, is required to substantiate this conclusion.

The country to the south of Big Marsh is entirely of dolerite.

(iv) *Middle Nive Belt.*—A narrow belt of shaley Triassic sediments with some associated current-bedded sandstones is exposed in the Nive valley between Tarraleah and the mouth of the Clarence River. This belt, the eastern and western margins of which are, for the most part, concordant igneous contacts with the underlying and overlying dolerite, is cut across by discordant dolerite intrusions connecting the dolerites above and below the sediments. A result of the transgressive dolerite has been, therefore, to break the narrow belt of sediments up into three or four elongated blocks thus:—

(*a*) At the mouth of the Clarence River: Triassic sediments are exposed in the bed of the Nive for a distance of 30 chains upstream from the mouth of the Clarence where they end abruptly against a discordant east-west dolerite intrusion. These sediments strike 25° (magnetic) and have a uniform dip of 12° to the east. The eastern margin of the sedimentary band is a concordant intrusive contact with Triassic sediments below and dolerite above. The western margin exposed on the north bank of the Clarence at 10 chains from its junction with the Nive and 10 feet above river level appears to be a shelving discordant igneous contact dipping 20° to the N.W., whereas the bedding of the sediments here dips very flatly to the east. This contact is definitely intrusive, the dolerite being the chilled microporphyritic variety.

The Triassic rocks exposed in this section of the Nive are greyish graphite-bearing clayey siltstones near the west edge of the belt (i.e., the lowest part of the sequence). At eight chains north of the mouth of the Clarence the mudstones and siltstones are overlain by hard current-bedded white quartz sandstones. These in turn are overlain at 16 chains north of the Clarence-Nive junction by white mudstones and siltstones, and still further upstream (i.e., higher in the Triassic succession) by greenish-grey well-jointed mudstones with layers to two feet thick of sandstone. No fossils have been found in the rocks exposed near the mouth of the Clarence River, but because of lithology and the occurrence of flake graphite in the siltstones of the lower parts of the sequence here exposed they are considered to be of Triassic age. These sediments have not been followed to the south, but appear to pass under the basalt cover and may join up with the next section to be exposed downstream in Wentworth Creek.

(*b*) In Wentworth Creek and downstream along the River Nive: Triassic *Phyllotheca*-bearing shales and associated current-bedded siltstones and sandy shales very similar to those exposed north of the Bronte Gorge have been traced from a point approximately three-quarters of a mile upstream along Wentworth Creek from the Nive for a distance of approximately three miles downstream along the Nive River. The Triassic here is a band approximately 100 feet thick which outcrops over a width averaging 10 chains between two intrusive dolerite sills. The best section exposed is in the Nive at 20 to 30 chains upstream from the mouth of Wentworth Creek, where the Nive has a south-westerly trend oblique to the strike of the sediments. The base of the section here, which is well-exposed on the west bank of the Nive, consists of thin interbedded light and dark grey shales in which *Phyllotheca* is comparatively abundant. *Phyllotheca* was also found in very micaceous shales in Wentworth Creek three-quarters of a mile upstream from its junction with the Nive.

The Triassic sediments of this belt dip to the east at 5° to 10°, but in the outcrops of Triassic sandy shales and siltstones in the bed of the Nive between half a mile and one mile south of the Nive-Wentworth junction the dips are very steep (up to 55° being noted). This is due probably to these rocks being in the immediate vicinity of the Nive fault. At one and three-quarters miles downstream from the Wentworth-Nive junction the sediments are cut off abruptly by a discordant dolerite intrusion approximately 10 chains wide, south of which the sediments continue for a short distance before becoming lost under the dolerite talus of the east bank. The sediments near this southern end of the belt being described are fine-scale current-bedded sandy shales best exposed on the east bank of the river, and are lithologically identical with the Triassic exposed to the north of Bronte Gorge. No further trace of these sandy shales has been found downstream, although a sandstone facies, presumed to be of Triassic age, has been found a short distance below Tarraleah Power Station.

(*c*) Tarraleah Power Station occurrence:—Coarse gritty sandstones are exposed on the west side of the Nive Valley a few chains south of the pipeline leading to the Tarraleah Power House and a fine-grained sandstone occurs on the east side of the Nive at approximately 20 chains downstream from the powerhouse—elsewhere in this locality the rocks are completely covered with talus.

The sandstone on the west bank of the Nive is a conglomeratic sandstone containing waterworn pebbles to 1 cm. diameter. It outcrops in a cliff 25 feet high immediately below the basalt (at an approximate elevation, 1500 feet) at approximately two chains south of the pipeline. No sandstone is exposed on the pipeline itself—dolerite is the only rock and it is very fine-grained and it appears that here again we have a discordant east-west contact of sediments and dolerite. The sandstone strikes 75° (magnetic) and dips 10° to the south. It is current-bedded, the attitude of the current bedding indicating that the source of the sediments was to the north-west. It is a much coarser facies than the sandstone of the east bank of the Nive below the powerhouse, but has thinner-bedded layers in which flake graphite can occasionally be seen and in this respect is similar to the sediments of the east bank. The sandstone is very quartzose, but carries a small proportion (less than five per cent) of clear microcline. That this sandstone is underlain by mudstone is evidenced by the finding of a small fragment of yellow-brown mudstone approximately 50 feet above river level at 10 chains south of the powerhouse. The west bank of the Nive was traversed for approximately one and a half miles below the powerhouse, but no further sediments were noted beyond a distance of 25 chains—south of this point solid dolerite and dolerite talus was the only rock seen.

The Triassic sandstones of the east bank of the Nive below the powerhouse are fine even-grained micaceous quartz sandstones carrying a little flake graphite and are, therefore, referred to the Triassic. The strike is 330° (magnetic) and dip 22° N.E. All contacts with the dolerite here are covered with dolerite talus.

(v) *Lower Nive Belt.*—In the extreme south-east corner of the mapped area a series of easterly dipping unfossiliferous greenish to chocolate shales with irregular lenses and sills of dolerite occur outcropping in the road cuts on the Tarraleah-Ouse Highway to the east of the Nive bridge. These are tentatively correlated with the Hamilton Shale Facies of the Knocklofty Formation of the Triassic, the correlation being based on lithology and the irregular nature of the dolerite intrusions within the shale which is a rather characteristic feature of the Hamilton Shale Facies (S. W. Carey, personal communication). These shales strike obliquely to the dolerite-shale contact, they show no contact metamorphic effects, and the dolerite is medium-grained at the contact, so it is considered that the contact between the main dolerite mass to the north-west and the shales is a fault (Nive Bridge Fault), which strikes in an E.N.E. direction.

(vi) *Butler's Gorge Belt.*—A belt approximately one and a half miles wide of Triassic quartz sandstones occurs to the east of Butler's Gorge townsite. It has a general north-south trend, but nowhere do the sandstones form good outcrops except in the bed of the Derwent River in the vicinity of 796N., 428E., where the overlying soil cover has been completely scoured away and the rocks are wonderfully exposed—they show very clearly in the air photos. They dip at 10° to the north-east, but near the western margin of the belt the dip steepens to 20° or 30°. Outcrops of the more steeply dipping sandstones are exposed in the sand quarries to the north of the main road at approximately one mile N.E. from Butler's Gorge. The true dip here is 20° N.E., but some steeper dips of 35° were noted—these may be due to very large-scale current bedding, but they more probably represent local steepenings in the regional dip. Exposures along the transmission line are very poor, the presence of the sandstone being indicated only by boulders and pebbles.

Nowhere has the actual contact of the sandstones with the dolerite to east and west been seen. Because of the occurrence of fine-grained dolerites along the western margin it is possibly an igneous contact, but this is by no means certain. The eastern margin is probably a faulted contact (the Wentworth Fault). This belt of sandstones has been traced to the north to beyond the transmission line but no trace of these rocks could be found on the Lyell Highway to the east of Derwent Bridge. Traverses to several miles south of the Lyell Highway at points where the sandstones were expected to be found indicated that the entire area here is of dolerite—probably largely residual from glacial deposits which cover extensive areas hereabouts.

The sandstones of this belt are essentially quartz sandstones with subordinate felspar. In places they become very clayey as in the westernmost part of the sand quarries one mile N.E. of Butler's Gorge. These quartz sandstones commonly show current bedding, which dips fairly constantly in the direction of 140° (mag.) indicating that the source of the material was from the north-west. In certain layers they contain small flat clay (shale) pellets. A little flake graphite was noted in some specimens from the western margin of this belt on the transmission line.

The detrital grains in these sandstones are generally angular indicating quick accumulation. No fossils have been found in any of the rocks from this belt so that no certain determination of their age is possible. Lithologically, however, they resemble the Triassic sandstones and they have, therefore, been assigned to this group. The presence of a little flake graphite may indicate that it belongs to the Knocklofty Sandstone Formation, but the thickness is more indicative of the Ross Sandstone Formation. The thickness of the Triassic sandstones exposed in this belt is approximately 1500 feet, much greater than any other Triassic exposure elsewhere in the country near Tarraleah.

Minor Occurrences of Triassic Rocks.—As has been noted earlier there are small occurrences of presumably Triassic sediments irregularly scattered throughout the dolerite. It is probable that there are many such small occurrences that are obscured by the thick timber and soil cover. For example, if it were not for the exposure by a small borrow pit of the sandstones on the west side of the road running north from Tarraleah at 10 chains south of the transmission line, their occurrence here, where the soil is covered by detrital dolerite boulders, would never have been suspected. The sediments exposed in this quarry consist of very friable sandstone which is only slightly lithified, overlying a brownish grey mudstone containing a little flake graphite. These mudstones bear some similarity to the Hamilton Shale Facies of the Knocklofty Formation of the Middle Triassic. The brownish mudstones outcrop in a drain on the west side of the road near the quarry and were proved to extend under the sands in the quarry by a hole put down to three feet with the posthole digger. These sediments, which are very flat-lying, extend to the east of the road as proved by another hole put down at about four chains east of the quarry. The friable sandstones in the quarry are intruded by dolerite and have been contact metamorphosed. The microscopic examination of this sandstone indicates that it is a quartz-felspar sandstone with a considerable amount of clear unaltered microcline and in containing microcline it is similar to the sandstones exposed near Tarraleah powerhouse. The most probable origin for this small patch of Triassic rocks is that it is an inclusion which has been broken off the roof of the dolerite sill and sunk into the dolerite magma forming a xenolith.

C. *Jurassic Dolerite.*—Dolerite is the most widespread of the rocks developed in this area. The various contacts of the dolerite with the small inliers of Permian and Triassic sediments have been described above. With a few exceptions the contacts are concordant and the dolerite masses appear to be sills connected in places by dyke intrusions (as in the Nive Valley upstream from Tarraleah). Near Forest Dale Farm on the Marlborough Highway the dolerite has arisen in the form of a dyke along the Forest Dale Fault. The characteristic vertical columnar structure of the dolerite sills is rarely visible in this area because of the plateau nature of the topography and the absence of scarps in this region. The west face of the Wentworth Hills to the north-east of Butler's Gorge is, however, a high scarp, probably a fault scarp, and here the typical columnar structure of the dolerite is clearly visible. The east face of the Wentworth Hills is a dip slope of the top of the dolerite sill so that there can be little doubt that the extensive area of dolerite between the Wentworth Hills and the River Nive is part of a single sill of dolerite. The dolerite throughout the region is much jointed and flat, easterly dipping joints (" bedding joints ") are common throughout the area, supporting the conclusion that the form of the dolerite is mainly concordant intrusions.

The petrology of the Tasmanian dolerites has been dealt with fully by Edwards (1942) and there is little to be added here except in connection with the significance of grain-size criteria for the determination of the nature, whether faulted or intrusive, of the contacts between the dolerites and the associated sedimentary rocks. At the actual igneous contacts the dolerite is very fine-grained, dense, and microporphyritic, consisting of small phenocrysts of olivine, augite, and plagioclase in an aphanitic groundmass. Under the microscope the texture is glomeroporphyritic, the augite and plagioclase phenocrysts being clustered together. The olivine phenocrysts are euhedral and extensively altered to pale green serpentine. The groundmass is a microcrystalline intergranular aggregate of plagioclase laths and pyroxene granules. Such basaltic olivine dolerite is confined to a distance of several feet only from the intrusive contact—beyond this the dolerite is coarser and grain size is not significant in determining whether the contact is intrusive or faulted. There is a tendency even in dolerite remote from contacts with the sedimentary rocks to be comparatively fine-grained with irregular segregations of coarser material. Coarse and fine dolerite specimens can be collected from the same boulder and this indicates that the grain size criterion for determining the nature of a contact between the sediments and dolerite here must be applied with caution. The occurrence of the microporphyritic olivine dolerite at the actual contact is, however, indisputable evidence that it is an intrusive rather than a faulted contact.

D. *Tertiary Rocks.*

(i) *Basalts.*—A series of horizontal olivine basalt lava flows overlies the Pre-Tertiary rocks unconformably. In the area examined they are confined to two distinct belts, the main belt trending parallel to the River Nive and the other belt, exposed only on the eastern margin of the area, along Duck Creek. Since only the western fringe of the Duck Creek basalt belt lies within this area it will not be described in detail and the remarks given here deal entirely with the Nive belt.

West of the Marlborough Fault the basalts are confined to a more or less north-south trending belt of country up to five miles wide along the Nive valley. The most extensive basaltic area is in the vicinity of Bronte where the basalts cover a more or less circular area approximately three and a half miles in diameter. This area has been flooded with basalt and subsequently cut through by the River Nive, which exposes a vertical thickness of basalt of approximately 330 feet. This basalt-covered area is walled in by higher dolerite hills to the west, north and east, and in Plate II., fig. 1, these hills can be seen rising above the level of the basalts.

Within the area mapped there are sporadic occurrences only of basalt to the north of the Bronte plains, but still further north beyond the margin of the accompanying map there are more extensive occurrences of basalt. South from the Bronte basalt-covered plains there are several prolongations of the basalt. One of these runs almost due south from Bronte as far as Nive Marsh (two miles north-east of Tarraleah village). Near its junction with the main basalt basin at approximately one mile south of Bronte this basalt belt is narrow (about 25 chains wide), but it broadens to the south so that at two miles south of Bronte it is approximately 100 chains wide. At three and a half miles south of Bronte it again narrows to 30 chains being interrupted by a ridge of the underlying dolerite and south of this point it again broaden to a belt one and a half miles wide to the west of Brady's Marsh. It is here that the basalts are best exposed (in Brady's Creek). South of Brady's Marsh this basalt belt pinches out except for several small outliers near Nive Marsh. Within this belt the basalts are thicker on the eastern than on the western margin, having apparently flowed into an elongated depression with an asymmetrical profile.

The other main prolongation from the Bronte basaltic area is from the south-west segment along the west bank of the Nive. This belt follows the west bank of the Nive throughout the entire area mapped. In places where west bank tributaries enter the Nive they have cut down through the basalts and exposed the underlying dolerite or sediments—in this way the Clarence River, and Wentworth and Horne's Creek have exposed the underlying dolerite which interrupts the basaltic belt. Throughout the length of this belt the basalt is thick along its eastern margin and thin along the western margin (fig. 4)—in other words the depression that has been filled by the basalt outpourings was of asymmetrical profile. This increase in thickness of basalt from west to east in both the belts that have been mentioned allows of two interpretations:—

(*a*) That these asymmetrical depressions are due to faults trending in a north-south direction with downthrow to the west and tilting of the fault blocks to the east.

(*b*) That these asymmetrical depressions are due to dip slope-escarpment topography resulting from the differential erosion of hard dolerite and softer sediments which have a gentle easterly regional dip.

Of these two hypotheses the second is preferred because:—

1. The depressions now filled with basalt trend in a general northerly direction, transgressing the N.W. trending fracture pattern in the dolerite.
2. Basalts have flooded over the northerly extension of the Nive Fault.
3. The regional dip throughout the area covered with basalt is flat to the east so that any pre-basalt topography carved out of alternately hard and soft beds would be likely to have flat dip slopes on the western sides of north-south valleys with steep escarpments on the eastern sides of such valleys.

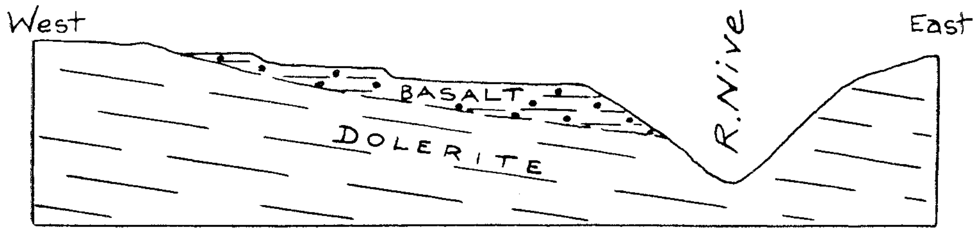

FIG. 4.—Diagrammatic cross-section of the Nive basalt belt to illustrate the structure of the basalt filled area which was in pre-basalt times an asymmetric valley with dip slope to west and escarpment to the east.

The basalt has a horizontal structure and is the result of a number of successive outflows of lava which yielded flows of the order of 50 feet thick, rather than a single basalt flood. In the course of the reconnaissance survey of this area it was impossible, because of time limitations, to map the separate flows and different basalt types which appear to be merely structural and textural variations due to the position of the basalt within a flow, i.e., scoria and scoria-breccia at the top and the more massive types lower in the flow. All of the basalts are olivine-bearing and the following textural types can be recognised:—

(*a*) *Massive, non-vesicular, olivine basalts* characterised by well-developed columnar jointing. These are almost black in colour, very fine-grained, non-vesicular and characterised by abundant small olivine phenocrysts which can be distinguished megascopically.

(*b*) *Micro-vesicular olivine basalts* of greyish colour, with minute reddish brown specks uniformly distributed throughout. These basalts have numerous very small irregular shaped vesicles. The noticable reddish brown specks are due to slight alteration of the tiny olivine phenocrysts to iddingsite.

(*c*) *Scoriaceous basalt* greyish in colour and characterised by numerous spherical vesicles to 5 mm. diameter. These, together with the scoria-breccias form the surface crust of the more massive flows.

(*d*) *Scoria-breccia* similar to the scoriaceous basalts, but having a fragmental structure. They are deposits of scoria fragments which have been weakly cemented by clayey material which is probably finer volcanic debris.

The best section of the basalts exposed in the area mapped is that in Wilson's Creek below the Tarraleah Forebay pond. This stream exposes a vertical thickness of approximately 600 feet of basalt. At approximately halfway down this section a thin band of greenish Tertiary sandstone was found interbedded with the basalt and at the base of the basalt a small outcrop of richly fossiliferous mudstone containing fossil leaves of the *Fagus* flora was found. These sub-basaltic mudstones with the *Fagus* flora are probably the equivalent of Lewis' Geilston Stage of the Late Miocene in the Hobart District (Lewis, 1946, p. 45), and thus the basalts are of Pliocene or later age.

Basalt Dykes in Dolerite.—In several places (e.g., in Horne's Creek at (797·8N., 438E.), Wentworth Creek at (799N., 438E.), and the River Nive at 804N., 439·8E.)), basaltic material was found associated with the dolerite. Nowhere was the basalt seen in direct contact with the dolerite, but the occurrence of very large blocks of basalt to 20 feet or more in length against the solid dolerite appear to be dyke intrusions, although the possibility that they are collapsed blocks from the higher valley walls must not be overlooked. The occurrence of basaltic rock in the River Nive at (804N., 439·8E.), can be clearly traced as a dyke on the air-photos—unfortunately, a specimen was not obtained of this material in the course of the field survey so that it cannot be petrologically compared with the rock from Horne's Creek. The basaltic dyke rock of Horne's Creek is very dense, dark grey to black, with rare olivine grains 2 mm. diameter and white zeolite amygdales to 3 mm. diameter. Under the microscope the constituents are olivine and pyroxene in approximately equal proportions, plagioclase laths and opaque iron ore. The olivine is fresh unaltered and euhedral and occurs in larger grains than the pyroxene towards which it is idiomorphic. It contains more olivine than the chilled microporphyritic selvages of the dolerite sills and appear to be more comparable to the olivine basalts than to the dolerites. These dykes, it is suggested, occupy the feeding channels through which the Tertiary basalts have been erupted.

(ii) *Sediments.*—There are two main types of occurrence of Tertiary sediments in the mapped area:—

(*a*) Interbedded with and lying below the Tertiary (? Pliocene) basalts. These comprise clays and sands which in one place (in Wilson's Creek at (790N., 441·5E.)), are richly fossiliferous, carrying abundant fossil leaves of the *Fagus* flora. Unfossiliferous inter-basalt clays and sands occur along the road running north from Tarraleah to the Lyell Highway, but the occurrences are too small to be indicated on the accompanying map. The main type of sediment is clay. Sands are very rare, but one interesting occurrence of sand interbedded with basalt occurs on the west side of the Tarraleah to Lyell Highway road at (808·6N., 438·3E.). The sediments here are loose unconsolidated sands in a band four to five feet thick interbedded with the basalt. It is a fine sand with the following mechanical composition:—

Retained on Tyler Screen No.	Mesh opening (mm.)	Weight (gms.)	Weight %	Cumulative weight %
32	0·495	0·06	0·12	0·12
60	0·246	19·56	39·12	39·24
115	0·124	22·20	44·40	83·20
250	0·061	0·78	1·56	85·20
passed 250	....	7·40	14·80	100·00

The products of the grading analysis were examined microscopically, thus:—

On 60 mesh:—Grains mostly angular, equidimensional, some show slight wear and frosting. Many grains have original crystal faces present. Consist entirely of quartz.

On 115 mesh:—Similar to that on 60 mesh, but a few grains are perfectly rounded and frosted indicating wind transport. Many grains have original crystal faces. There are, therefore, two distinct crops of detrital grains present. Consists entirely of quartz.

On 250 mesh:—Consists predominantly of quartz, but carries a small proportion of "heavy" minerals. The quartz is mostly sharp and angular as in the coarser grades, but some are rounded and frosted, indicating wind action. The heavy black minerals can be separated with a small electro-magnet, but they are not sufficiently magnetic to be magnetite and since they yield positive tests for both Fe and Ti these grains are presumably ilmenite.

From these characteristics it is evident that this sand has not suffered much transport before deposition and that the grains have been derived from two sources, one crop having suffered no transport the other having been subjected to wind transport.

The Tertiary age of these sediments cannot be doubted because of their association with the Tertiary basalt and the occurrence of leaf fossils *(Fagus)* in the Wilson's Creek mudstone.

(*b*) Occurring in areas remote from the Tertiary basalts. The main occurrence of these Tertiary sediments is along the south side of the Derwent Valley east of Butler's Gorge. The sediments here include slump-folded and current-bedded sandstones and shales with interbedded conglomerates. These rocks outcrop for a distance of two miles along the south bank of the River Derwent and near the eastern margin of the occurrence they extend to the north bank of the river where there are several very good exposures. These sediments are well-lithified and at first glance appear to be Triassic, but they overlie the Triassic sandstones and dolerites unconformably and moreover occasionally contain dolerite pebbles in the conglomeratic layers. They are horizontally bedded, but show slump-folding and, especially in the conglomeratic layers, current bedding. The slump folding indicates a surface of deposition sloping down to the north-west and the current bedding indicates that the source of the detrital material was from the north-east. Because of the absence of fossils the age of these sediments cannot be fixed exactly, but the occurrence of dolerite pebbles in the conglomerates indicates that they are definitely post-Mesozoic and they are put down tentatively here as Tertiary. Their age with respect to the basalts is unknown. These sediments are overlain by a light yellowish sandy soil which extends over the flat-lying country to the south of the Derwent. This sandy soil is made up of fine sand with angular grains and has a comparatively high heavy mineral content (10·2 per cent by weight of the total sample), which consists largely of angular pyroxene grains with a minor amount of opaque iron ore and a few odd grains of pinkish garnet. The heavy mineral crop, with the exception of the garnet, is undoubtedly almost entirely derived from the breaking down of dolerite. The light fraction consists largely of quartz with minor turbid felspar and, in the grades coarser than 115 Tyler Mesh, consists of approximately equal proportions of angular unworn grains and sub-rounded frosted grains. On the whole the light sand grains are poorly rounded and the detrital materials have suffered but little transport. These materials have resulted from the quick accumulation of sediments in a depression lying to the west of the Wentworth Fault, the development of which was probably due to the Wentworth Fault downthrowing to the west.

E. *Pleistocene and Later Rocks.*—The Pleistocene rocks in this area are glacial tills which have been recognised in the westernmost parts of the mapped area only. These tills occur as a thin veneer overlying the older rocks (Triassic sandstones and Jurassic dolerites) and cover extensive areas along the Derwent north of Butler's Gorge, along the north bank of the Derwent east of Butler's Gorge, and to the south of the Lyell Highway in the vicinity of Derwent Bridge. The country covered by these glacial deposits is characterised by a bouldery surface in which the dominant boulders are of dolerite. Quartz boulders, however, occur occasionally and their presence can always (in this area) be regarded as indicative of the glacial tills and they serve to indicate the origin of the dolerite-boulder strewn areas, i.e., whether they are glacial or due to the normal breakdown of an underlying dolerite (which is the predominant rock type of the area). The Pleistocene till is often overlain at the surface by Buttongrass swamp areas a number of which were sampled by the post-hole digger. The till consists of material varying in grade from large dolerite boulders down to the finest clay and a laboratory examination was made of the sand fractions of some of these tills. So far as the sand content of the tills is concerned all the samples are similar and the following description of a sample from depth 30 inches in the marsh at (796·3N., 429·8.E), can be regarded as typical of this rock.

It is an iron-stained yellowish sandy clay with fragments of dolerite to two inches in diameter and quartz to a quarter of an inch diameter. After the clay fraction is removed there is a considerable sandy residue of poorly graded material varying from very fine up to an eighth of an inch diameter. The minerals of this sand fraction are predominantly quartz with subordinate felspar (including some microcline). The larger grains show very little abrasion and on the whole the grains are very angular, many having their original crystal faces present. A small proportion, however, are rounded and have a frosted surface. The heavy black minerals of smaller size are very angular and show no signs of abrasion. The occurrence of so much quartz sand in this specimen is not of marked significance since the Triassic quartz sandstones occur in their vicinity, but the presence of similar quartz sand fragments in a specimen from two and a quarter miles north of Butler's Gorge, remote from the sandstones becomes significant—the occurrence of these angular quartz grains, as with the larger quartz pebbles, is an important indicator of the glacial till.

The Derwent Valley upstream from the Clark Dam (at Butler's Gorge) appears to have been dammed with a terminal moraine in Pleistocene times—amongst the boulder accumulations which occur over a considerable area about half a mile north of the Clark Dam there are occasional large blocks (to 8 feet by 8 feet by 5 feet) of quartz schist which could have only been carried on glaciers from the older (Pre-Cambrian) formations to the west and north-west of this area.

The recent deposits in this area include river alluvium (mainly dolerite boulders) and talus deposits (mainly angular dolerite fragments accumulated along the steep valley walls of the main streams).

3. Geological Structure.

The geological structure of the mapped area is essentially a gentle easterly dipping series of sediments ranging from the Permian to the Triassic which has been intruded by thick dolerite sills, which form the predominant rocks now exposed at the surface. The dolerite for the most part appears to be in the form of easterly dipping concordant intrusions (judged by dip slopes, columnar joints, " bedding " joints in the dolerite, and conformable chilled contacts with the associated sediments), but in places the dolerites transgress the bedding of the associated sediments (e.g., in the Nive Valley north from Tarraleah) to form connecting dykes between the main sills. This easterly dipping structure, which extends over the entire mapped area is interrupted by N.-S. striking faults which have downthrows to the west. The main faults are:—

(*a*) *Marlborough Fault.*—This fault strikes in a N.-S. direction and has been traced from a point at co-ordinate position (808N., 447E.) in a northerly direction to the northern margin of the mapped area. South of the Lyell Highway the fault has dolerite both to the east and west and as a result it is very difficult to trace its exact course. This fault can be clearly seen on the air photos as it brings dolerites and Triassic sandstones on the west side into juxtaposition to the more readily eroded Permian sediments on the east. This fault is a normal one dipping steeply (approximately 60°) to the west and it throws down to the west, the estimated minimum throw being 3800 feet. It can be best seen on the south side of Serpentine Creek from a point on the Marlborough Highway at four miles from Bronte, because here the Permian is in faulted contact with dolerite. In spite of the enormous throw on this fault there is no apparent disturbance of the Permian strata in its vicinity, and the Permian Fenestella mudstones which outcrop in a horizontal layer about halfway up the valley wall can be seen to preserve their apparent horizontal attitude to the contact with the dolerite. On topographic evidence alone, one would be tempted to place the fault to the west of the west-facing escarpment, which is situated approximately five chains to the west of the contact between the dolerite and the Permian and to consider the dolerite to be a dyke. Tracing the fault to the north it will be seen, however, that due west from Forest Dale Farm, the dolerite has cut out and we have Triassic quartz sandstones against the Permian rocks and moreover at this point the fault line scarp faces east in spite of the fact that the west block is downthrown. This scarp is a fault line-scarp rather than a fault-scarp (fig. 1).

(*b*) *Forest Dale Fault.*—This fault can be traced from a short distance south of the Forest Dale homestead in a south-easterly direction for a distance of three and a half miles. This fault is pre-dolerite and has been intruded by a dolerite dyke. There is no evidence of the direction of dip of this fault nor of the amount of throw (because, as outlined above in the section dealing with Permian stratigraphy, the Permian strata on both sides of the fault have not yet been correlated).

(*c*) *Nive Fault.*—This fault is exposed on the south-east bank of the River Nive near its junction with Wentworth Creek at (797·3N., 438·8E.). This fault cannot be definitely seen elsewhere in the area, but the distortion of the bedding in the Triassic sandy shales in the bed of the Nive for a distance of one mile downstream from the outcrop of the fault indicates that going downstream the fault trends along the actual river bed. North from the outcrop of the fault the

Nive swings to the east and the fault is thought, because of deformation of the Triassic shales at three-quarters of a mile upstream along Wentworth Creek, to continue to the N.N.W. along the Wentworth. The entire belt of Triassic rocks exposed here appears to lie to the east of the Nive Fault. This fault is of interest because it can be seen clearly in spite of the fact that the wall rocks are entirely of dolerite. The fault zone (Plate VIII, fig. B), is approximately five chains wide with most of the shattering and shearing confined to a zone one chain wide. The fault is vertical and the actual fault surface is represented by a band three inches wide of slickensided green clayey gouge with dolerite breccia on the west side (Plate VIII, fig. B). The dolerite for half a chain on either side of the actual fault surface is very fractured and has many small seams of green clayey gouge and open joints which are partially filled with well-crystallised dog-tooth calcite. A petrological examination of the dolerites from this fault zone shows that the main mineralogical change in these rocks due to the faulting is in the development of greenish brown clayey material replacing the felspars. There is no apparent change in the pyroxene and at one inch from one of the gouge zones the dolerite is unaffected mineralogically. Microscopic examination of the dolerites, therefore, yields no information regarding the proximity of a fault.

A distinct flexuring of the fracture systems in the dolerite can be seen adjacent to the actual fault surface (Plate VIII, fig. B), and this flexuring indicates that the west side has been downthrown with respect to the east side. The actual amount of movement cannot, owing to insufficient data, be calculated, but it must be considerable to produce the high degree of fracturing and shearing noted.

(*d*) *Wentworth Fault.*—The west face of the Wentworth Hills (802N., 428E.) appears to be a fault scarp which continues to the south along the eastern boundary of the Triassic sandstones and thence south along the long straight southerly course of the River Derwent. From the topography the west side is downthrown and this is supported by the occurrence of Tertiary sedimentary deposits in a depression lying to the west of this fault zone. The actual existence of this fault will only be proven by further work to the north and south of the area so far mapped.

(*e*) *Nive Bridge Fault.*—The contact between the Triassic sediments and main dolerite mass, exposed at (783N., 448E.) on the Tarraleah Highway at three-quarters of a mile east of the Nive Bridge, appears to be a fault as the shales strike obliquely to the contact, they are not contact metamorphosed by the dolerite and the dolerite is medium grained. This contact (the Nive Bridge Fault) strikes in an E.N.E. direction and so is markedly different from the other faults that have been described above. From the evidence so far available in this area it is impossible to give any estimate of its displacement nor of the relative directions of movement of the two walls of this fault.

(*f*) *Fracture Pattern in the Dolerite.*—In addition to the major faults which are described above, a well marked fracture pattern is present in the dolerite areas. These fracture systems in the dolerite can be clearly distinguished on the air-photos in spite of the dense timber cover. There are two sets of these fractures, one trending N.E. and the other trending N.N.W., and they maintain very constant direction over the whole of the mapped area. When seen on the ground they consist generally of a zone to several chains wide of closely-spaced steeply-dipping joints, but some of the dark lines seen on the air-photos are actual shatter zones and another proved to be a basaltic dyke in the dolerite. It will be evident, therefore, that any such evidences of "shear" structures on the air-photos must be individually examined on the ground before one can definitely state whether they are zones of closely spaced joints, or faults, or dykes. The north-east trending closely spaced joints dip steeply (80°) to the north-west. To this group belongs the Clark Dam Fault (Plate VIII, fig. C) exposed in the excavations for the eastern abutment of the Clark Dam at Butler's Gorge. This small fault zone strikes 55° (mag.) and dips 85° N.W., and the main shatter zone is four feet wide, parallel to which is a strongly jointed zone about 30 feet wide. Calcite veinlets one inch wide are associated with the fractures. A well-defined shatter zone belonging to the N.W. trending set of fractures is exposed in the bed of the River Nive at (803½N., 440E.)—this shatter zone is approximately one and a half chains wide and in it the dolerite is brecciated and traversed by irregular white veinlets which strike in the general direction 150° (mag.) and dip 45° to the S.W. The white mineral of these veinlets is the zeolite laumontite and appears to be the result of zeolitisation along the fractures in the faulted dolerite produced by vapours associated with the vulcanism which gave rise to the Tertiary basalts.

All of these " shear " zones seen on the air-photos are indicated on the accompanying geological map. Not all of them have been visited so that their nature (except those actually examined in the field) is not known with certainty. They appear to be conjugate fracture systems associated with the development of the major faults which, as noted above, strike in a general north-south direction.

4. Geological History of the Area.

The geological history of the mapped area began in Permian times with the deposition of the fossiliferous marine sediments of the Marlborough Series. The detrital material of these sediments was deposited from floating ice and glacial conditions continued throughout the Permian at least until the deposition of the Risdon sandstone. The overlying Ferntree mudstones, which are free from ice-rafted boulders probably indicates a decrease in intensity of the Permian glaciation.

The Permian marine sedimentation was followed in Triassic times by the deposition, in widespread lakes, of freshwater sandstones, and shales which in places carry fossil plant *(Phyllotheca)* remains. Owing to the impossibility of correlating the isolated inliers of Triassic sediments no detailed history of the Triassic Period can be attempted. The next main event was the intrusion, in the form of sills, of dolerite. This was perhaps preceded by some faulting (e.g., the Forest Dale fault was either pre-dolerite, or was developed during the intrusion of the dolerite, for it is now represented by a dolerite dyke). Subsequent to the intrusion of the dolerite there was further faulting along north-south lines resulting in the major fault structures of the area which appear to be step faults which throw down to the west. These movements may be associated with those which resulted in the general regional tilt of the rocks to the east and resulted in the well-defined fracture pattern seen in the doleritic areas.

The next major event was the extrusion of the Tertiary basalts which filled asymmetric erosion depressions on the plateau resulting from the long continued erosion of the block-faulted area. The basalts are not the result of a single eruption, but rather of a succession of fissure eruptions yielding flows of the order of 50 feet thick. The last phase in the geological history is the Pleistocene glaciation which has left its mark on the area examined in the form of a thin layer of glacial till in the westernmost section of the area.

IV. ACKNOWLEDGMENTS.

The field work in the Tarraleah area was carried out in connection with investigations on behalf of the Hydro-Electric Commission of Tasmania, and this summary account of the regional geology of this area is published through the courtesy of the

Commission. I am indebted to Professor S. W. Carey, who spent a considerable time prior to the commencement of the field work in showing me many of the type sections in the country between Hobart and Tarraleah, and who has throughout the course of the work contributed much in the course of discussion in the field. I am grateful to him also for having critically read my manuscript. My thanks are due also to Dr. A. H. Voisey for discussion in the field of the succession exposed in the Marlborough Permian inlier.

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PLATE VII.

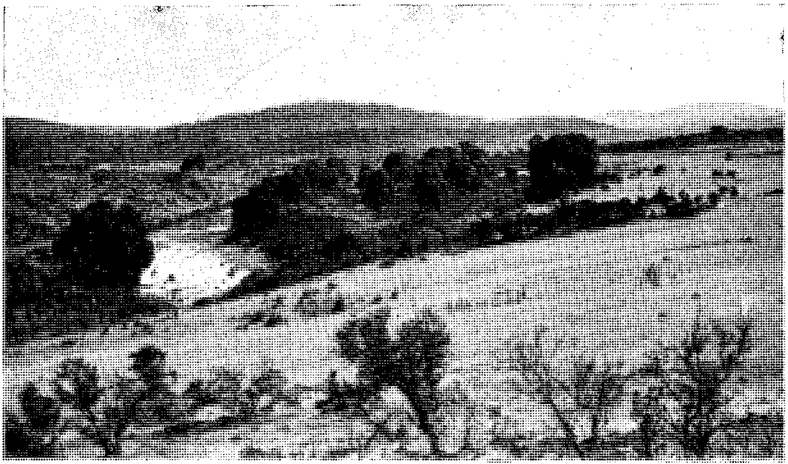
Geological map of the country in the vicinity of Tarraleah. The grid lines on this map are at 10 kilo-yard intervals and refer to the grid on the 4-mile State map of Tasmania published in 1944. The original maps from which this geological map has been made are on a scale of 20 chains to one inch and show considerably more detail than can be shown in this map. These 20-chain maps are the property of, and are filed by, the Hydro-Electric Commission, Hobart.

PLATE VIII.

A. The Nive Valley looking upstream from the Nive Bridge on the Lyell Highway, showing the dolerite hills (in distance) rising above the basaltic areas (foreground and middle distance). The flat topography of the basaltic areas can be clearly seen in the middle distance.

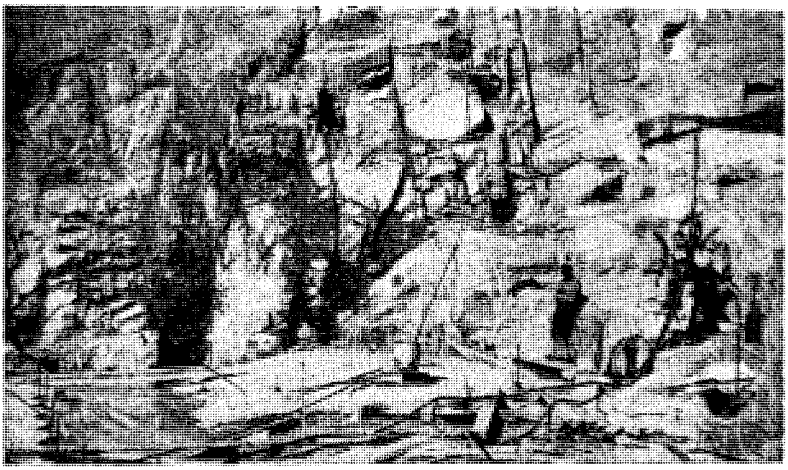
B. The Nive Fault exposed at the junction of Wentworth Creek and the River Nive. View looking south along the strike of the fault. Both walls are of dolerite. Note curvature of fractures on west side of fault and intense brecciation of the dolerite near the fault (in vicinity of hammer).

C. Clark Dam fault exposed in excavation for the eastern abutment of the Clark Dam at Butler's Gorge. This fault zone is in dolerite and is typical of the north-easterly trending shear zones in the dolerite which are indicated on the accompanying geological map. (Plate VII.)



A

B.



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