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GEOLOGY AND STRUCTURE OF THE MIDDLE DERWENT VALLEY

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(With 8 figures and 4 coloured maps)

ABSTRACT

An area of 130 square miles of the Middle Derwent Valley lying between New Norfolk and Hamilton has been geologically mapped. The Permian sub-greywacke type sequence consists of 1300 feet of sandstone, siltstone, mudstone and limestone deposited on a stable 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; mineralogical variations from the normal tholeiitic dolerite to granophyre have been traced. Evidence for liquid immiscibility is present towards the base of the sill. The Jurassic structure is interpreted as a cauldron subsidence. Faulting is accompanied by dolerite intrusion of transgressive to concordant sills, which are like cone-sheets near the root zone. Various Tertiary faults combine to form a stepped graben, the axis of which trends north-west, resulting in the formation of a chain of lakes and lowlands. In late Tertiary times, large outpourings of olivine basalt and associated tuffs, at least 350 feet thick, overran the lakes and partly filled the valley. Several flows of basalt have been mapped and five periods of volcanism have been recognised. The inter-basaltic periods are marked by either lake sediments or fossil forests. The graben faulting controlled the drainage pattern both during pre-basaltic times and subsequently.

INTRODUCTION

The area mapped lies in the middle Derwent Valley comprising four ten-kiloyard grid squares, namely, Mt. Spode, Macquarie Plains, Glenora and Plenty and is covered by the aerial photographs Ellendale runs 1 to 10 and Styx runs 1, 2 and 4. Tertiary basalts were mapped on a scale of 1 inch equals 400 feet, using a base map, provided by courtesy of the Hydro-Electric Commission, Hobart. Details from this have been incorporated in the 1 mile = 1 inch map. Specimen and thin section numbers quoted refer to material lodged in the Geology Department, University of Tasmania.

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 graben. Permian and Triassic rocks with minor dolerite and Tertiary basalts and lake sediments form the valley, while dolerite hills like Mt. Spode, Mt. Belmont and Moogara Plateau border the valley on either side and rise to heights of 1,500 to 2,000 feet. Small hills of resistant Triassic sandstone and Tertiary basalt rise to 500-600 feet elevation in the valley. The area is drained by the Derwent and its tributaries i.e., Russell Falls, Styx and Plenty Rivers and smaller rivulets such as Allen Vale Rivulet, Belmont Rivulet and Dry Creek. The drainage is controlled for the most part by either the structure or resistant rocks. Though the elevation in the area does not exceed 2,000 feet, the gradient of the hills is quite steep and deep gullies have been cut in the resistant rocks. The physiography could be said to be in a late youthful stage.

PERMIAN SYSTEM

General

Rocks belonging to this system have received great attention in the Hobart district and several geologists have studied them. Voisey (1938), Lewis (1946), Banks (1952, 1955) and Banks and Hale (1957) are responsible for the present knowledge of the Permian rocks in Tasmania. Permian rocks from the Bundella Mudstone upwards are exposed in the area on the upthrown side of the Glen Fern Fault and west of Glenora up to Westerway.

Bundella Mudstone

The top 35 to 40 feet of this formation are exposed on the upthrown side of the Glen Fern Fault at grid 489.000, 733.050. The rock is an olive grey, non-fissile siltstone, with angular fragments of quartz, feldspar, muscovite and rock fragments with glacial erratics of quartzite and phyllite ranging in size from a fraction of an inch to a couple of inches.

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Faulkner Group

This group is exposed overlying the Bundella Mudstone. The first member is a quartz-rich, fissile, thinly bedded sandstone, noticeably micaceous and in parts cross-bedded. Overlying this is a six feet thick, well-sorted, olive grey carbonaceous siltstone which is unfossiliferous except for vague plant fragments. The section above this is covered for a height of 60 to 70 feet. The next member seen is a pale yellow to orange coloured feldspathic sandstone with angular to sub-angular fragments of quartz and feldspar with patches of bryozoa. This formation is correlated with the Rayner Sandstone (Banks and Hale, 1957).

The correlation of these formations from the upper Bundella through the Faulkner Group to the Rayner Sandstone is open to question. There are neither good sections nor is there diagnistic fossil evidence to prove or disprove the correlation. This correlation is suggested because these formations underlie the Cascades Group with diagnostic fossil evidence and within the area there appears to be no structural discontinuity.

Cascades Group

A good section of this group is exposed on the spur going south-south-east from the Glen Fern-Moogara road crossing from 450 feet to 770 feet and overlies the Faulkner Group. The Dry Creek Fault throws down the section on the west side by at least 150 feet. The Cascades Group in this locality is approximately 320 feet thick and consists of Nassau Siltstone, Berriedale Limestone and Grange Mudstone.

The Nassau Siltstone is 10 to 15 feet thick and contains angular grains of quartz, and little feldspar. Numerous fossils are present, especially species of *Strophalosia* and *Fenestella*. The other fossils are pectinoids, spiriferids and fragments of pelecypods. Towards the top the formation becomes more calcareous.

The calcareous siltstone and limestone about 150 feet thick form the Berriedale Formation. Individual beds are a few feet thick separted by thin fissile siltstones. The limestones range from calcirudite to calcilutite. They are generally impure and consist of clastic grains of quartz and erratics of quartzite and other metamorphic rocks. Important fossils are species of *Fenestella, Stenopora,* Spiriferids, *Aviculopecten* and corals. Towards the top the limestone passes into Grange Mudstone.

Grange Mudstone is exposed both on the east and west side of Dry Creek and attains a thickness of 150 to 160 feet. Here the formation consists of non-fissile to fissile siltstone. The rocks are mostly yellow to brown and rich in fossils. Erratics are common. Another small outcrop of Grange Mudstone is exposed a mile and a half south of Westerway on the first bench of the dolerite hill.

" Woodbridge Glacial Formation "

This formation attains a thickness of 280 feet and is composed of rhythmic alternation of sandstone and siltstone. The rocks are grey when freshly broken and weather to yellow and yellowish brown. Erratics are more profuse than in the underlying or overlying formations. Towards the base and 50 feet from the top fossiliferous siltstones occur. The top horizon forms a marker bed and is exposed near grid 489.900, 731.000.

Risdon Sandstone

Overlying the " Woodbridge Glacial Formation " is an 8 to 10 feet thick bed of feldspathic sandstone with coarse, sub-rounded quartz and feldspar; it is unfossiliferous.

Ferntree Mudstone

The Ferntree Mudstone lies above the Risdon Sandstone and below the Cygnet Coal Measure or where the latter is absent below the Triassic Ross and Knocklofty Formations. Ferntree Mudstone is exposed on either side of Dry Creek and attains a thickness of 400 feet and is faulted against the dolerite. In the Karanja and Westerway area it attains a thickness of 600 feet. Good exposures are seen in the railway and P.W.D. quarry near Westerway. West of Karanja a certain amount of baking is noticed due to the proximity of the dolerite roof. North of Russell Falls River this formation is disconformably overlain by the Triassic sandstone. Besides the Risdon Sandstone three more sandstone horizons are noticed in the Ferntree Formation, along the numerous timber tracks north of Westerway and along the track west of grid 488.500, 730.900. Such quartzose members in the Ferntree Formation are described by McKellar (1957, pp. 8-9) from the Great Lake area.

TRIASSIC SYSTEM

General

Disconformably overlying the Permian System is a group of Triassic to Lower Jurassic age. This disconformable relation was earlier recognised by several workers (Nye, 1921, 1924; Hills and Carey, 1949; and Banks, 1952). The erosional break is seen at grid 475.000, 746.400, and 471.100, 745,000 and west of Hollowtree Road. At the first two localities an angular unconformity is suggested by the discordant attitudes of the Permian and Triassic beds.

The subdivision of Triassic rocks into different formations is difficult owing to rapid facies variations and lensing out of beds. Jennings (1955, p. 175) expressed a similar opinion with regard to the Wayatinah area. General lithology and fossil evidence, at the present state of knowledge, do not allow definite correlation. However, two distinct formations can be recognised, 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, the sandstones exhibiting pronounced cross-bedding and slump structures. These, where exposed, form a distinct group of beds forming cliffs with salt efflorescence and can be recognised as a formation. McKellar (1957, p. 4) has described 650 feet of massive quartz sandstone from the Great Lake area which he has grouped as Ross Sandstone. Further work on the Triassic stratigraphy is needed to decide the stratigraphic status of these, either as a separate formation, or as a basal member of the Knocklofty Sandstone and

Shale. Since these form a recognizable unit they deserve to be considered separately and in this area such rocks have been mapped as Ross Sandstone.

Ross Sandstone

Sandstones recognized as Ross are exposed on the fault-line scarp of the Magra Fault, on the Norton-Clarendon Horst and west of Allen Vale Rivulet forming a strike ridge in the latter area. Lithologically they consist of conglomerates towards the base and sandstones towards the top. The conglomerates are mainly quartz conglomerates containing pebbles of reef quartz, quartzite and intraformational mud pellets, set in a quartzose matrix. The sandstones are medium to coarse-grained with white, sparkling quartz and authigenic silica as cement. Minor amounts of muscovite, graphite and iron oxide are present.

These sandstones are thickly-bedded and show sigmoidal cross-bedding and slump structures in the Norton-Clarendon Horst and on the Magra fault-line scarp. In the latter locality alternation of coarse and medium-grained sandstones occurs; each major alternation is of the order of 60-80 feet with minor rhythms included in them. The cross-bedding and slump structures indicate a current direction from north-west with a south-east sloping floor. 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 exposed in the Plenty area on the downthrown side of the Glen Fern Fault and east of Gretna and Mt. Spode.

The sandstones are white to grey, and consist of feldspar (10%), with minor amounts of muscovite and graphite along bedding planes. The cementing material is usually argillaceous with varying amounts of iron oxide. The sandstones are thinly-bedded to flaggy and friable. Sedimentary structures such as cross-bedding and ripple marks are common. Intraformational mud pellets are not uncommon and form beds up to three to four inches thick.

The argillaceous sediments range from siltstones to shales and interdigitate with the sandstones . A dirty green colour is most common, while purple and white colours are also frequent. These lutites break into rectangular blocks. On the Moogara Road at grid 486.000, 733,500 is a bed of mudstone, dark brown to purple in colour, with mottling of purple blotches. When freshly broken it is dirty green in colour. In the road cutting at least 10 feet is exposed and the thickness is probably even more. Jennings (1955, p. 178) records a 100 feet thick bed of dense mudstone at Wayatinah.

A conglomerate bed, 30 to 35 feet thick, occurs in this formation in the north-west trending spur north of Peckham Vale and the north-south ridge west of Allen Vale Rivulet, at an elevation of 1,100 feet. This is underlain by Ross Sandstone nearly 400 feet thick.

Plant fossils are common in the shaly beds. *Dicroidium odontopteroides* is found east of Rose Garland; worm casts are also found in the shale beds at grid 486.900, 747.800.

"Feldspathic" Sandstone

This formation overlies the Knocklofty Formation and is overlain unconformably by the Tertiary lacustrine sediments or basalts. Good sections are exposed in the Plenty area, around Salmon Ponds along the Lyell Highway from Gretna to Bluff Road.

Here the formation consists of medium to fine grained feldspathic sandstones with interbedded shale, carbonaceous shale and inferior coal. The sandstones consist of angular to sub-rounded grains of quartz, feldspar, mica and rock fragments, set in an argillaceous to chloritic matrix. A calcareous matrix is not uncommon. The feldspar is usually fresh but when exposed on the weathered surface it is kaolinised and gives the rock a speckled appearance. Shaly members are fine grained and range from white or grey to black and carbonaceous. Those at Plenty east of the basalt quarry on the Lyell Highway contain minute crystals of gypsum. Inferior coal occurs at Plenty and near Marshall's house at Macquarie Plains. Cross-bedding is common in the sandstones and indicates a current direction from west-north-west and north-north-west.

A thin section of the feldspathic sandstone (8707) consists of 50% sub-rounded to rounded grains of quartz, 20% anhedral grains of feldspar (orthoclase and plagioclase) and 25% of angular rock fragments set in an argillaceous matrix. The angular rock fragments include quartzite, schist and some basic igneous rocks.

Environment and Sedimentation

The Triassic rocks are members of the orthoquartzite suite of Pettijohn (1949) with the possible addition of volcanic material, all deposited under lacustrine or swampy conditions on a shallow, slowly sinking floor. During the "Feldspathic" Sandstone time possible addition of volcanic material is suggested by the fresh plagioclase. The presence of angular rock fragments suggests an elevation of source land and indicates that earth movements or volcanism became active during this period.

JURASSIC (?) DOLERITE

Extensive intrusions of dolerite which took place after the deposition of Triassic rocks form the next common rock in the region and are exposed over a wide area. The contacts with the pre-dolerite sediments are either sill-like or discordant. The most irregular intrusions are in the Permian and the Knocklofty Formation in the Glenora and Mt. Spode map sheets. Generally the base of the sill is uniform while the roof zone is quite irregular and rafts of sediments are a common feature on the sheets quoted.

Contact metamorphism is a very minor feature. The sediments are rarely altered for more than a few feet away from the contact. Usually no effects are visible i the dolerite 50 to 100 feet away from the contact. At the intrusive contact the dolerite is chilled with phenocrysts of orthopyroxene. Away from the contact zone the dolerite is medium to coarse-grained, grainsize increasing towards the top of the sill. It is generally massive with crude columnar jointing and develops a system of cooling fractures near the contact.

Dolerites weather in a spheroidal form and the extent of weathering is quite irregular. Although near faults the weathering may be intense and may extend to a greater depth, generally the depth of weathering is only a few feet. Dolerite gives rise to extensive talus and scree material on steep hill slopes and thickness of this may be very variable.

The age of the dolerite intrusion cannot be fixed with any degree of certainty. Lewis and Voisey (1938, p. 38) and later authors have suggested a Jurassic age for the Tasmanian dolerites. 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). It is proposed in this section not to discuss the petrology in detail but to place on record a few outcrops of petrological significance.

A specimen collected from the contact of dolerite and basalt at grid 483.000, 751.900 is interesting. The rock in hand specimen (8683) is fine-grained, light buff-coloured with a granophyric texture. Under the microscope it has a complex texture, which appears somewhat igneous, and consists of quartz (55%), orthoclase (35%), with ferromagnesian mineral (10%), mostly mica and chlorite. No pyroxenes were seen. The quartz grains are anhedral and have irregular margins riddled with inclusions, the central portion of each grain being free from inclusions. The feldspar is mainly orthoclase. While this also has irregular margins, projecting outwards are lath-shaped protrusions giving an amoeboid appearance. Between these grains of quartz and orthoclase are randomly oriented lath-shaped bodies, probably plagioclase, giving a texture like that of the dolerite.

The texture and composititon of the rock may have arisen in one of two ways. Firstly, the rock could be a dolerite, silicified by the contact metamorphism of the overlying basalts, thus retaining remnants of igneous texture; secondly the rock could be an extreme differentiate of the dolerite magma giving rise to a granophyre. In this case the former view is suggested, since the outcrop is in contact with Tertiary basalt.

A specimen collected south-east of Rose Garland at grid 484.600, 743.300 is a fine-grained and dense rock with a dark greenish-grey colour. The rock shows amygdules filled with calcite and quartz and shows nodules of a dark material. In hand specimen it could be mistaken for amygdaloidal basalt. Under the microscope the rock is fine-grained dolerite with plagioclase (50%), pyroxene (30%) and mesostasis. The dark amydgaloidal nodules under the microscope appear to be of fine mesostasis surrounded by the normal fine-grained dolerite. The edge, often sharp, is lined with tiny laths of plagioclase (slide 8691).

The occurrence of distinct globules of mesostasis within the fine-grained dolerite may be explained either as a result of liquid immiscibility or the squeezing of mesostasis into the vesicles. Direct evidence of silicate immiscibility in nature is 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 class embedded in much larger quantities of a second class. From these experiments and other experiments on actual tektite, they concluded " that the so called ' lechatelierite ' inclusion in tektites most probably represents a state of liquid immiscibility in a silicate melt ". This occurrence of globules of fine mesostasis in a fine-grained dolerite may be a case of natural liquid immiscibility in a silicate melt.

An advanced stage of the differentiation of dolerite magma occurs in the Bloomfield area at grid 490.000, 754.500. Specimens 8684, 8685, 8680 and 8688 were collected from different zones commencing from what was recognised in the field as dolerite to granophyre. Specimen 8689 was collected from the northern slope of the adjacent hill. Mineralogical variations are represented in the two diagrams Figs. 1 and 1a. Specimens 7544, 7550 and 7558 are from the Mt. Wellington sill and specimen 3250 is from the Red Hill granophyre.

On the orthodox view of differentiation by crystal settling, the decrease in the percentage of pyroxene up to sp. 8685 is normal, but the increase seen in spp. 8680 and 8688 is anomalous. The increase of quartz and orthoclase is to be expected. The reason for the iron oxide increasing up to sp. 8685 could be that the pyroxene separating out is pigeonite low in iron. The sudden decrease in the percentage of iron could mean that the excess iron goes to pyroxene and separates out as iron-rich augite, ferro-augite. In the same specimen the mesostasis is also greater 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 unconnected trends, one separating as granophyre and the other separating as pegmatite. The granophyre separation could occur in the normal course of differentiation with enrichment of lighter residue as stated earlier. 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 be due either to enrichment of water at different times or to variations in the thickness of the column of magma differentiating, or possibly to both. Thus the differentiated dolerite at Bloomfield forms the link between the Mt. Wellington dolerite and the Red Hill granophyre (see slides 3250 and 8680).

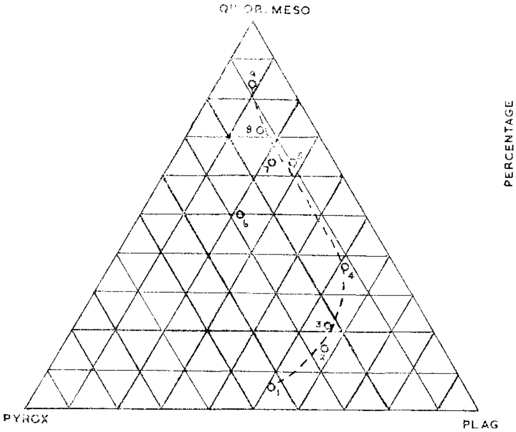


FIG. 1 VARIATION DIAGRAM OF BLOOMFIELD DOLERITE.

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

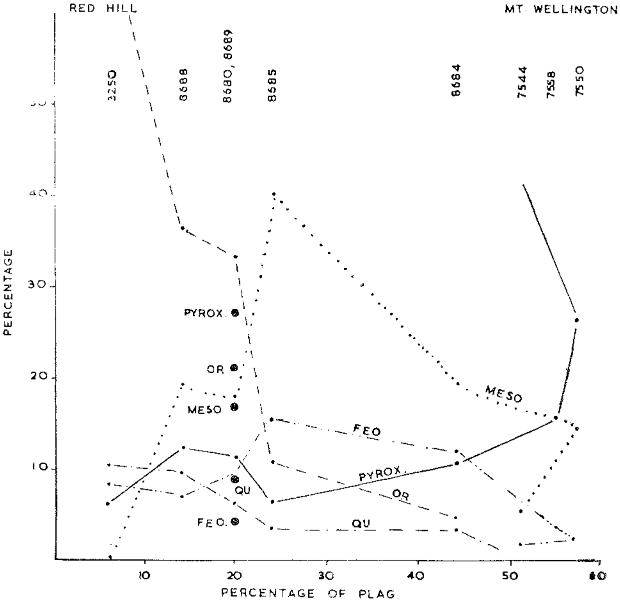


FIG. 1A VARIATION DIAGRAM OF BLOOMFIELD DOLERITE

TERTIARY SYSTEM

Tertiary Lake Sediments

Earlier references to the Tertiary lake sediments in this area are few in number. Johnston (1888) described the fossiliferous lignites and clays from the junction of the Styx and Derwent Rivers. Banks (1955, p. 9) made a brief reference to these sediments.

Th Glenora and Bushy Park area formed a lake bottom during the period prior to Tertiary volcanism. Banks (1955, p. 8) called this the 'Glenora Lake'. This lake extended from Meadowbank Road to Plenty in a south-easterly direction and from Clarendon homestead to the present Styx River in a north-south direction. The basal conglomerate bed exposed in the Norton and Clarendon property, on the Meadowbank Road, and on the Dobson Highway west of Glenora marks the northern and western limits to this lake. The basal conglomerate bed at the Norton property and on the Meadowbank Road is 30 to 40 feet thick and contains boulders of dolerite, pebbles of Precambrian (?) quartz schist and Owen Conglomerate. The pebbles of the conglomerate bed on the Dobson Highway show a high degree of rounding and polishing. The fossil wood lying on the high dip slope at Meadowbank and the polishing of pebbles probably indicate a steep precipitous western edge to the lake. Sub-basaltic conglomerate beds are seen near Macquarie Plains station and in the Plenty basalt quarry. Interbedded with the conglomerates are sandstones. When the lakes were dry these sandstones formed a soil cover supporting forests. Overlying the conglomerate beds are 150 to 200 feet of siltstones, claystones and feldspathic sandstone. Good sections of these are seen in the Glenora area. The clay beds contain leaf impressions. During volcanic quiescence sediments accumulated on the uneven surface of the basalt country and such interbasaltic sediments are seen in the Kenmore basalt hill.

Tertiary Basalts

The Tertiary basalts cover an area of 19 square miles. The greatest development is seen in the Glenora, Macquarie Plains and Norton areas extending from the Hamilton map sheet to Plenty. Two isolated exposures occur in the Plenty map sheet. In the Glenora and Bushy Park area the basalts attain a thickness of 350 feet and in the Plenty area a thicknes of 120 feet. Looking at the areal distribution it appears that the basalts are confined to the valley areas and that the exposures at Plenty were once continuous with the main basalt sections at Bushy Park.

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 the Midlands (Nye and Blake, p. 26), to early Pleistocene for the basalts of the Central Plateau (Lewis, 1935, p. 176). In the Wynyard District they overlie and underlie the Fossil Bluff Sandstone of Upper Oligocene age (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). The youngest dated sediments under the basalt in the Launceston area and in the Ouse area of the Derwent basin are Lower Oligocene or older (Gill and Banks, 1956). Edwards (1949, p. 115) showed that the Tasmanian basalts exhibit petrological affinities with both pre- and post-Miocene volcanic rocks of Victoria. No evidence is yet available from this area as to the age of the basalt.

In the Glenora and Bushy Park areas seven flows have been recognized and their correlation within this area has been established from several measured sections and a summarised sequence of the Tertiary volcanic history is presented in Fig. 2. The tuff horizons have been interpreted as explosive phases and the sub-basaltic conglomerate and sediments have been taken to represent periods of quiescence. 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 quiescence were possibly of a great length, sufficient to cool the lava field and to support vegetation and forest of at least a thousand years standing. Flow 7 may not have been the final flow as the Derwent River has eroded the upper surface of the Kenmore hill.

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

Indicating fossil wood horizon & volcanic phases

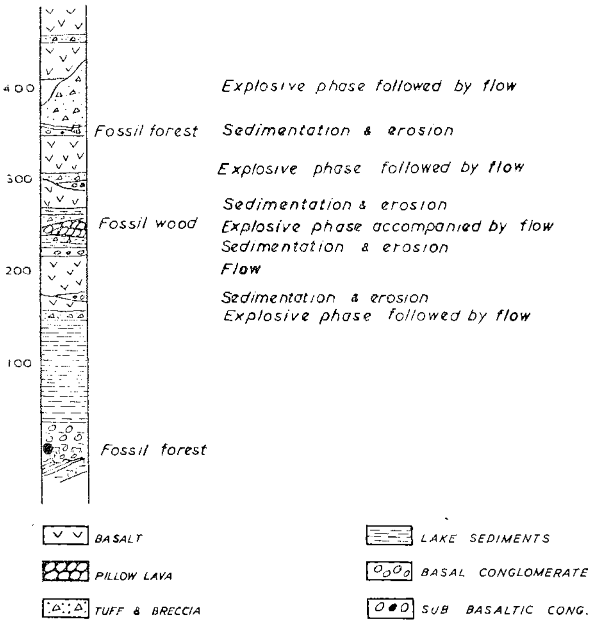


FIG. 2.

The pattern of the basalt outcrops downstream from Ouse suggests that the basalt flowed down the valley. In addition there appears to have been a chain of centres along the graben, all tapping portions of the same magma chamber and thus having a very close resemblance in chemical and mineralogical composition. The thick tuff bed at Kenmore hill and the dip of the flows east of Allen Vale Rivulet suggest a possible centre between Allen Vale Rivulet and Clarendon trig station.

The basalts of the Glenora-Bushy Park areas are of two types, according to Edwards' classification (1949), namely Ouse Type, and Bridgewater Type with some intermediate varieties. The classification is purely textural and relates therefore to the cooling history. The type depends on the thickness of flow and condition of cooling.

QUATERNARY SYSTEM

The post-Tertiary has been a period of erosion and deposition along river courses. Rocks of this period include superficial deposits of rock slides, screes, talus, and river gravels. River gravels and alluvium are best developed along the Derwent River. Three terraces have developed at altitudes of 500 feet, 350 to 400 feet, and at 200 feet, the present terrace being at 75 to 100 feet. Of these the 200 feet terrace is most extensive and extends from the mouth of the Styx River to New Norfolk. The first two river terraces are post-basaltic and pre-Quaternary in age.

STRUCTURE

The structure of the area is dominated by the effects of two periods of epeirogeny, one during the Jurassic 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 cauldron subsidence. This was followed by intrusion of tholeiitic magma, in the form of concordant and disconcordant intrusions. The resultant uplifted topography was subjected to a long period of erosion and peneplanation which lasted many millions of years and produced a mature peneplain (Carey, 1947, pp. 31-46). Owing to this long peneplanation, isostatic inequilibrium was set up and culminated in strong epeirogeny during the Tertiary. This epeirogeny has resulted in graben faulting and was followed by volcanic activity with outpouring of olivine basalt. Due to these two superimposed epeirogenies the structure caused by the latter is more pronounced than that of the former, and has even obliterated the earlier one to some extent.

Jurassic Structure

Bloomfield Fault

The dominant Jurassic structure is the Bloomfield cauldron subsidence in the Mt. Spode map sheet. The Bloomfield Fault forms a partial ring fault, a 90° arc of a circle, bringing the Triassic Knocklifty Formation against the Ferntree Formation with an estimated throw of 1,000 feet. In the middle of the arc, is a dyke-like body which Carey suggests (pers. comm.) acted like a feeder to the main intrusion. The Bloomfield ring fault has been cut off on the south-eastern side by the Askrigg Fault (= Black Hills Fault of Macquarie Plains map sheet; renamed to prevent confusion with the Black Hills Fault of Woolley (1959) which is not continuous with it) of Tertiary age. The physiographic expression of this Bloomfield structure is that the Bloomfield area forms a flat-lying area with a Triassic raft at an elevation of 1,100 feet. Immediately inside the peripheral fault, dolerite forms a circular ring, with an average relief of 300 to 500 feet above the surrounding country. Through this ridge, deep gullies have been cut, along tensional joints leaving steep sided hills.

To relieve the stress, radial faults have developed half a mile north-north-east of Peckham Vale house, west of the Allen Vale Fault and at the eastern end of the map sheet just outside the area. The Peckham Vale Fault runs in a north-westerly direction with an estimated downthrow of 500 feet to the north-east. The Triassic formations have discordant attitudes on either side of the fault. Further north-east along this fault dolerite has been intruded.

The fault at grid 488.500, 748.100 runs in a north-westerly direction and a strong linear is visible on the aerial photos. The displacement deduced from the relation of Ross and Knocklofty Formations is of the order of 300 to 400 feet. The age of this fault is open to doubt. The pattern of dolerite outcrops suggests a post-dolerite age but at grid 488.050, 749.050 baked Triassic sandstones and shales of the "Feldspathic" Formation indicate a pre-dolerite age. In the present work the age of this fault is taken as Jurassic. The third radial fault falls just outside the Mt. Spode map sheet and hence is not considered here.

Running across the Black Hills Road is a Jurassic fault trending 350° with a very steep dip towards the west. This fault stops at the Triassic-dolerite contact in the south. Along this pre-dolerite fault dolerite has intruded as a dyke 15 feet wide and exhibits evidence of post-dolerite movement with brecciation, shattering and deposition of secondary calcite along the fracture planes.

Jurassic faults in the Glenora area.

West-north-west of Glenora on the north side of the Russell Falls River is an east trending Jurassic fault with throw to the south. This fault acted like a feeder to the dolerite intrusion which has spread as a transgressive sill on both sides of it. From the base and roof relation of the sill, the throw on this fault may be anything from 1,000 to 1,500 feet.

The Karanja-Westerway strip forms an upthrown block bordered by two sub-parallel Jurassic faults trending roughly 300°. In the Westerway area there are four Jurassic faults trending 270° and 300° producing a wedge-shaped, down-faulted block of Knocklofty Formation. Along Dry Creek in the Plenty area is another Jurassic structure trending roughly north.

To visualise the Jurassic structure in the presence of 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 accompanied by cauldron subsidence.
2. The stress on this ring fault was relieved by radial and peripheral faults and radial tension joints.
3. The two sub-parallel faults in the Glenora-Westerway area possibly formed faults tangential to this major structure.
4. Dolerite has intruded these structural weaknesses as transgressive to concordant sills and the intrusion of the dolerite is wholly or partially controlled by these faults.

From the Jurassic structural pattern described the Gretna Fault may be a Jurassic structure, but the base and roof relation of the dolerite outcrop, around the Hollowtree Road suggests a Tertiary age. To explain both the features it is suggested that Tertiary movements occurred along a Jurassic linear.

Nature of Dolerite Intrusion

To understand the nature and form of the dolerite intrusion a structural contour map has been constructed from the elevation of the dolerite contact with pre-dolerite sediments (Fig. 3). The structural map is a reasonable first approximation. The structure and form of the dolerite deduced from it fit into the known field evidence and give reasonable sections.

From the structural map it is seen that the dolerite intrusion in the Bloomfield area originated as an east-west dyke and spread as a transgressive sill accompanied by the Bloomfield cauldron subsidence. The structure is interpreted as a small cone sheet, dyke-like in its root zone (Fig. 4). This is corroborated by the field evidence of a steep shelving contact in the north, a conformable contact in the south, and the final granophyric differentiate of the dolerite at the suspected dyke position.

The block south-west of the Allen Vale Fault is the roof zone of a down-faulted portion of the sill rising towards the north-east. The successive blocks southwards form down-faulted blocks of the same intrusion let down and tilted by the Tertiary faults. The Belmont dolerite block forms a sill rising towards the north-east and transgressing stratigraphically from the Knocklofty Formation to the "Feldspathic" Formation.

The Mt. Spode portion of the sill again stratigraphically transgresses from the Knocklofty Formation to the "Feldspathic" Formation to the east. On the left bank of the Derwent River are a few dolerite exposures which form the erosional outlier of the Bloomfield sill.

The dolerite exposures on the right bank of the Derwent River in the Glenora and Moogara area may be upthrown blocks of the same intrusion or may have originated from a different centre. The dolerite block east of Upper Plenty rises topographically towards the east and stratigraphically from the Cascades Group to the Knocklofty Formation.

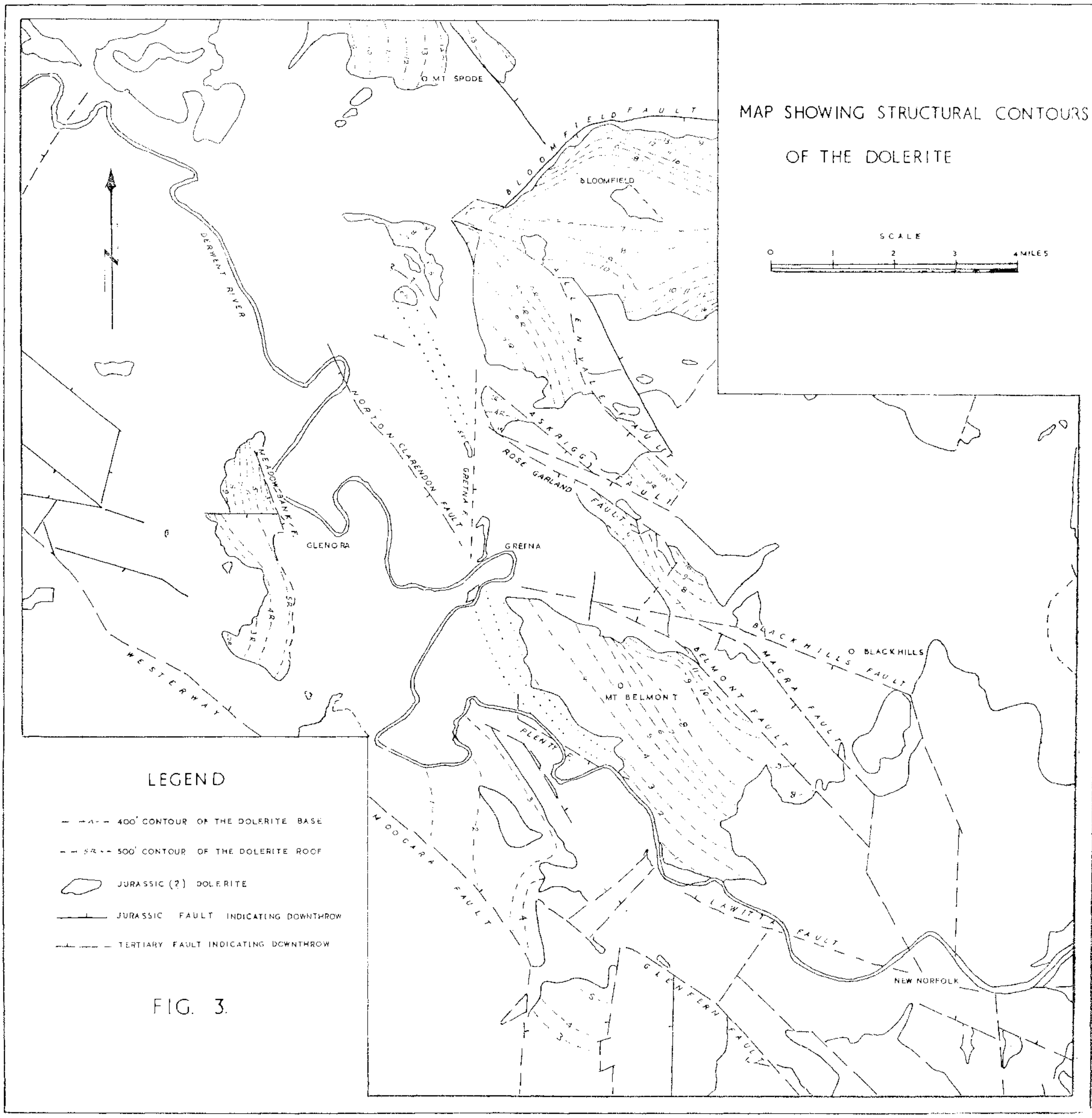
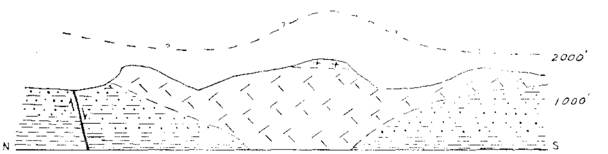


FIG. 3.



PERMIAN FERNTREE MDS TRIASSIC SS&SH DOLERITE
GRANOPHYRE

FIG. 4 DIAGRAMMATIC SECTION ACROSS BLOOMFIELD INTRUSION

Sufficient data are not available to construct the structural contours for the Moogara-Westerway dolerite block. The dolerite block west of Glenora has intruded along a Jurassic fault, the southern portion being a roof zone rising eastwards, while the northern portion rises westwards.

Tertiary Structure

The Tertiary epeirogeny resulted in block faulting of graben type with major faults generally trending at 300° and minor and secondary faults trending at 340° and north-east. The important major faults are Glen Fern, Moogara-Westerway and Lawitta Faults on the western and south-western side of the Derwent River and the Plenty, Belmont, Rose Garland (= Magra Fault of Macquarie Plains Sheet), Askrigg and Allen Vale Faults on the east and north-eastern side of the river with throw towards the north-east and south-west respectively. These major faults lie on either side of a line extending from New Norfolk to Glenora and from Bluff Road to Hamilton. Faults on the southern side of this line have a downthrow to the north-east, while those to the north of the line have a downthrow to the south-west, producing a graben. The Glen Fern and Moogara-Westerway

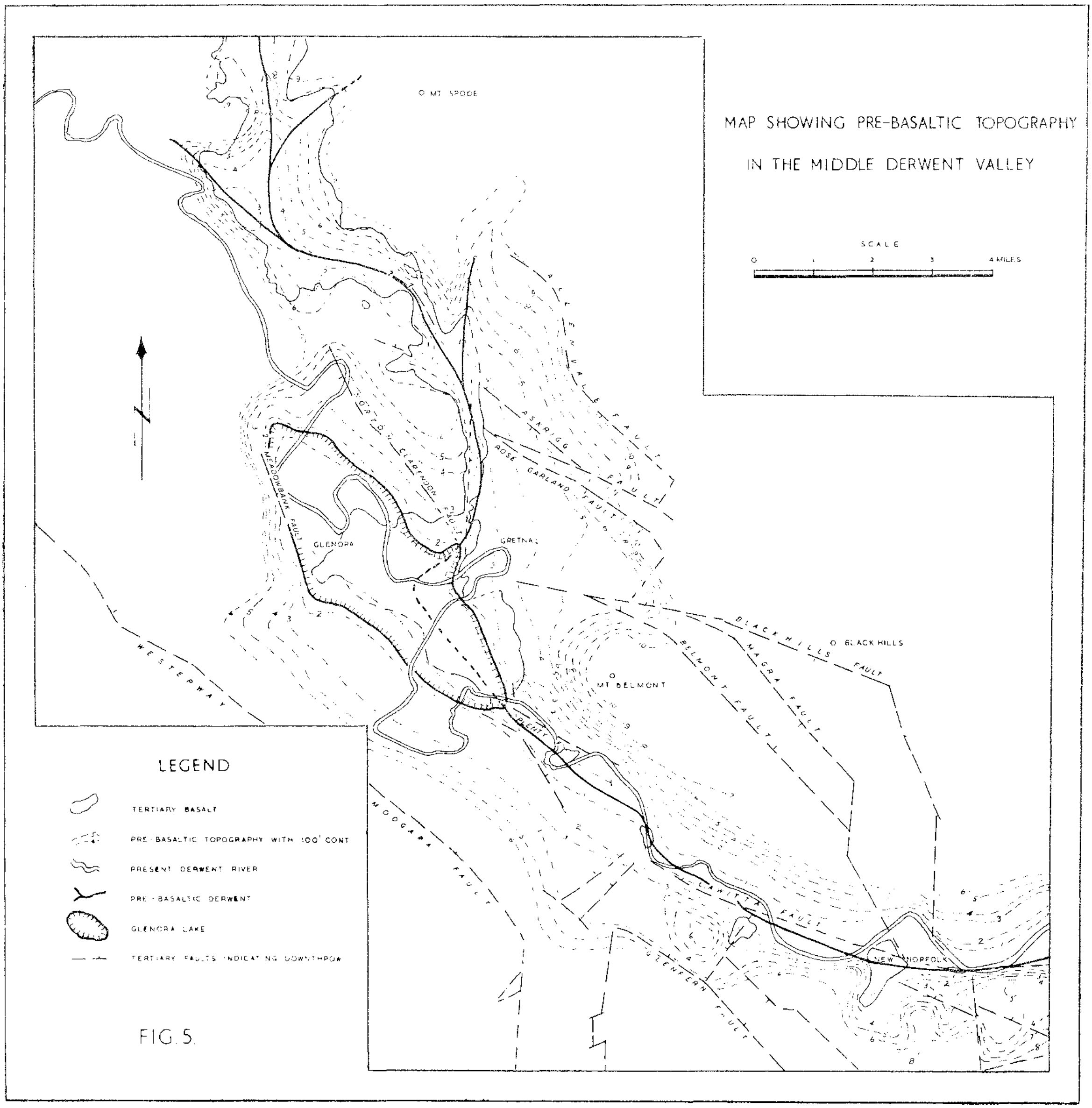


FIG. 5.

Faults extending over 15 miles with a throw of 1,800 feet to the north-east form the south-western limit of the Derwent Graben. The Lawitta Fault, with its probable continuation with the Meadowbank Fault, with a throw of 500 feet, again to the north-east, forms the inner limit of the graben. These two sub-parallel faults have a cumulative throw of 2,300 feet. The Plenty and Belmont Faults add another 500 feet or so.

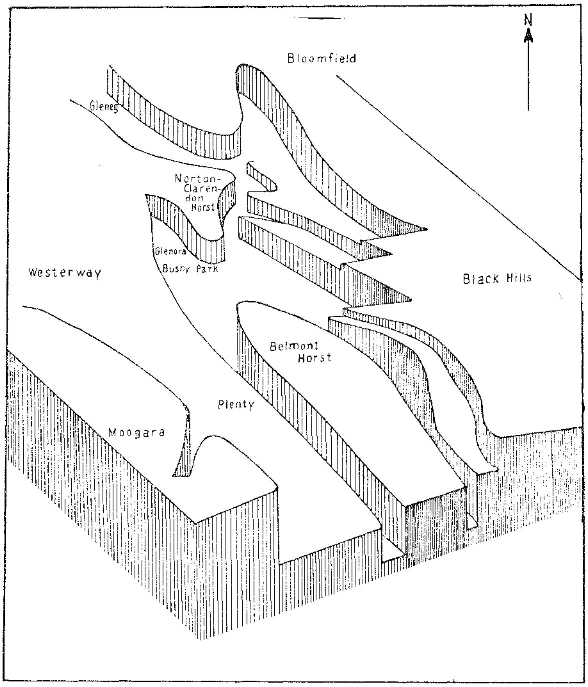
On the northern side of this axis are again three sub-parallel step faults. The Rose Garland, Askrigg and Allen Vale Faults have a total throw of 2,800 feet towards the south and south-west and form the northern side of the Derwent Graben. The Gretna and Norton-Clarendon Faults form a horst in this graben. Similarly the plenty and Belmont Faults form another horst extending in a north-westerly direction roughly parallel to the graben axis. These two horsts lie *en echelon* on opposite sides of the graben axis.

All major faults are normal gravity faults. The major trend being 300°, the stress direction is at right angles to it, i.e., 30°, and is tensional. A secondary stress field was probably present which accounts for the other faults in the 340° and north-east direction.

EVOLUTION OF THE MIDDLE DERWENT VALLEY

The history of the middle Derwent Valley commences after the Tertiary epeirogeny, which initiated the Derwent Graben. This graben formed the main drainage channel during the post-epeirogenv-pre-basaltic times and post-basaltic times. A map of the pre-basaltic valley as it existed after the Tertiary faulting is shown as Fig. 5. The diagrammatic sketch (Fig. 6) is a perspective view. In the discussion that follows, it is assumed that there has not been any differential movement since the extrusion of the basalts and the discussion should be read with the proviso that post-basaltic movement, if subsequently proved, could affect the interpretation.

From the contour map (Fig. 5) it is seen that the graben floor was very uneven with steep fault scarp faces and elevated horsts. The Norton-Clarendon Horst was roughly 600 feet high and the Belmont Horst was 1,500 feet high plus the amount which has been eroded since then. The sides of the graben were at least 2,000 feet high. North-west of Norton trig. Station it is seen that the basalts cut the 300 feet contour and do not cut the lower contours on the south side, indicating that this side formed a saddle between the " Glenora Low " and the " Gleneg Low ". Attention is drawn to the fact revealed by the contours shown in the map that the basalt on the " Gleneg Low " goes down to below 300 feet above sea-level, whereas the 300 foot contour on the " Glenora Low " is shown closing 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 Low ". Therefore it is inferred that the graben was very uneven with lakes and low-lying areas. The pre-basaltic Derwent flowed through these low-lying areas and lakes connecting them through a series of cascades and rapids. The ancestral Derwent and two other streams, one from the west and one from the north-east flowed into the " Gleneg Low ". The Russell Falls and Styx Rivers flowed into the Glenora Lake. These two lows were connected by the pre-basaltic Derwent flowing roughly parallel to the Lyell High-



DIAGRAMMATIC RECONSTRUCTION OF MIDDLE DERWENT VALLEY AFTER THE TERTIARY EPEIROGENY

FIG. 6.

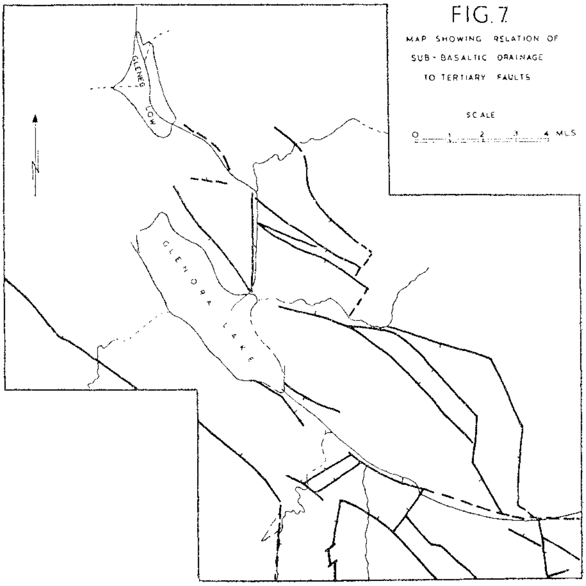


FIG. 7

MAP SHOWING RELATION OF SUB-BASALTIC DRAINAGE TO TERTIARY FAULTS way under the basalt-filled area. The Allen Vale and Belmont Rivulets joined this from the north and east. The drainage pattern immediately after an epeirogeny is normally understood to be controlled by the structure. In this respect the ancestral Derwent was no exception and its course was controlled by the Tertiary faults (see Fig. 7).

There are four possible interpretations to explain the 'high' between the "Glenora Low" and the 'Gleneg Low". They are:—

1. The basalts followed so soon after the block faulting that there was not 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 was protracted, commencing before the basalts but continuing almost contemporaneously with them 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 Low" was completely filled with lake sediments to spill point well before the time of the basalt. However the overflow river followed the shatter zone of the Askrigg Fault along which it was able to erode a narrow defile to a depth of below 300 feet above present sea level. With this new level the soft silts of the "Gleneg Low" suffered rapid erosion and were largely re-excavated and removed down the defile. Basalt in due course filled the "Gleneg Low" as well as the narrow defile connecting with the "Glenora Low".
4. There has been depression of the "Gleneg Low" with respect to the "Glenora Low" by post-basaltic movement. Of these four interpretations perhaps the third is the most probable. Nothing has been found in the area to suggest post-basaltic differential movements.

After each basalt flow, there were inevitable shallow undrained depressions caused by the irregularities of the basalt surface. These rapidly filled up with lacustrine sediments and cobbles of basalt and dolerite along the stream beds. Soils developed and forests grew before destruction by tuff showers or lava. Successive filling of the lakes and valley by basalt dislocated the drainage system with consequent development of a new system of drainage. The new courses tended to be along either side of the basalt field, as lateral streams. The diversison of the Derwent took place beyond Ouse. The river flowed on the south-west side of the basalt field as a lateral stream and joined the Glenora area which was still a comparatively broad low area. While cutting its course the Derwent meandered at 500 feet elevation and later at 350-400 feet elevation. The river at this latter elevation meandered over the Kenmore basalt tableland. Possibly at this time the narrow gap between Sugarloaf Hill and the southern edge of the basalt at Glenora was closed either by the basalts or the dolerite, or the northern extension of the Lawitta Fault still formed a 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 "Lake Glenora" diverted the Styx River to flow at a higher level as a lateral stream between the basalts and the Moogara dolerite plateau. The Styx River vigorously carved a course roughly parallel to its present course and pushed northwards until it joined the Derwent. The Allen Vale Rivulet occupied a position roughly parallel to its present course further east and progressively migrated to its present position and was assisted by the various creeks and the Belmont Rivulet. The courses of the Plenty River and Dry Creek were not affected to any degree by the basalt floods. These flowed down from the Moogara and Glen Fern plateau in a series of cascades and rapids bringing with them a lot of sediments which were deposited in the valley. The Derwent River assisted by all these rivers rapidly eroded the basalt floor in the New Norfolk area and has left remnants of basalts at a higher elevation, and flowed as a lateral stream on the north side of the basalt-filled valley.

Thus it is apparent from the map, Fig. 8, and the description given above that the drainage of the Derwent Valley in this part is controlled by the Tertiary structure. The resistant dolerite was also partially responsible for keeping the Derwent within the graben.

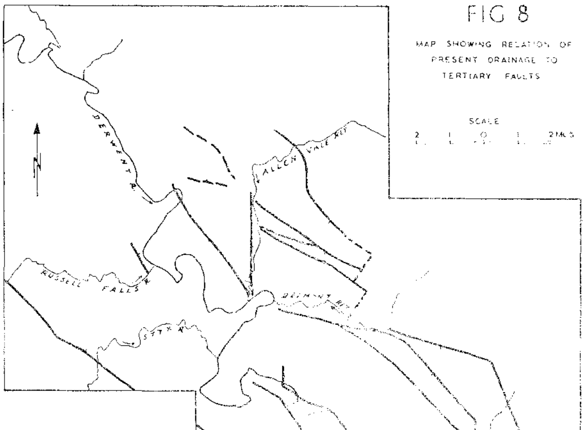


FIG 8
MAP SHOWING RELATION OF PRESENT DRAINAGE TO TERTIARY FAULTS

ACKNOWLEDGEMENTS

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Lastly the writer expresses his gratitude to the Commonwealth Government of Australia and to the Government of India for the opportunity afforded to do research at the University of Tasmania and for the research grant under the Colombo Plan awarded by the Commonwealth of Australia for this purpose.

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GEOLOGY OF TASMANIA

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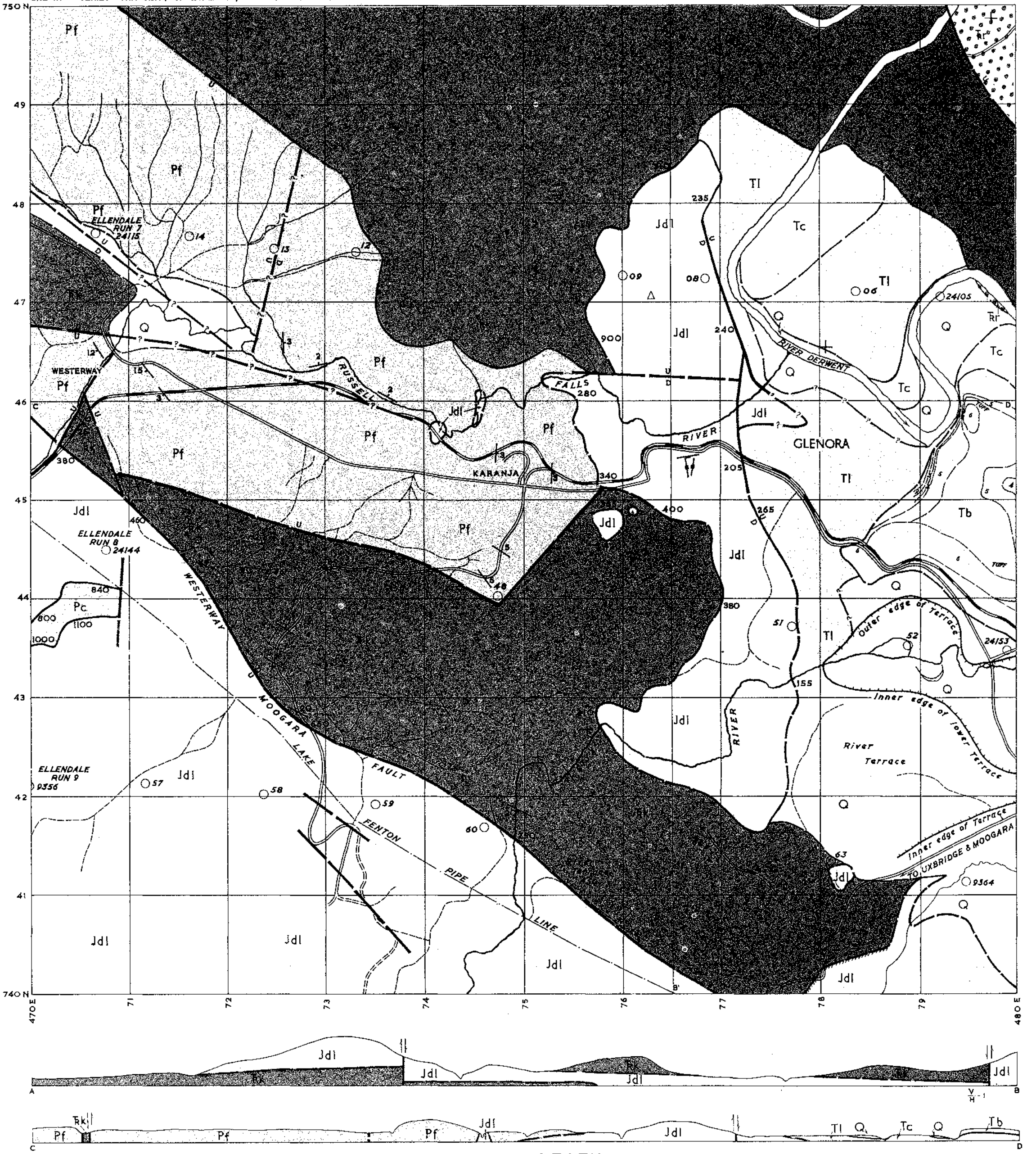
GLENORA

4774



LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED
- FAULT – POSITION APPROXIMATE
- FAULT INFERRED
- FAULT CONCEALED
- FORMATION BOUNDARY

Dolerite Boundaries

- CONCORDANT SILL
- DISCORDANT INTRUSIVE BOUNDARY
- EDGE OF RIVER TERRACE
- STRIKE AND DIP OF STRATA
- HORIZONTAL DIP
- VERTICAL JOINTS
- STRIKE AND DIP OF JOINTS
- ROAD
- RAILWAY LINE
- VEHICULAR TRACK
- FOOT TRACK

NUMBERS ON DOLERITE BOUNDARIES ARE TOPOGRAPHIC HEIGHTS.

NUMBERED LINES ON BASALT INDICATE FLOWS REFERRED TO IN TEXT.

Quaternary System

- Q — ALLUVIUM AND RIVER SEDIMENTS

Tertiary System

- Tl — LACUSTRINE SEDIMENTS
- Tc — CONGLOMERATES

Triassic System

- Rk — KNOCKLOFTY SANDSTONE AND SHALE
- Rr — ROSS SANDSTONE

Permian System

- Pf — FERNTREE FORMATION
- Pc — CASCADES GROUP

IGNEOUS ROCKS

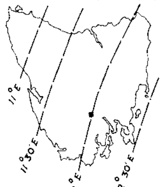
Tertiary System

- Tb — BASALT

Jurassic (?) System

- Jdl — DOLERITE

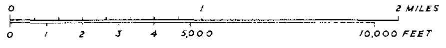
KEY MAP SHOWING MAGNETIC DECLINATIONS. SECULAR VARIATION 7 MINS. P.A.



Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Lands and Surveys Dept. and Hydro Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

MAPPED BY M. A. ANANDALWAR 1957

SCALE



GEOLOGY OF GLENORA

SHEET 4774

Physiography

The Westerway-Moogara plateau forms the main feature to the south and south-west of the sheet. Pre-basaltic "Lake Glenora" forms the basin bordered by the western end of the Kenmore Hill and Sugarloaf Hill. The Derwent River has developed entrenched meanders. The Styx River flows in the area as a lateral stream with prominent depositional flats.

Stratigraphy

The Permian Ferntree Mudstone is exposed from Karonja to Westerway. The overlying Triassic rocks on the north side of Russell Falls River show an angular unconformity with the underlying rocks (475 • 746.4). A conglomerate bed at the base of the Knocklofty Formation is exposed in the same area. Tertiary lake sediments in the Glenora area include 30 feet of basal conglomerate and 150 to 200 feet of sandstones and claystones. Claystones in the Dobson Highway east of Glenara contain plant fossils.

Structure

The Westerway-Moogara Fault forms the main structural feature and is exposed in the Styx Valley Road. The Meadowbank Fault and the Clarendon-Norton Fault define the Derwent Graben.

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GEOLOGY OF TASMANIA

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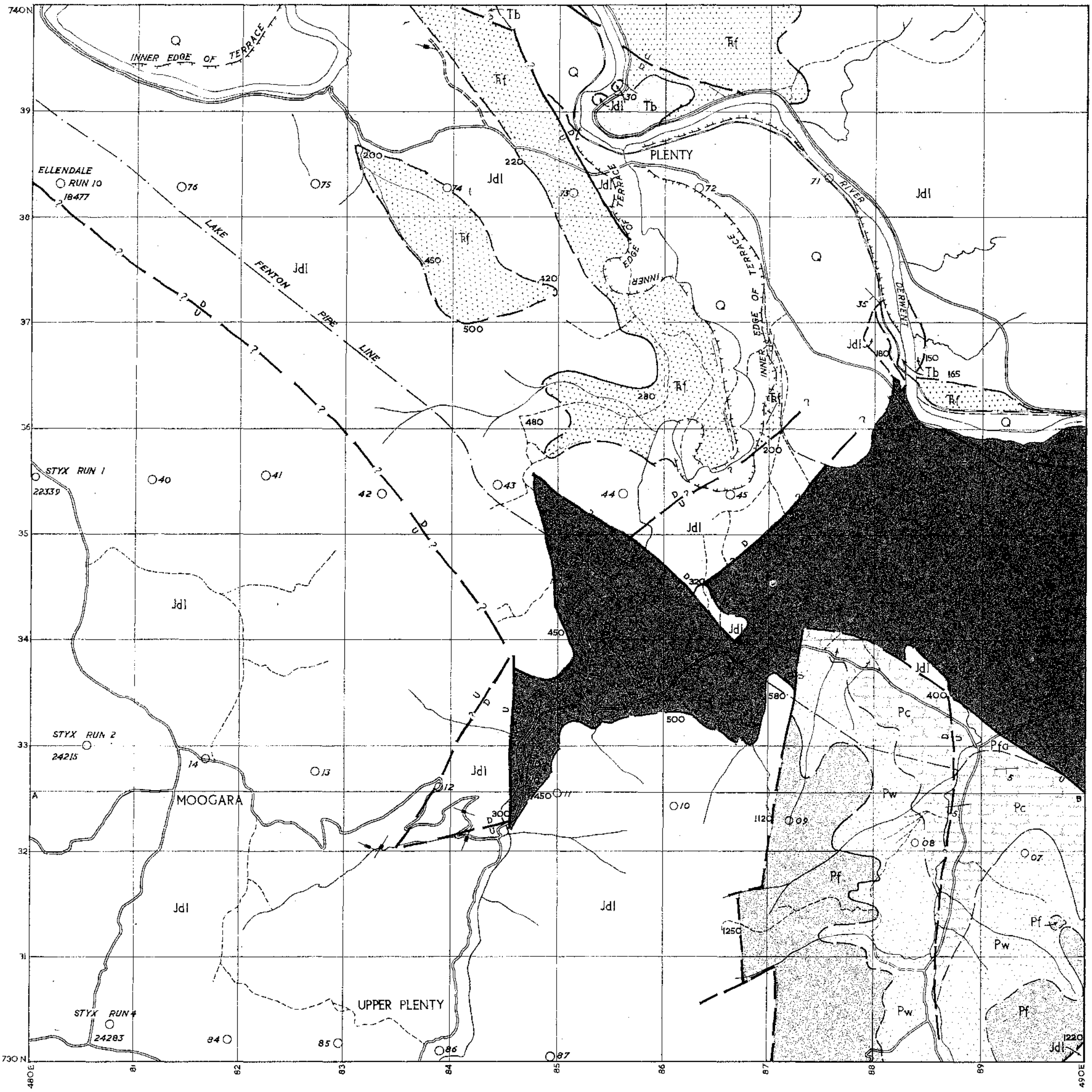
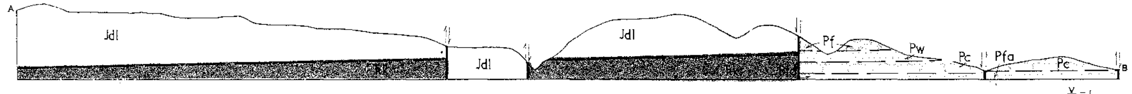
PLENTY

4873





LEGEND

FAULT WITH DOWNTHROWN SIDE INDICATED

FAULT POSITION APPROXIMATE

FAULT INFERRED

FORMATION BOUNDARY

FORMATION BOUNDARY POSITION APPROX.

Dolerite Boundaries

CONCORDANT SILL

DISCORDANT INTRUSIVE BOUNDARY

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Pfa — FAULKNER GROUP

IGNEOUS ROCKS

Tertiary System

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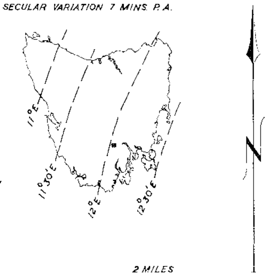
Jurassic(?)System

Jdl — DOLERITE

Compilation from aerial photographs. Trigonometric Station Control by courtesy Forestry Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

MAPPED BY M.A. ANANDALWAR 1957

KEY MAP SHOWING MAGNETIC DECLINATIONS
SECULAR VARIATION 7 MINS. P.A.



SCALE

0 1 2 MILES

0 1 2 3 4 5,000 10,000 FEET

GEOLOGY OF PLENTY

SHEET 4873

Physiography

Moogara plateau (the north-eastern face of which is a fault line scarp) forms the major feature rising to a height of 2000 feet. Quaternary depositional flats around Plenty are noteworthy.

Stratigraphy

The spur south of the Glen Fern Road and Moogara Road junction exposes a complete sequence of Permian rocks from Bundella Mudstone to Ferntree Mudstone through the Faulkner and Cascades Groups. The Knocklofty Formation and "Feldspathic" Sandstone are exposed around Plenty.

Structure

The Glen Fern Fault with a throw of 1800 feet is exposed at the Glen Fern-Moogara Road junction, bringing Bundella Mudstone and the Knocklofty Formation into contact. The Westerway and Moogara Faults form the continuation of the Glen Fern Fault. The Lawitta Fault has a throw of 500 feet towards the Derwent River. The Plenty Fault with a throw in the opposite direction delimits the Derwent Graben.

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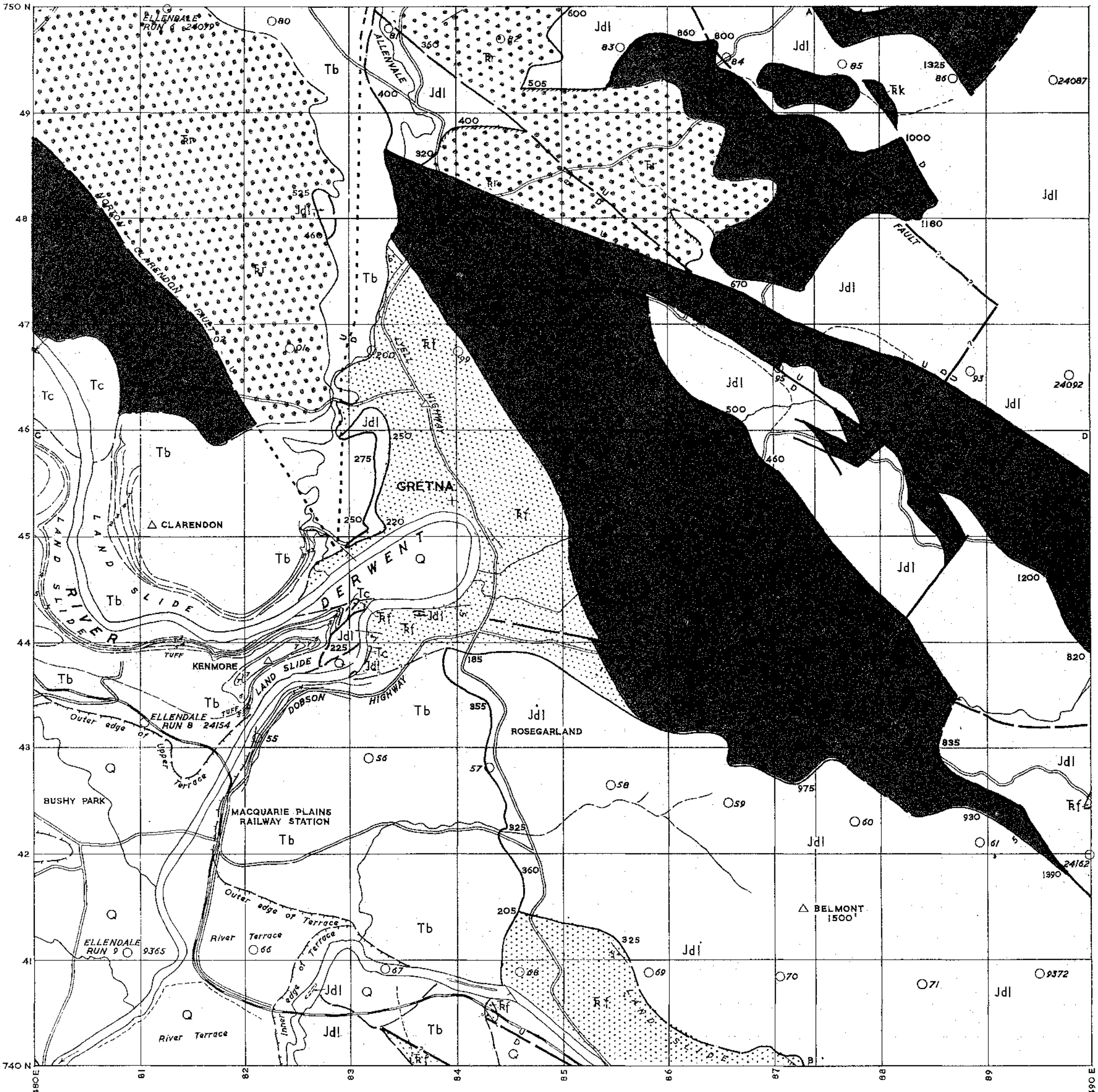
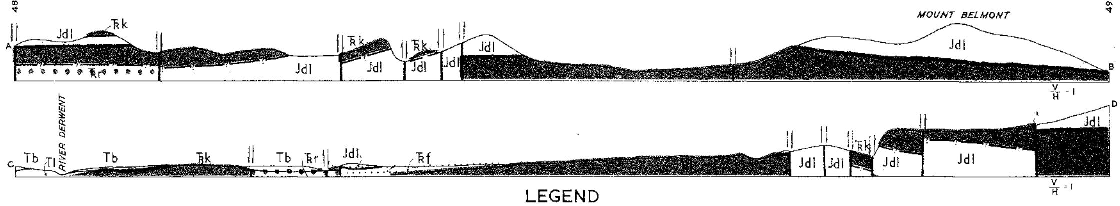
MACQUARIE PLAINS





LEGEND

FAULT WITH DOWNTHROWN SIDE INDICATED
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IGNEOUS ROCKS
Tertiary System
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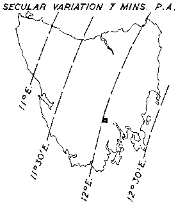

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MAPPED BY M. A. ANANDALWAR 1957

— SCALE —
0 — 1 — 2 MILES
0 1 2 3 4 5000 10,000 FEET

GEOLOGY OF MACQUARIE PLAINS

SHEET 4874

Physiography

Mt. Belmont (dolerite) rises to a height of 1500 feet. The Black Hills range rises to 2000 feet further east. Kenmore forms a basaltic tableland in the middle of the Derwent Valley.

Stratigraphy

The Triassic Ross, Knocklofty and "Feldspathic" Formations are exposed in the Clarendon and Gretna area. Tertiary lake sediments and basalts form the main feature of the Derwent Valley. A tuff bed at Kenmore is 75 feet thick and includes big boulders of dolerite.

Petrology

East of Rose Garland at grid 484.6 • 743.3 near the base of the Belmont sill is an amygdaloidal dolerite with globules of mesostasis. Basalts in the Kenmore cliff carry brown opal with an abnormal specific gravity.

Structure

The Mogra, Askrigg and Belmont Faults form a system of step faults on the east side of the Derwent Graben. Clarendon and Mt. Belmont form horsts in this graben. A volcanic centre is suspected west of Allen Vale Rivulet.

References

Anand Alwar, M.A., 1960, Geology and Structure of the Middle Derwent Valley. **Pap. Roy. Soc. Tasm.** Vol. 94.

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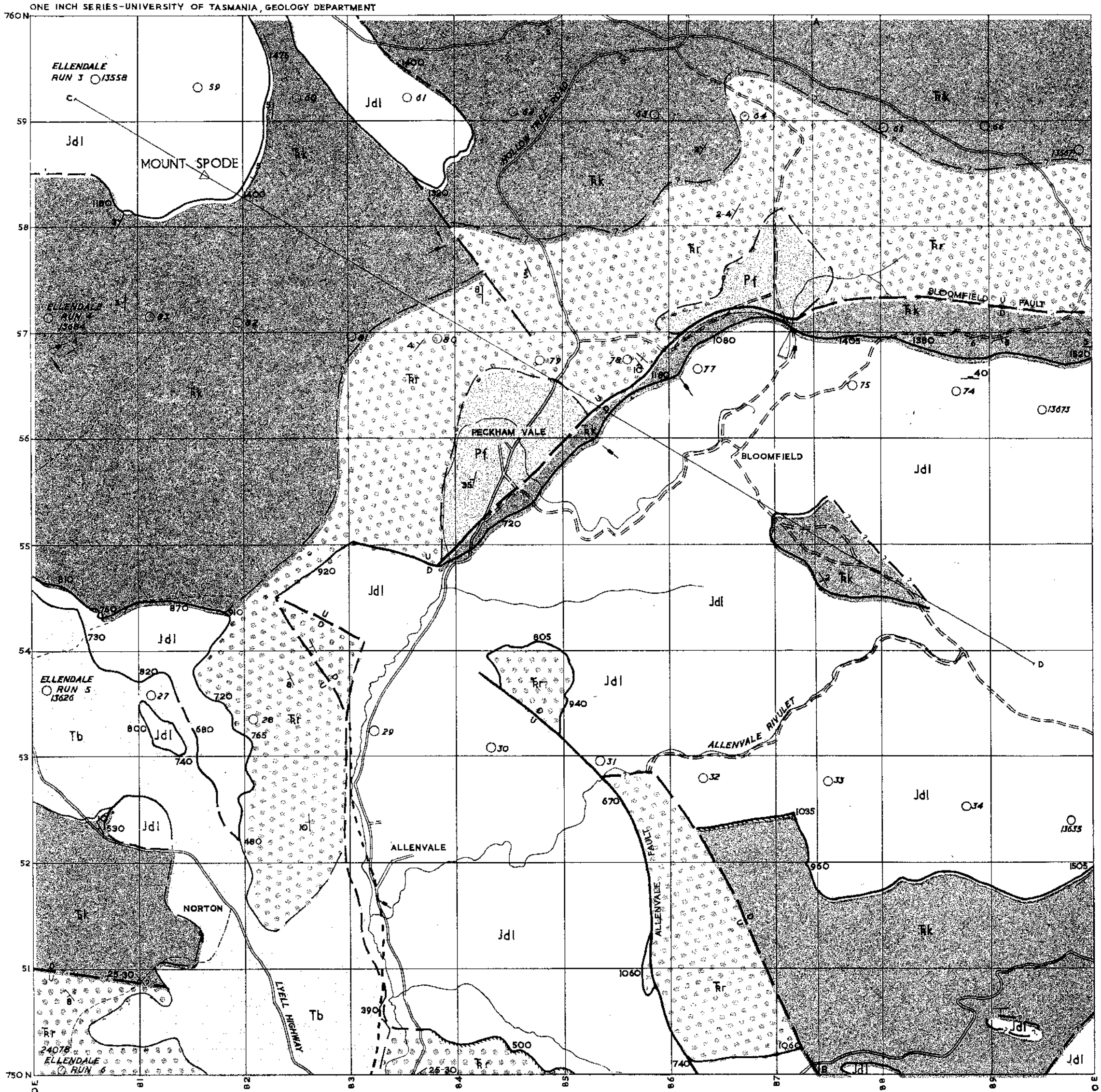
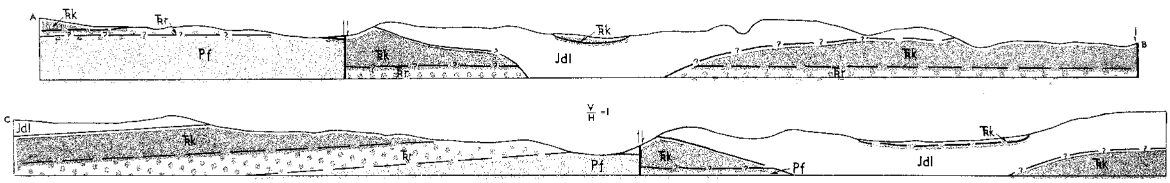
Gulline, A. B., 1959, Coal Prospects of the Macquarie Plains and Plenty Areas **Tas. Dept. Mines Tech. Repts.** 3, pp. 108-111.

GEOLOGY OF TASMANIA — MOUNT SPODE — 4875

ONE INCH SERIES–UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT





LEGEND

- FAULT WITH DOWNTHROWN SIDE INDICATED (U / D)
- FAULT CONCEALED
- FAULT POSITION APPROXIMATE
- FAULT INFERRED
- FORMATION BOUNDARY
- FORMATION BOUNDARY APPROXIMATE
- Dolerite Boundaries
  - CONCORDANT BOUNDARY
  - DISCORDANT INTRUSIVE BOUNDARY
- VERTICAL JOINT
- STRIKE AND DIP OF JOINTS
- STRIKE AND DIP OF STRATA
- ROAD
- VEHICULAR TRACK
- FOOT TRACK

NUMBERS ON DOLERITE BOUNDARIES ARE TOPOGRAPHIC HEIGHTS

Triassic System
- Ꞧk — KNOCKLOFTY SANDSTONE AND SHALE
- Ꞧr — ROSS SANDSTONE

Permian System
- Pf — FERNTREE FORMATION

IGNEOUS ROCKS

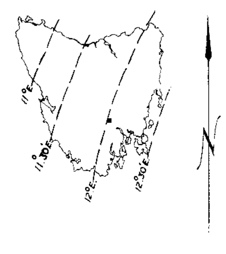
Tertiary System
- Tb — BASALT

Jurassic(?)System
- Jdl — DOLERITE

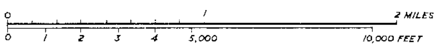
Compilation from Aerial Photographs. Trigonometric Station Control by courtesy Lands and Surveys Dept. and Hydro Electric Commission. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7.

MAPPED BY M.A. ANANDALWAR 1957

KEY MAP SHOWING MAGNETIC DECLINATIONS
SECULAR VARIATION 7 MINS. P.A.



—SCALE—



GEOLOGY OF MOUNT SPODE

SHEET 4875

Physiography

Physiography is dominantly controlled by the structure and the complex dolerite intrusion. Mt. Spode a dolerite mass, rises to a height of 1600 feet with Triassic rocks flanking the eastern and southern sides.

Stratigraphy

The sedimentary sequence includes the Permian, Ferntree Mudstone, overlain by Triassic Ross and Knocklofty Formations with conglomerate at the base of the Ross Sandstone. The conglomerate bed near the base of the Knocklofty Formation is of stratigraphic significance (488.4 • 755.8) Igneous rocks include Jurassic dolerite and Tertiary basalts.

Petrology

Granophyric differentiates of the Jurassic dolerite are seen east of Bloomfield at grid 490 • 754.5. Contact metamorphism of the dolerite due to Tertiary flows is seen west of Allen Vale homestead (483 • 751.9).

Structure

The Bloomfield area forms a centre of dolerite intrusion accompanied by cauldron subsidence. The Bloomfield Fault forms a partial ring fault with a throw of 1000 ± feet. Radial tensional faults and joints are present.

References

Anand Alwor, M.A., 1960, Geology and Structure of the Middle Derwent Valley. **Pap. Roy. Soc. Tasm.** Vol. 94.