THE GEOLOGY OF THE NEW NORFOLK-BLACK HILLS DISTRICT

By

D. R. WOOLLEY
*Geology Department,
University of Tasmania*

(With 2 Text Figures and 2 Maps)

ABSTRACT

The rocks exposed in the New Norfolk and Black Hills map squares are predominantly sediments of Permian and Triassic age, and dolerite of Jurassic (?) age. There are also three small masses of Tertiary basalt, and extensive river sediments along the valley of the Derwent. These latter are possibly of two ages—Tertiary and Pleistocene. The Permian sediments are mudstones, sandstones, and marine limestones, with a total thickness of nearly 1,200 feet. Glacial erratics are common in these rocks, but they become fewer toward the top of the system. The Triassic sediments are dominantly coarse, well sorted sandstones, with some shaley bands, which were deposited in a terrestrial environment, under warm, arid conditions. Their thickness exceeds 1,000 feet.

The dolerite is very extensive, and has a strong effect on the structure and physiography of the area. The form of the intrusions is in detail very irregular, but, viewed as a whole, the dolerite masses are approximately sill-like.

Tertiary faulting has also had some effect on the physiography of the area. The faults are approximately vertical, and appear to have been formed under tensional conditions. Most of these faults strike in a south-easterly direction, and a wide down-faulted block trending in this direction appears to have influenced the course of the Derwent River to the west of New Norfolk.

The basalt outcrops in three separate masses, each of which is close to one or more Tertiary faults, and it is thought that there were at least two, and possibly three, separate flows. The largest of the basalt masses, at the town of New Norfolk, probably changed the course of the Derwent River to some extent. The river sediments were in part deposited after the extrusion of the basalt, but some of them are probably older than the basalt. They consist of sands and gravels.

INTRODUCTION

The area under study consists of two ten-thousand-yard map squares and is bounded on the west and east by the grid lines 490000 yds. E. and 500000 yds. E. respectively and on the south and north by the grid lines 730000 yds. N and 750000 yds. N. respectively. The northernmost of the two squares will be referred to as the Black Hills square and the southern one as the New Norfolk square. The total area is approximately 65 square miles. The town of New Norfolk is about 20 miles from Hobart and is reached by means of the Lyell Highway, which is for this part of its length a sealed bitumen road.

Access to the New Norfolk square is very good, as there are a number of roads and vehicular tracks scattered through the area, which allow easy access to any part of the square. In strong contrast, however, is the Black Hills square, where much of the country is almost inaccessible. The only road passing through this square is the Back River Road from New Norfolk, one branch of which goes to Gretna, the other branch ending a little to the north-east of Black Hills. Apart from this road, there are some vehicular and foot tracks; and a Hydro-Electric Commission transmission line which runs almost north-south through the square.

The geology of the area was plotted onto aerial photographs of the Hobart and Brighton runs and then transferred to a base map using a rectiplanograph. The base map was prepared by the slotted template method, in conjunction with the base map for the Dromedary and Brighton squares, which were mapped by McDougall (1959*b*). The lay-down for the four squares was controlled by the use of twenty trig. points.

Heights were measured with an aircraft-type altimeter and were corrected for atmospheric variation by plotting diurnal variation curves. An Abney level was used to a small extent, when measurements outside the limit of accuracy of the altimeter (accurate to the nearest five feet) were needed.

ACKNOWLEDGMENTS

The writer wishes to express his appreciation of the interest and encouragement received from members of the staff of the Geology Department of the University of Tasmania while this work was being completed. Mr. M. R. Banks, in particular, has given much assistance in the preparation of the report. Acknowledgment is also made to the Bureau of Mineral Resources for permission to publish this report, and for financial assistance received in the form of a Bureau Cadetship.

PHYSIOGRAPHY

The relief of the area is considerable, and with the exception of the valley of the Derwent River, very rugged. The highest point in the area is the summit of Mt. Dromedary, which is 3,245 feet above sea level, and the minimum height, at Boyer, is only very slightly above sea level. The high nature of the hills is in part a result of the resistance of the dolerite to erosion and this has also caused most of the streams of the area to be still in the mountain tract. The drainage of the area is controlled by two main physiographic features, namely the River Derwent, and the high dolerite ridge running north-west from Mt. Dromedary. This ridge forms a divide in the drainage system, the most important stream flowing north from it being Grahams Creek. There are three main creeks flowing south from the divide into the Derwent, and these are Belmont Creek, Johnnys Creek, and Back River. The main drainage north into the Derwent is provided by the Lachlan River and Sorell Creek.

The dominant feature of the drainage of the area is, of course, the Derwent River. This is a large river and at the town of New Norfolk it is about 150 yards wide. In this area it appears to have passed through a late valley tract or early plains tract in its development, but has since been rejuvenated, and is now eroding earlier flood-plain deposits.

The topography of the area is controlled to a considerable extent by the dolerite, which forms the major portion of the hills in the north of the New Norfolk square and in the Black Hills square. The resistant nature of the dolerite causes these hills to be quite rugged, and only in the actual valley of the Derwent has the dolerite a subdued topography.

Besides the dolerite, the two most extensively occurring rocks are the sediments of the Knocklofty Formation (Triassic) and the Ferntree Formation (Permian). Both these formations have horizons which form strong positive features, usually in the form of cliffs. In the Knocklofty there is a resistant band approximately 50 feet above the base, which forms cliffs up to 30 feet high. These cliffs are particularly noticeable around the hills to the immediate east of Magra. Other parts of the Knocklofty Formation also form high cliffs, under certain conditions, and the best example of these are the cliffs along the banks of the Back River, just before it joins the Derwent. The middle parts of the Ferntree Formation also form high cliffs in some places, the highest of these being along the banks of the Derwent, particularly at The Rocks. The upper and lower parts of this formation do not have such a positive outcrop and usually occur as scree material.

Of the other Permian formations exposed in the area, only the Risdon Sandstone outcrops at all strongly and this formation commonly forms low cliffs. Outcrop of the "Woodbridge Glacial Formation", the Grange Mudstone, and the Berriedale Limestone is usually very poor.

The development of the present topography has been mainly determined by the distribution of the dolerite and by the Tertiary faulting. The area can be divided into three broad regions, namely, the high dolerite hills composing the greater part of the Black Hills square, the wide valley of the Derwent, and the high dolerite hills at the extreme south of the area. The northern region owes its height partly to the resistant nature of the dolerite, and partly to the Tertiary faulting, which has raised the northern side. The high dolerite hills in the south of the area are also partly due to the transgressive nature of the dolerite intrusion and partly to Tertiary faulting, which here has thrown the southern side up. The central region, that of the wide valley of the Derwent, is a low-lying area between the two upthrown blocks. This down-faulted block seems to have controlled the course of the Derwent to the west of New Norfolk, but this will be discussed more fully under Structural Geology.

The basalt (especially the large flow at the town of New Norfolk) may have had some effect on the course of the Derwent. This mass of basalt probably diverted the Derwent to the north, where it eroded the high cliffs at The Rocks. The original course of the river was probably through the centre of the town, as indicated by the present distribution of the river sediments. However, this would mean that at least some of the river sediments are older than the basalt, and there is no direct field evidence to support this.

STRATIGRAPHY

Permian System

Berriedale Limestone

The oldest rocks exposed in the area belong to the Berriedale Limestone, which outcrops at 902319 (Hobart Sheet). (The Army system of co-ordinates has been used, the area being covered partly by the Military one-mile Hobart map sheet and partly by the Brighton one-mile sheet.) At this locality, the section is terminated at the base by the Tertiary Glen Fern Fault, and the Berriedale Limestone, which outcrops in a small quarry, is overlain by approximately 100 feet of Grange Mudstone. Below the Berriedale Limestone there is an interval of approximately 100 feet of no outcrop, which possibly represents the Nassau Siltstone.

The thickness of the Berriedale Limestone cannot be measured at this locality due to the poor outcrop. The formation is a dense grey foetid limestone, generally slightly sandy but containing patches of pure calcite. It contains rare quartz erratics, of the order of $\frac{1}{8}$ to $\frac{1}{4}$ inch long. The most striking feature of the rock, which is a calcarenite to a calcilutite, is the very great number of fossils it contains, mostly in broken fragments. Spiriferids and fenestellids are the dominant forms. Pectens up to three inches across are present, and there are a few small ramose stenoporids. One specimen of a planispirally coiled gastropod, probably *Warthia*, was seen.

Grange Mudstone

Only the upper parts of this formation are exposed in this area, the thickest section being on a hill slope commencing at 996345 (Hobart Sheet), where there are 90 feet of it exposed between a sill-like dolerite body below, and the " Woodbridge Glacial Formation " above. The top of the Grange Mudstone is marked by very coarse, very poorly-sorted sandstone, which has been taken as the basal member of the Woodbridge. Near the base of this section, the sediment is strongly baked by the dolerite intrusion and the greenish, cherty appearance, which is characteristic of the formation at a slightly higher level, is also probably a baking effect.

Near the base of the section, the sediment is a greenish-grey to buff-coloured fine-grained mudstone, generally well sorted and containing few erratics. Fenestellids and stenoporids are very abundant and spiriferids and *Strophalosia* are present but not common. Two species of small gastropod are present, one planispirally coiled and one trochospirally coiled; neither occurs commonly. About 50 feet above the dolerite, there are still some floaters of the green, cherty-looking rock, and some of these have a large amount of a white mineral which gives the rock a spotty appearance. In thin section, this rock is seen to contain abundant sub-angular to angular quartz grains, of silt size and smaller (about 50%). Of the remainder of the rock, prehnite forms a considerable proportion, having presumably been formed under thermal metamorphic conditions at the time of the intrusion of the dolerite. Near the top of this section, the formation is slightly coarser-grained, although it is still a mudstone. The character of the fauna changes slightly in the relative abundance of the different species. *Strophalosia typica* is quite abundant, and spiriferid brachiopods are also common. Of the latter the most characteristic is a small long-hinged species, which is unidentified.

In the section described above, fossils besides spiriferids and *Strophalosia typica* are rare near the top. A very similar fauna has been seen at the top of the Grange Mudstone at two other localities, 987322 and 991327 (Hobart Sheet). At 987322 the formation is a white even-grained mudstone, containing masses of *S. typica*. There are also a few fenestellids and ramose stenoporids and an occasional pectinacean. Other brachiopods are not common. At 991327, the formation is distinctly coarser-grained, and is almost a fine sandstone. It is richly fossiliferous, the most abundant species again being *S. tyica,* but here other brachiopods are very common. Of these, the long-hinged spiriferid mentioned above is the most common, and *Terrakea* sp. is also present. The thickness exposed at these two localities is about 50 feet, but the base is covered by younger river gravels, so the total thickness of the Grange cannot be measured here.

At 902319 (Hobart Sheet), above the outcrop of Berriedale Limestone, there is a mixture of boulders of Berriedale Limestone and Grange Mudstone and it is difficult to tell exactly how thick the latter is in this section. It has been estimated at approximately 100 feet.

" Woodbridge Glacial Formation "

This formation consists of a series of fine, medium and coarse grained sandstones, totalling about 270 feet, characterised by a large number of erratics. It underlies the Risdon Sandstone and overlies the Grange Mudstone. The composition of the formation is dominantly quartz, but in some of the more poorly-sorted, coarser bands, there are appreciable amounts of feldspar. The erratics play a major role in the composition of the rock, and they have a very wide range of size, from particles of medium sand size up to small boulders a foot or more in diameter. They are mostly quartz and quartizite, but erratics of schist, slate and phyllite are also quite common and there are rare granite pebbles. The colour is generally cream or buff, but in some cases it is pale-grey. The bedding is almost exclusively thick, but it does not outcrop strongly and for the most part the distribution of this formation must be interpreted from the distribution of float material.

Some horizons in the " Woodbridge Glacial Formation " are extremely fossiliferous, but the major part of its thickness is quite barren. The base is usually very fossiliferous, the best exposure of this horizon being opposite the Boyer factory, just south of the Lyell Highway, at 990327 (Hobart Sheet). Here were found pectinaceans (about two inches across), *Strophalosia typica,* various spiriferids (including *Grantonia* and *Neospirifer*) in large numbers, some small trochospirally coiled gastropods, and a few fenestellids and ramose stenoporids. The basal 50 feet of this locality are very fossiliferous, with very little change in the fauna from that described from the base. One addition to the assemblage at a higher level is *Dielasma*. Above the 50-ft. level, fossils become very rare, with only scattered fenestellids and spiriferids persisting for another 20 feet. The fauna at the base of the " Woodbridge Glacial Formation " occurs in a very coarse, very poortly sorted, whitish sandstone. It contains quartz and slate erratics up to one inch long, and these vary from angular to sub-rounded. The matrix consists dominantly of sub-angular quartz fragments with minor amounts of angular feldspar fragments. In some specimens (28156, U.T.G.D.) there is practically no finer material, but in other specimens, the amount of very fine-grained material (silt size and smaller) becomes quite large, and in specimen 28161, the whole matrix is fine grained. There is a wide range of sizes in the erratic fragments, which grade up from coarse sand size to pebbles an inch long. They are mainly quartz, but a few slate fragments are also present in most specimens. The fine-grained parts of the rock occur in small lenses, and are sometimes slightly better sorted.

Proceeding up the section opposite Boyer, the formation remains a coarse, poorly-sorted sandstone, but about 40 feet above the base, bands of slightly finer-grained sandstone begin to alternate with the coarse sandstone. The erratics also become a little more varied in composition with some schist and granite pebbles up to three inches long. In this section, the basal member is approximately 40 feet thick and is overlain by a medium to coarse grained, poorly-sorted sandstone (although better sorted than the basal member), which contains numerous erratics up to ¼-inch long, and rare erratics up to an inch long. This member contains a few fenestellids and spiriferids in the lower 20 feet. The member is about 30 feet thick in this section, although this is only an estimate based on the distribution of float material.

The base of the " Woodbridge Glacial Formation " is well exposed in a section behind the Boyer factory at 987343 (Hobart Sheet). Here it has a very similar lithology to that described above, and contains numerous fossils, including pectinaceans and brachiopods. Amongst the latter there are some which are of the " martiniopsid " type and a very long-hinged spiriferid. At this locality the fossils are almost entirely confined to the bottom 15 feet and above this level the formation becomes slightly finer-grained and contains fewer erratics. The coarse sandstone in this section is about 80 feet thick (this includes both the coarse sandstone members described in the previous section).

In the Boyer section the basal coarse sandstone is overlain by a fine-grained, greyish sandstone, containing many small erratics about ⅛-inch long, and a few up to one inch long. This fine sandstone member forms a important part of the formation, and in the Boyer section it is approximately 110 feet thick. A quarry in this sandstone has provided good exposure at 982339 (Hobart Sheet). Here the member is a massively-bedded, fine-grained sandstone, buff to pinkish in colour. There are fairly large numbers of erratics, and these are nearly all in the size range ⅛ to ½ inch, although there are a few up to three inches long . This member is completely unfossiliferous.

Above the grey fine-grained sandstone member there is another coarse sandstone, which is poorly sorted and richly fossiliferous. It is a dominantly quartzitic sandstone, but contains small amounts of feldspar and argillaceous material. The particles in the matrix are mainly in the medium sand size range and are sub-angular to sub-rounded. The erratics, which are nearly all quartz or quartzite (apart from a few slate fragments), vary greatly in shape, size and roundness. This member is 70 feet thick in the section behind Boyer, where the base of the outcrop is at 979339 (Hobart Sheet). It is very fossiliferous, with a dominantly molluscan fauna. Large pectinaceans occur frequently and *Stutchburia* is a characteristic genus. Rare " martiniopsid "-type brachiopods have also been found. The lack of outcrop of this member is often accentuated by the presence of large amounts of scree material from the overlying Ferntree Formation and, as a result, it has only been examined at a small number of localities. Large amounts of float occur at 999452 (Brighton Sheet) and here there are numerous fossils, including *Stutchburia, Warthia,* a small species of *Myonia* and various spiriferids.

The topmost member of the " Woodbridge Glacial Formation " is a band, about 20 feet thick, of fine-grained sandstone or mudstone (the lithology varies slightly at different localities). In the section behind Boyer, this member is a pale-brown mudstone, mainly well-sorted, but containing an occasional erratic from one to two inches long. This member is also extremely fossiliferous, the two most characteristic species being *Strophalosia ovalis* and *Terrakea solida* (N. G. Lane, pers. comm.). These occur in great numbers, generally preserved as internal and external moulds. Many other species occur in this member, including spiriferids (rare), *Protoretepora ampla* and other fenestellids, and a small trochospirally coiled gastropod (also rare).

This member does not have a strong outcrop, as it is easily weathered, and is often covered by scree from the Ferntree Formation.

The total thickness of the Woodbridge in the section behind Boyer is approximately 290 feet .

Well exposed sections of the " Woodbridge Glacial Formation " are not common, but two sections, apart from the ones described above, have been measured. The first of these is exposed on a steep hill slope along the north bank of Mount Rivulet at 998313 (Hobart Sheet). At the base of the section here, there is a sill-like dolerite intrusion into Grange Mudstone. Overlying the baked Grange, is a coarse, poorly-sorted sandstone containing numerous brachiopods, which has been taken as the basal member of the " Woodbridge Glacial Formation ". Fenestellids, stenoporids and pectinaceans also occur, slightly above the base. This member grades up into a medium to fine grained sandstone which is poorly sorted and contains an appreciable amount of clayey material. It is buff-coloured and erratics are large but not numerous. The boundary between these two sandstones is not exposed. Above the fine-grained sandstone is another coarse-grained sandstone, which is whitish and contains many erratics which are mostly less than ¼-inch long. This member is probably equivalent to the upper coarse sandstone member in the Boyer section, but no fossils were found in this locality. In this Mount Rivulet section there is no outcrop of the top member but several large boulders of mudstone containing *Strophalosia* were found. The top of the formation was found only by means of the strongly outcropping Risdon Sandstone which directly overlies the top of the Woodbridge, and the total thickness of the latter formation in this section is approximately 300 feet.

The other complete section of the " Woodbridge Glacial Formation " is a road section just south of the town of New Norfolk, commencing at 958313 (Hobart Sheet). This section has practically continuous outcrop from the base of the " Woodbridge Glacial Formation " through to about 100 feet above the base of the Ferntree Formation. The lowest rock is a creamy-white sandstone, coarse-grained and very poorly sorted. Angular quartz fragments up to ⅛-inch long are quite common and the size of the particles making up the matrix grades down to mudstone size. Small amounts of feldspar are present as angular fragments. Spiriferid brachiopods are present in small numbers but no other fossils were seen. The erratics at this level rarely exceed ¼-inch in length and there are only a few as long as this. They are sub-rounded quartz pebbles. The base of the formation is not exposed but it is thought that the lowest exposure is very close to the base, probably within ten feet of it. This basal member is approximately 24 feet thick and is for the most part of the same lithology, although there are some bands which are slightly finer-grained.

The basal member grades up into fine-grained, buff-coloured sandstone, which is moderately well sorted, although there are scattered erratics of smaller dimensions (about ⅛-inch long). The boundary between these two members is gradational, with alternating bands of coarse and fine sandstone, so the thickness of them has been fixed somewhat arbitrarily. The fine-grained member has a fairly constant lithology, but it contains some coarser patches, in which the erratics become slightly larger. The thickness of this member is about 56 feet, but as both the top and the bottom are gradational, this thickness is of necessity, only approximate.

Overlying the fine-grained sandstone member is a thick succession (about 160 feet) of coarse, poorly-sorted sandstone alternating with a fine to medium grained sandstone that becomes fairly well sorted in places. The base of this member has been taken as a three-ft. band of coarse, poorly-sorted sandstone containing dominantly quartz particles 1/16 to ⅛ inch across, set in a matrix of quartz fragments of medium sand size. The matrix also contains small amounts of angular feldspar grains. Erratics are numerous in this member but the number and size varies considerably. Some bands become very coarse-grained, due to an increase in the number of erratics, while other bands, which contain fewer erratics, appear relatively fine-grained and moderately well-sorted. The erratics are mostly quartz and quartzite but there are also a few slate and schist pebbles and rare granite pebbles. There is a wide range of size amongst the erratics, which vary from less than ⅛-inch up to small boulders several inches long. Fossils are rare in this member, the only ones found being two specimens of a planispirally coiled gastropod, which may be *Warthia*, right at the top.

The topmost member in the section is a fine-grained, creamy-white sandstone, which is well sorted and contains only rare erratics. This sandstone contains a small number of *Strophalosia* and a few ramose stenoporids.

This section was measured with an Abney hand level, and the thicknesses have been corrected for the 5° W. dip of the beds, which strike at 200°. The total thickness of "Woodbridge Glacial Formation" exposed in this section is 260 feet. This is in good accord with the thickness of 270 feet recorded at Mt. Nassau (Banks and Hale, 1957). The difference is probably due to the fact that this section is not quite complete at the base.

There appears to have been a marked increase in the intensity of glaciation at the beginning of the deposition of this formation, indicated by the large number of erratics it contains near the base. Erratics become fewer and smaller toward the top of the formation, possibly indicating a gradual decrease in the severity of the glacial conditions.

Risdon Sandstone

This formation is a coarse, usually well sorted sandstone about 20 feet thick, which lies immediately above the "Woodbridge Glacial Formation" and below the Ferntree Formation. It is relatively very resistant to erosion and has a strong, positive outcrop. Quartz is the most abundant mineral in its composition, but fairly large amounts of feldspar are also present. The colour varies from brown to buff, due to iron staining, but becomes white in strongly weathered specimens.

The matrix of the rock is composed of coarse sand-size, sub-angular to sub-rounded quartz fragments, with smaller amounts of angular to sub-angular milky-white feldspar fragments. Set in this matrix are variable amounts of quartz pebbles ranging in length from ⅛-inch to three inches and mostly sub-rounded or rounded. These pebbles are mainly an opaque-white quartzite and on weathered surfaces they stand out strongly against the dark matrix. The pebbles are often concentrated in small lenses, especially near the base of the formation. Scattered mica flakes were seen in some specimens. Current bedding was observed at only one locality.

The thickness of the formation has not been determined accurately because of lack of suitable exposure in the area. On the sides of hills, where the Risdon Sandstone often outcrops well, it may be exposed for a thickness of ten feet, but the underlying and overlying beds are in all cases covered with scree material. The best exposure for a measurement of thickness is in a road section behind the Boyer factory at 980341 (Hobart Sheet). Here the top can be found accurately, but the base is indistinct. The thickness in this section is approximately 20 feet.

A thin section has been cut from a specimen which is a coarse, moderately well-sorted sandstone with a red colour, containing coarser, conglomeratic patches with quartz and quartzite pebbles up to an inch long. In the hand specimen the composition appears to be mainly of quartz, with small amounts of feldspar.

In thin section, this rock is seen to be composed almost entirely of angular to sub-angular quartz fragments, ranging in size from about ⅛-mm. long up to about 1 mm. long. The majority of the fragments are in the ½-mm. to ¼-mm. range. About 5% of the rock is composed of angular feldspar fragments, and there are some sub-rounded slate and schist particles up to ½-mm. long. There is no fine-grained matrix, and the grains are held together by a haematitic cement, which imparts a reddish colour to the rock.

The current bedding and the conglomerate lenses in this formation lead to the conclusion that it is a very shallow water, near shore deposit, possibly shoreline in part. However, the scarcity of erratics in the upper part of the underlying "Woodbridge Glacial Formation" is thought to indicate a retreat of glaciation, which would probably be accompanied by a rise in sea level. It is difficult to reconcile the shallow water aspect of the Risdon Sandstone with this probable rise in sea level and it seems that the only explanation of this problem is to invoke a slight tectonic uplift of the area immediately prior to the deposition of the Risdon Sandstone.

Conditions appear to have been very stable during the deposition of this formation, since the bedding is very thick, and in some exposures the whole sequence is homogeneous, without any bedding break.

Ferntree Formation

In this area the Ferntree Formation is approximately 600 feet thick and occupies a stratigraphic position between the Risdon Sandstone below, and the Triassic System above. The Cygnet Coal Measures do not occur in this area. Lithologically, the formation consists of siltstones and fine-grained sandstones which are composed dominantly of quartz with small, variable amounts of argillaceous material. The colour of the formation is variable, and can be white, light-grey, cream or buff. In the higher beds, the formation has a mottled appearance, with grey and creamy-brown patches, these different coloured patches often being associated with materials of different grain size. The number and size of erratics is also very variable. In the lower beds, small erratics of the order of 1/16 to ⅛ inch long are numerous, with rare erratics one inch long. In the higher beds the number of erratics increases considerably and, although there are some bands that contain practically no erratic material, other bands contain a considerable amount, with the erratics ranging in size from less than ⅛-inch up to several inches.

The bedding in the Ferntree Formation is mainly thick, but some bands have a much finer bedding, with some quite shaley bands.

The fauna of this formation is very sparse, and fossils have been found at only three localities. At 980349 (Hobart Sheet) a few moulds of brachiopods have been found, of which one appears to be a "martiniopsid". This locality is the only one where the stratigraphic position of the fossils is known, and here they occur about 350 feet above the base of the Ferntree. At 928329 (Hobart Sheet), a few spiriferids and pelecypods were found as internal and external moulds.

The third locality, where a relatively rich fauna was found is by the water tanks, just to the west of New Norfolk, at 944327 (Hobart Sheet). Most of the fossils were found in the float material from the excavation of the tanks. Several species of brachiopod were found, including one with a very long hingeline. Several pelecypods were also found, including one similar in appearance to *Myonia*. One specimen contains a number of individuals of *Hyolithes*.

The best section through the Ferntree Formation was found in a road section behind the Boyer factory, commencing at 980341 (Hobart Sheet). Here there are about 500 feet of continuous outcrop from the base up, but the top 100 feet are not exposed.

At the base, overlying the Risdon Sandstone, is a pale-grey, fine-grained mudstone, which is white on weathered surfaces, with a thickness of approximately 175 feet. This member will be referred to as member "A". The bedding is generally thick, with beds two to three feet thick, but some bands have a slightly shaley bedding. The beds have an uneven fracture roughly parallel to the bedding, which causes the rock to break into large flakes when hit. The rock is composed mainly of quartz particles, and in the hand specimen it appears to be a fine-grained sandstone. Erratics, almost exclusively of quartz, are fairly common, although they rarely exceed 1 mm. in length. There are, however, rare large erratics about two inches long, and also scattered mica flakes in this member. The beds dip 5° S. and strike at 270°. In thin section, it is seen that 15-20% of the rock is composed of angular quartz fragments, 1/16 mm. to ¼ mm. long, with some scattered feldspar fragments up to ¼ mm. long. There are also a few smaller, silt-size quartz fragments. This material is set in a very fine-grained matrix, whose composition is indeterminate, although it certainly contains considerable amounts of mica, presumably authigenic.

The next member, Member "B", is 85 feet thick and consists of massively-bedded, medium-grained, poorly-sorted sandstone. It is white in colour, and weathers to a pale cream. In the hand specimen, the major part of the rock appears to be material of medium to coarse sand size, with some fragments up to ½-inch long. Quartz and slate are the most common rock types among the erratics, which are very numerous. In thin section the rock is an apparently unorganized jumble of mineral fragments (mostly quartz, but with appreciable amounts of feldspar), and some rock fragments, set in a fine-grained siliceous matrix. The majority of the fragments are of the order of ¼-mm. long, but they range in size between 3 mm. and ⅛-mm. The quartz fragments are very irregular in outline, generally angular and with a low sphericity. The feldspar fragments are generally slightly more regular, having broken along cleavage planes, but these also are angular. Not many rock fragments are present, but those that are have elongated outline, are sub-rounded, and are up to ½-mm. long. They are fine-grained micaceous slate, and the shape of the fragments is apparently strongly controlled by the schistosity planes. The matrix, which comprises about 30% of the rock, consists of silt-sized particles, ranging in size up to the finest sand grade. The majority of these particles are quartz.

Member "C" comprises 20 feet of shaley mudstone. In the hand specimen it appears to be fine grained and moderately well sorted, with very few erratics. The colour of fresh surfaces is cream to grey, but weathered surfaces are brown. Some faint impressions are preserved in this member and it is thought that they may be the remains of plant stems. In thin section, about 60% of the rock is seen to be composed of a fine, fairly even-grained mudstone, dominantly quartzitic, but containing appreciable amounts of mica, which is presumed to be authigenic. The remainder of the rock is made up of very coarse patches, containing angular fragments ranging from $\frac{1}{8}$ mm. to 2 mm. long, although the majority are about $\frac{1}{4}$ mm. long. There are also a few sub-rounded elongated fragments of a fine micaceous slate or schist. These larger particles are mostly concentrated into small lenses.

Above this member comes 40 feet of greyish mudstone, with a slightly shaley bedding, which has been called Member "D". This member, in the hand specimen, appears to be moderately well sorted, with practically no erratics and seems to contain a moderate amount of argillaceous material. Towards the top it becomes massively bedded, and slightly coarser-grained. The number and size of the erratics also increases, and there are small patches that are slightly iron-stained. A thin section from near the base (Spec. 7594) is a fine-grained, well-sorted mudstone, dominantly siliceous, but containing small amounts of authigenic mica in the matrix. Very few of the fragments are more than $\frac{1}{8}$ mm. long and most of them are less than 1/16 mm. long, and are hence in the silt range of size. The fine-grained, indeterminate matrix makes up about 50% of the rock. A thin section from near the top of the member (Spec. 7596) differs mainly in having a greater proportion of coarser material with the matrix comprising only about 30% of the rock.

Member "E", which is about 30 feet thick, is slightly gradational with Member "D". It is a poorly-sorted, fine-grained sandstone, containing numerous erratics of coarse sand size, and some of larger size. The member is massively bedded, with beds three to four feet thick. In parts it is extremely hard and breaks with a conchoidal fracture. The colour is very variable, ranging from grey and buff to pink. A few poor fossils were found in this member fairly close to the base; they are internal moulds and casts of spiriferid brachiopods.

The topmost member in the formation, Member "F", is a medium to coarse grained sandstone, very poorly sorted and varying in colour from a creamy-brown to a medium-grey. It often has a characteristic blotchy appearance, with patches of grey and brown, the different colours being associated with material of different grain size. The bedding is massive and the outcrop is quite strong for the lowermost 50 feet, but the top part of the member does not outcrop, apart from varying amounts of float material. It probably extends through to the base of the Triassic System, which would make the thickness about 150 feet. Near the base of this member, the rock is a medium-grained, very poorly-sorted sandstone, mainly gray in colour. Quartz is dominant in the composition, both in the erratic material and in the matrix, but small amounts of feldspar are present in the matrix, and some of the coarser fragments, which are up to $\frac{1}{2}$-inch long, are slate. Some doubtful organic remains were found near the base of this member (Spec. 7597). A thin section from near the base (Spec. 7597) has about 60% angular quartz fragments $\frac{1}{8}$-mm. to $\frac{1}{4}$-mm. long. There are also a few scattered feldspar fragments. The remainder of the slide is composed of fine-grained (coarser silt sizes) quartzitic matrix, the distribution of which is variable. In some parts of the slide, there is practically no matrix, and the larger particles are packed together so that these areas have the appearance of a well-sorted sandstone. In other parts of the slide, the matrix is dominant, and contains only a few coarse fragments. The rock has been classed as a medium-grained sandstone. Higher in the member, there are cleaner bands, and also some finer-grained bands, but, on the whole, it remains a medium-grained, poorly-sorted sandstone. Mica flakes are quite common at some levels and there are rare larger erratics up to two inches long.

Unfortunately, the topmost 100 feet of the Ferntree never have a strong outcrop in this area and it has not been possible to measure this part of the formation with any accuracy. Scree material lithologically similar to Member "F" of the Boyer section, has been found in several places, but often the upper part of the Ferntree is covered by scree material from the overlying Knocklofty Formation. At 968499 (Brighton Sheet), there is a considerable amount of scree material, consisting of a grey, fine to medium grained blotchy sandstone similar in appearance to Member "F". It appears to be about 160 feet thick, and float material ocurs to within 30 feet of the Triassic. Worm casts are common in this rock.

At 964407 (Brighton Sheet), on the Black Hills road, there is a band about two feet thick, which is a fine-grained mudstone, very poorly sorted, soft, and slightly friable. It contains numerous quartz erratics up to $\frac{1}{4}$-inch long, which are sub-angular to sub-rounded. This band seems to reflect more strongly glacial conditions than other parts of the upper Ferntree Formation, and probably represents a minor re-advance in glaciation. Its stratigraphic position is approximately 100 feet below the top of the Ferntree. There is practically no outcrop between this band and the Triassic, but just below the base of the Triassic (which does not outcrop—the base has been estimated on the basis of float distribution), there is a band about six feet thick of fine-grained, yellow-brown, friable sandstone. This is thought to be very close to the top of the formation. It contains very rare erratics.

At 914336 (Hobart Sheet), a thin band of coarse, poorly-sorted sandstone outcrops. This is similar to the Risdon Sandstone in its lithology, and its mode of outcrop is also very similar. It can be traced around the side of a hill for about half a mile. A small outcrop of a lithologically similar rock has been seen at 970348 (Hobart Sheet), but here it does not outcrop in a band as in the first-mentioned case. The stratigraphic position of the former outcrop is not known, but it is probably the same as that of the latter outcrop, which occurs about 200 feet below the top of the Ferntree. A thin section from this outcrop shows about 80% of angular to sub-angular quartz and feldspar fragments from $\frac{1}{4}$-mm. to $\frac{1}{2}$-mm. across, set in a very-fine-grained quartzitic matrix, which contains appreciable amounts of authigenic mica. Most of the coarse fragments are quartz, of which the majority are clear and colourless, but some are cloudy with inclusions; others are strongly shattered, and some have a wavy extinction, indicating that at least part of the material in this rock was derived from a metamorphic terrain. About a tenth of the coarse fragments are plagioclase, which is usually clear and colourless. Some of the fragments have an almost complete crystal outline. There are a few scattered mica flakes and some sub-rounded slate and schist fragments up to 1 mm. long.

This band appears to have been deposited quickly, without much water transport, as indicated by the large amount of feldspar present and the angular nature of the particles. It is very similar to the Risdon Sandstone in hand specimen, but seems to be less well-sorted. In thin section it differs from the Risdon mainly in the presence of the fine-grained matrix. Similar sandstone bands from the Ferntree have been reported by Fairbridge (1949) and Ford (1956), but the bands described by these authors are less than 150 feet above the base of the formation.

Finally, a note with regard to the name of this formation. Up to the present, the name Ferntree Mudstone has been widely used, but in this area at least, the formation contains considerable amounts of sandstone, and in accord with Section 3, paragraph 14 (*a*), of the Australian Code of Stratigraphic Nomenclature, it is suggested that it be renamed Ferntree Formation.

Triassic System

In the area under discussion, it has been found impractical to divide the Triassic sediments into Knocklofty Sandstone and Shale, and Springs Sandstone, since characters of both these formations are present. These sediments have been mapped as a single unit, which is called here the Knocklofty Formation.

This formation overlies the Ferntree Formation of the Permian System with a probable slight disconformity, evidence for which is inconclusive. Firstly, the presence of basal grits in some localities indicates some break in deposition. Secondly, in Specimen 7572, from 962374 (Brighton Sheet), there are scattered flakes of a soft mudstone, which could be Permian sediment, and, if this is the case, a disconformity is certainly indicated. Thirdly, dips at the base of the Knocklofty Formation appear to be slightly different from those at the top of the Ferntree Formation, although the smallest stratigraphic interval at which measurements have been made is 70 feet.

The basal grit, or granule conglomerate, appears to form a thin, discontinuous band at the base of the Knocklofty Formation, but this never outcrops, and its distribution and thickness must be estimated in all cases from concentrations of boulders. This rock consists mainly of angular to sub-rounded quartz fragments which range from medium sand size up to granules $\frac{1}{8}$-inch across. Feldspar varies from about 5% to 15% of the composition, mainly as angular particles. There is practically no fine-grained matrix, but some specimens are a reddish colour, due to the presence of small quantities of ferruginous cement. Small disc-shaped cavities in the rock probably represent weathered mud pellets.

Apart from the basal granule conglomerate, the lithology of the Knocklofty Formation is exceedingly uniform. It is mainly a medium to coarse-grained sandstone, usually well sorted and consisting almost entirely of sub-angular to rounded quartz fragments. There are very small amounts of feldspar in some specimens and occasional mica flakes have also been seen. Graphite flakes are common near the base. Fine-grained matrix is practically non-existent in most cases.

Interbedded with the sandstone are thin beds of very fissile shale. This is very easily weathered and is seldom seen, solid outcrop having been observed at only two localities. The best of these is at 918348 (Hobart Sheet), in a road cutting on the Lyell Highway, near a water pumping station. Here there are shale beds up to a foot thick and the rock is a fine-grained, well-sorted mudstone, composed dominantly of quartz but also containing considerable amounts of mica, which give it a strong sheen. It is a pale-greenish colour.

Lack of any distinctive marker beds in the Knocklofty Formation makes stratigraphic work on this formation practically impossible. The nearest approach to marker beds are two horizons at which mud pellets and charcoal fragments occur. The mud pellets have been found in several specimens, but all quite close to 935307 (Hobart Sheet). The actual mud pellets have weathered out, leaving a disc-shaped cavity about an inch in diameter and $\frac{1}{8}$-inch thick. The stratigraphic position of these pellets is not known. The charcoal fragments have been seen at only one locality, 912432 (Brighton Sheet), and all the ones seen occurred in a single large boulder; they are all between $\frac{1}{4}$-inch and $\frac{1}{2}$-inch long. The stratigraphic position of these fragments is not known, either, since they occur only a few feet above a sill-like dolerite intrusion. They are probably plant remains that were carbonised at the time of the dolerite intrusion.

The total thickness of the Knocklofty Formation is not known, but it is certainly over 1,000 feet. The formation caps the hill rising behind the Boyer factory, and the thickness exposed here (incomplete) is approximately 1,100 feet. There is also a considerable thickness exposed along the old Black Hills road, where the Knocklofty overlies the Ferntree, and is overlain by dolerite. The thickness of this section, also incomplete, is just over 1,000 feet.

" Feldspathic Sandstone "

One small outcrop of this formation has been found. It is a block about one mile long and a quarter of a mile wide, which is bounded on the north and north-east by the Tertiary Magra Fault, and on the west by a fault of probable Jurassic age. The southern boundary is formed by an approximately concordant dolerite body which overlies the sandstone. This block is completely isolated from other Triassic sediments, but it is assumed to be younger than the Knocklofty Formation, due to its lithological similarities to the " Feldspathic Sandstone ", which occur above the Knocklofty Formation in other parts of Tasmania.

The rock consists mainly of sub-rounded to sub-angular quartz fragments of medium to coarse sand size, with about 15-20% of milky-white feldspar fragments. There is also some dark-greenish black mineral, probably ferromagnesian, which gives the rock an overall greenish tinge. There is very little fine-grained matrix, and the rock is very friable and easily weathered.

Jurassic (?) System

Dolerite

The age of the dolerite is not known, but evidence from other parts of Tasmania suggests that it is probably Jurassic. The form of the intrusions will be discussed under Structural Geology.

The dolerite is mainly a dark-grey, medium-grained rock, composed of pyroxene (augite, pigeonite, and hypersthene), and plagioclase, with minor accessory minerals. The plagioclase laths are commonly zoned from oligoclase at the edge, to labradorite in the centre. Local variations are present in the dolerite, and the most common is the fine-grained, chilled dolerite at the contacts with sediments. Very coarse phases have been seen at a few localities.

Tertiary System

Basalt

There are three separate masses, all close to the town of New Norfolk, and all probably small flows. The smallest body, occupying an area of roughly a quarter of a mile, is centred at 910340 (Hobart Sheet) and overlies the Knocklofty Formation. This basalt borders a small Tertiary fault, and is close to the larger Lawitta Fault, also of Tertiary age.

The second body occurs on the Lyell Highway just east of Millbrook Rise, and has a maximum exposed thickness of 30 feet. This may have originally been part of the large flow which occurs within the town of New Norfolk. The best exposure of the main body is at 956333 (Hobart Sheet) in the banks of the Lachlan River, where it forms cliffs about 30 feet high. The most remarkable feature here is the columnar jointing. The columns, which are of the order of three to six inches across, dip at various angles, and in one place form a syncline-like structure.

In the hand specimen, the basalt is a dense, very-fine-grained rock, containing amygdales often filled with calcite, and nodules of olivine up to an inch across. In thin section it is seen to be an alkali basalt of the basanite group, and contains large amounts of iddingsite. A more detailed investigation of the basalts in the Derwent Valley has been made by McDougall (1959A).

In all cases the basalts occur near the intersection of two Tertiary faults, and some relation, tectonic if not temporal, is indicated. The age of the basalts is not known accurately. They overlie Triassic sediments, and underly river sediments of unknown age. They are apparently later than the Tertiary faulting.

Quaternary System

Pleistocene (?) Series

Extensive gravels and sands occurring along the valley of the Derwent River have been given a Pleistocene age by Lewis and Murray (1935) and Lewis (1945), who have correlated them with different phases of the Pleistocene glaciation. However, this age is not substantiated by any fossil evidence and is open to some doubt. The question of the age of the deposits will be discussed more fully later.

The best outcrops of these deposits are at Millbrook Rise (970329 and 980327, Hobart Sheet), New Norfolk (957336, Hobart Sheet), the new Lachlan Park Hospital (957327, Hobart Sheet), and Boyer (969,337, Hobart Sheet).

At Millbrook Rise the sediment is a gravel which rests on a basalt surface and contains pebbles of a very wide range in size, varying from sand-size particles up to small boulders six inches across. The pebbles and larger blocks are mostly of Permian sediments, and these are mostly angular to sub-rounded, with a low sphericity. There are also numerous dolerite boulders, which are well rounded and have a high sphericity, and some basalt pebbles, mainly sub-angular. Some well-rounded quartz pebbles are presumably second or later cycle material, having weathered from the Permian sediments. This deposit shows rudimentary bedding, with coarser, very pebbly bands alternating with finer bands containing only a few pebbles.

The deposit at Boyer is also mainly gravel, with pebbles almost entirely of Permian sediment. There are no dolerite or basalt pebbles, but there are a few second cycle quartz pebbles weathered from the Permian sediments. The pebbles in this deposit are angular to sub-angular, and do not appear to have been transported for any great distance. They are often tabular or discoid in shape, so that there is a pronounced preferred orientation parallel to the rudimentary bedding. The pebbles in the lower part of this exposure are rarely more than two inches long, but in the higher parts of the exposure they reach a length of six inches quite commonly. The pebbles are set in a matrix of fine sand and silt-size particles, which comprises about 40-50% of the deposit. The whole deposit is quite friable.

There are bands and lenses of the order of two to three inches thick in this deposit, which vary in pebble content. Some of these contain very few pebbles, and others contain very little fine-grained material. Besides these small lenses, there is one very large lens which contains practically no pebbles. This is a fine to medium grained sand, almost entirely quartz, well sorted and moderately lithified, although still quite friable. It is medium brown in colour. In the road cutting, this band is about 20 yards long, and about five feet thick at its thickest part, but a similar lens occurs at a slightly lower level, in a different part of the cutting, and it is possible that the two are continuous. The thickness of the sandy lens is extremely variable, and at one place it changes from five feet to six inches, within a horizontal distance of about two yards and then thickens again to four feet in a similar distance. All the irregularity is at the top of this band, the bottom being quite regular, and almost horizontal. It appears that after the deposition of the sandy layer, strong current action eroded channels in it, and that these channels were later filled with coarse gravel. This suggests that the deposits are fluviatile rather than lacustrine.

In the road cutting at New Norfolk, the deposits are a medium to coarse sand, and have some signs of bedding. In the excavations for the new Lachlan Park hospital, the deposit is similar, although it cannot be seen whether or not this deposit is bedded. The average grain size of the sand here varies slightly between outcrops, and in some it becomes quite coarse, composed dominantly of sub-rounded to rounded quartz fragments. In some parts the average grain size is rather small, with a considerable amount (40-50%) of argillaceous matrix, and sub-rounded quartz fragments. Small plant stems, about ¼-inch in diameter and an inch long, were found in an upright position in one of the finer patches, and portion of a silicified tree trunk, about three feet long and a foot thick was found in a horiznotal position in one of the coarser patches.

The extent of the river sediments it difficult to determine, since, towards the margins of the valley, they are covered by scree from the hills, and the extent in the direction of the river is also obscured by younger deposits. The most extensive area of the deposits is in the region immediately to the east of New Norfolk, where they have a north-south extent of about 1,500 yards as they run up into the valley of the Lachlan River, and an east-west extent of nearly 4,000 yards, decreasing to a thin band along the present river banks.

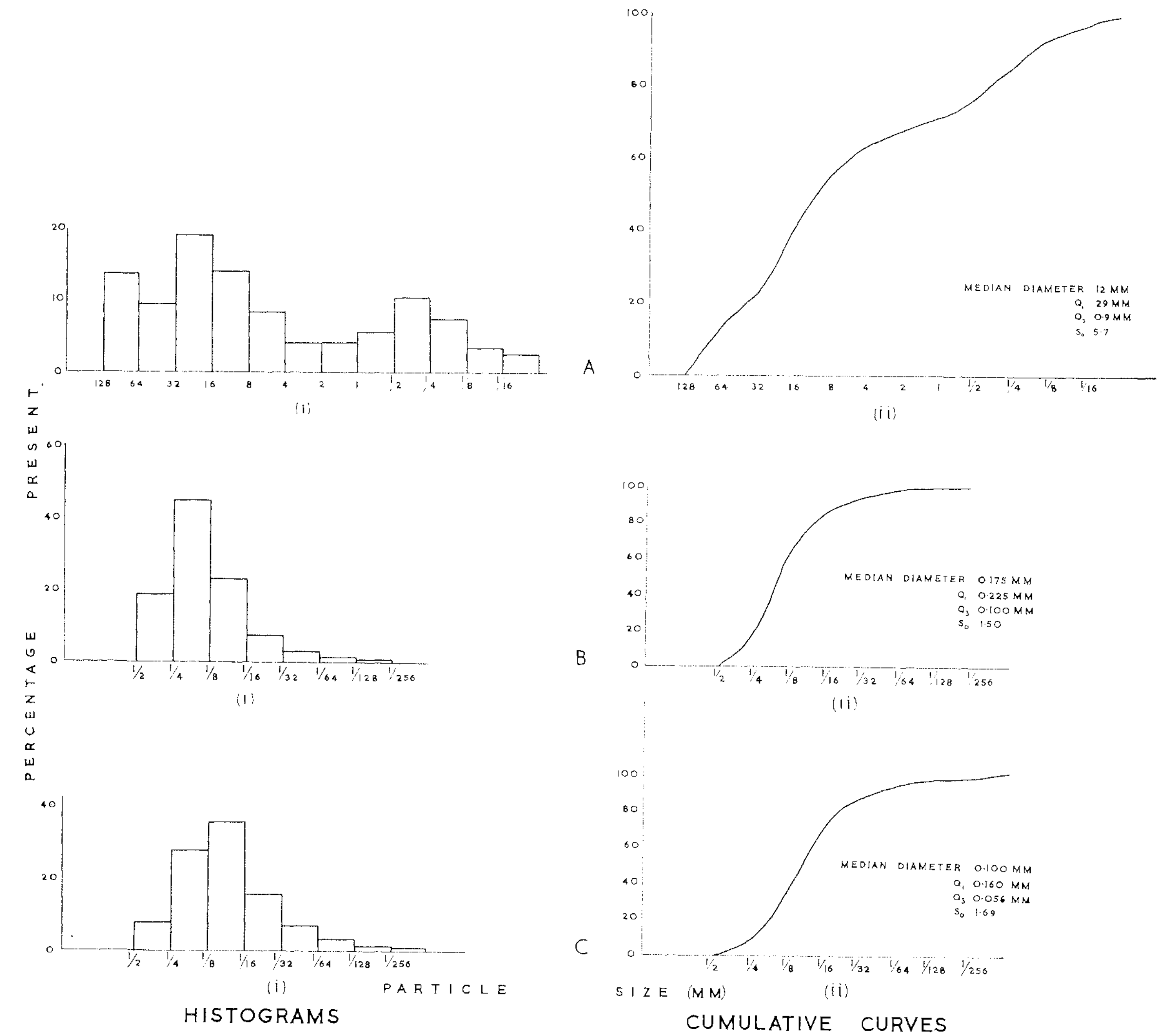


FIG. I

The deposits are also quite extensive on the north side of the river, to the west of Boyer, where the east-west extent is 2,000 yards, with a maximum width of 1,000 yards.

Three mechanical analyses were carried out on these sediments. One sample of the gravel, from the exposure half a mile east of Millbrook Rise (977328, Hobart Sheet), was analysed and two sand specimens, from:—

(*a*) approximately one mile west of Boyer, in the road cutting where the road passes under the railway line, at 969337 (Hobart Sheet). The specimen was taken from near the base of a sand lens about four feet thick;

(*b*) the road cutting just outside the town of New Norfolk, on the Hobart side, at 956336 (Hobart Sheet).

These results are shown graphically as histograms and cumulative curves in the accompanying diagrams (Fig. 1). Consider first the histogram of the gravel specimen (Fig. 1A). There are a large number of grades represented, showing that the sediment is poorly sorted. The histogram has a bimodal aspect, with high concentrations in the -32 $+16$ mm. and $-\frac{1}{2}$ $+\frac{1}{4}$ mm. ranges. These features of poor sorting and bimodality are characteristic of fluviatile conglomerate deposits (Pettijohn, 1949).

The histograms and cumulative curves for both the sand specimens are similar in appearance, with a high concentration in the finer sand sizes and a gradual decrease down through silt sizes. Neither specimen has appreciable amounts of very fine-grained material; the New Norfolk specimen (Fig. 1B) has only a negligible amount finer than 1/256 mm., and the Boyer specimen (Fig. 1C) has only 1% less than 1/256 mm. The main difference between the two sands is that the Boyer specimen is slightly finer. This is shown mainly by the different position of the mode, which, in the Boyer specimen, falls in the $-1/8+1/16$ mm. grade. The finer character of the Boyer sand is also shown by the smaller amount of material in the $-\frac{1}{2}+\frac{1}{4}$ mm. and $-\frac{1}{4}+\frac{1}{8}$ mm. grades and the relatively larger amount of material in the silt grades. The degree of difference is shown by the median diameters (see Fig. 1).

By the nature of the field occurrence, with channel cut-and-fill structure, it is thought that the Boyer sand is a fluviatile deposit, and from the very similar nature of the mechanical analyses of the two sand specimens, it is thought that the New Norfolk specimen is also a fluviatile rather than a lacustrine deposit. The large number of grades represented in these sands also suggests a fluviatile origin, since Pettijohn (1949) states that fluvial sands normally have six or seven grades present.

The age of the river sediments has already been mentioned as being Pleistocene, according to Lewis, who states that they are younger than the basalt. He correlates them with different phases of the Pleistocene glaciation in Tasmania. From the field evidence, they certainly do appear to be younger than the basalt, and it is quite certain that some of them, at least, are post-basaltic, since gravels can be seen to lie directly on basalt in the exposure just east of Millbrook Rise. At the site of the new buildings of the Lachlan Park Hospital, outcrop of the river sediments has been found within about 100 yards of the basalt outcrop, and at a height of 30 feet above the basalt. On the other hand, however, the river sediments exposed in the road cutting on the Lyell Highway just outside New Norfolk (957336 Hobart Sheet) are at a lower level than the basalt, although no basalt can be seen to directly overlie the sediments.

Recent Series

River deposits assigned to this age are of limited extent along the banks of the Derwent and some of its tributaries, notably the Lachlan River. They occur at levels of less than five feet above the river's summer level, and are presumably flood gravels. There are also fairly extensive mud flats along the river to the east of New Norfolk. Dolerite boulders are very common in the gravels. The areal extent of these deposits has been determined mainly from aerial photographs, on which they show as much darker areas than the older, Pleistocene (?) river sediments.

STRUCTURAL GEOLOGY

The structure of the area is dominated by the intrusions of dolerite, which are probably of Jurassic age. The forms of the intrusions are quite variable, and, although the dolerite bodies taken as a whole are approximately sill-like, truly concordant contacts are not common. In general, the contacts seem to vary from roughly concordant to strongly transgressive and some vertical contacts have been seen. The sediments along intrusive contacts are often strongly baked, the baked material usually occurring as float. These contacts are commonly obscured to some extent by dolerite scree.

The other main feature of the structure of the area is the fairly extensive post-dolerite faulting, which is presumably of Tertiary age. Most of these faults trend in a south-easterly direction, cutting across the south-west corner of the area. Most of them are small, having a throw of only two or three hundred feet, although there is one much larger one (Glen Fern Fault), which has a throw of over 1,000 feet. They are vertical or near vertical faults and seem to have been formed under tensional conditions.

The major portion of the dolerite appears to be a single body, extending over most of the Black Hills square, and coming south into the northern parts of the New Norfolk square, with the lowest part running south to the Derwent, along the western edge of the area. The base of this mass has a contact varying from nearly concordant to very strongly transgressive, and its stratigraphic position varies from high in the Ferntree Formation, to over 1,000 feet above the base of the Knocklofty Formation. The base of this mass is approximately concordant where it intrudes the Ferntree Formation, at a height of about 700 feet above sea level, in the northern part of the New Norfolk square. From here the base rises with a strongly discordant contact into the Knocklofty

Formation, with the contact trending in a northerly direction.

The height of the base is raised by approximately 700 feet by the Tertiary Magra and Black Hills Faults, and then, becoming approximately concordant, it runs along the valley of the Back River. It swings around the head of the valley, and then trends along the side of the ridge leading to Mt. Dromedary. It continues along this ridge in a series of concordant and discordant stages and finally swings around the southern side of the mountain, becoming strongly discordant, and getting lower in stratigraphic height, till just to the east of the eastern boundary the base of the dolerite is only slightly above the base of the Triassic.

The base of the dolerite probably attains its greatest height, both topographically and stratigraphically, a short distance to the north of the head of the Back River valley. Where the base is exposed at the extreme northern boundary of the Black Hills square, the height has dropped by about 400 feet and its position in the sequence has dropped to about 600 feet above the base of the Triassic. To the north-west, the base decreases in height from the head of the Back River valley, where the maximum exposed height is just over 2,000 feet (about 1,000 feet above the base of the Triassic), to about 1,300 feet at the northern end of a small exposure terminated at the south by the Tertiary Black Hills Fault (912442, Brighton Sheet). The base of the dolerite here rises to the south, and is almost 1,700 feet against the fault, the contact here appearing to be slightly discordant.

Further south, there is a small block of "Feldspathic Sandstone", whose northern boundary is the Magra Fault. Both these faults have their southern side downthrown, with a total throw of 600-700 feet. The base of the dolerite on either side of the faults is now approximately the same, so it would seem that there was a rise in the base of the dolerite of about 600 feet between these two blocks before the Tertiary faulting. One explanation is that there was Jurassic movement along the line of the Magra Fault, with the southern side upthrown. The later Tertiary movement was then in the opposite sense.

To the south of these two faults, the base of the dolerite falls in a series of concordant and discordant contacts, down to river level in the bed of the Derwent. The southern limit of the dolerite is not known, since along the valley of the Derwent it is covered by younger river gravels. It can be placed with some degree of accuracy at one locality only, namely in the banks of the river where it crosses the western boundary of the area. Here there is a small outcrop of Triassic sandstone on the south bank of the river and dolerite outcrops in cliffs in the north bank. Just to the west of this locality the contact is shown fairly closely, and seems to be strongly discordant. In this part of the area the base of the dolerite falls very low in height, but stratigraphically it remains high in the Knocklofty Formation.

Along the eastern half of the extreme northern boundary of the Black Hills square, the base of the dolerite is approximately sill-like, but for the most part the contact runs just north of the boundary and only cuts into this area for a short distance. The dolerite is intruded into the Knocklofty Formation at a considerable, but not accurately-known, height above the base.

Another dolerite mass, not as extensive in outcrop as the one just described, occurs in the south-east part of the New Norfolk square. This mass is intruded into the Grange Mudstone and the top, which is the only part exposed, seems to be approximately concordant, with the top about 100 feet below the upper limits of the formation. There are some irregularities in this contact, however, and at one place the dolerite rises right to the top of the Grange. This lower body appears to be connected to the higher one in the Triassic sediments by a dolerite mass in the central southern part of the New Norfolk square. On the east and west this mass is bounded by almost vertical contacts, and the dolerite rises from a horizon about 100 feet below the top of the Grange Mudstone, up to a level high in the Ferntree Formation. Further south, it probably rises right into the Triassic.

The south-eastern corner of the New Norfolk square seems to have been lifted by the lower dolerite mass, and to the south of the town, Grange Mudstone has been lifted to a level equal to that of the middle parts of the Ferntree. This means an uplift of about 400 feet or more and some tilting was probably involved, since other parts of this block do not seem to have been raised by an equal amount. The northern extremity of this block is marked by a fault of Jurassic age, which is revealed as a vertical dolerite contact, associated with baked sediments, which cuts off the northern end of the two dolerite inliers exposed in the two creeks to the east of New Norfolk. These two contacts were probably part of the Jurassic fault, but the two parts have been offset by the Tertiary Boyer Fault. There is some possibility that the Boyer Fault had some transcurrent movement, since the two parts of the Jurassic fault have been offset by a considerable distance, although the dolerite contacts appear to be vertical.

The Tertiary faults of the area form a system of south-easterly trending faults, with some shorter ones running approximately north-south and north-north-east. The largest of these is the Glen Fern Fault, which cuts across the extreme south-west corner of the area, throwing Berriedale Limestone against Knocklofty Formation and hence having a throw of nearly 1,200 feet. This fault, which has the north side downthrown, continues into the square to the immediate west of this one, and it is connected to the Lawitta Fault running about east-west along the Derwent Valley, by a small fault striking about north-north-east. The Lawitta Fault is exposed in the cliffs in the north bank of the Derwent at the Lawitta railway station, where the Ferntree Formation can be seen to be thrown against the Knocklofty Formation. The exact throw is not known, due to lack of complete knowledge of the stratigraphy of these two formations, but it his been estimated at between three and four hundred feet. This fault is not exposed at any other locality and the remainder of its length in this area is covered by river sediments.

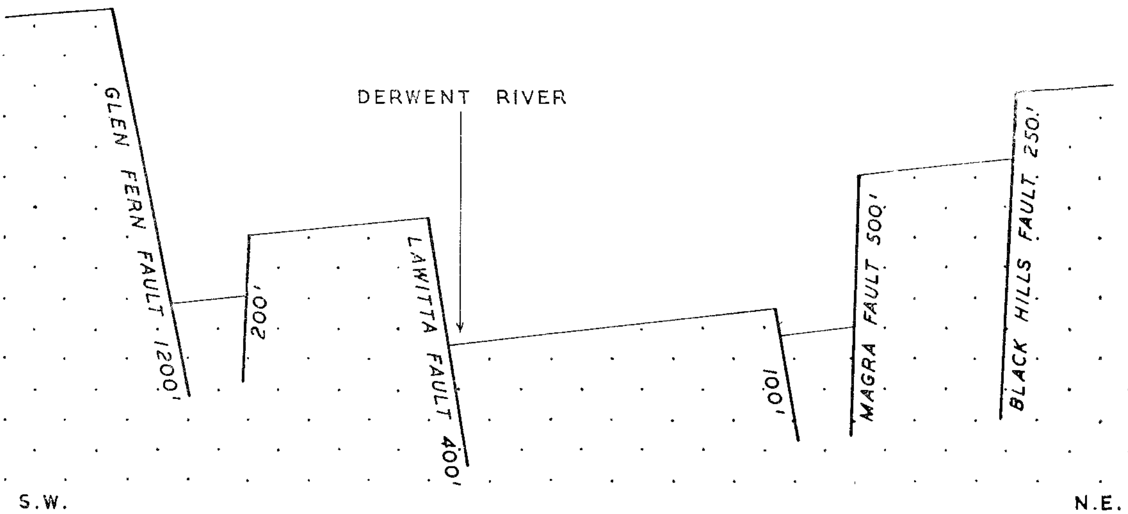


FIG. 2.—Diagramatic S.W.-N.E. sketch section across the Derwent Valley, showing geological structure. Length of section, about five miles.

Hence the exact location of the fault is impossible to find, but certain restrictions on its position make a fairly accurate estimate possible. It is thought that the fault continues from Lawitta to the centre of the town of New Norfolk, and on to Millbrook Rise, where it probably changes to a due easterly direction. The eastern continuance of this fault is open to some doubt, however, since there is very little displacement of beds across the river, although there is some change in dips.

Two other important faults are the Magra Fault and the Black Hills Fault. The throw of the former cannot be estimated accurately, since it throws Triassic against Ferntree, but 500 feet is thought to be a conservative figure, with the south side downthrown. The Black Hills Fault can be seen to have a throw of approximately 250 feet at several places where is displaces the base of the Triassic, and this fault also has the south side downthrown. Thus the Tertiary faults of the area form a wide downthrown block, bounded on the south by the Glen Fern Fault, and on the north, by the Magra and Black Hills Faults. Two other smaller faults complicate the picture slightly, so that the overall picture is one of a series of grabens, horsts, and step faults, as shown in Fig. 2 (not to scale). This down-faulted block runs in a south-easterly direction to the west of New Norfolk and it appears to have had a strong effect on the course of the River Derwent, which flows along the depressed area of the block. At New Norfolk, the Derwent changes to an easterly direction, and appears to flow out of the down-faulted block. The reason for this is not clear, but the extrusion of the basalt at New Norfolk probably diverted the river to the north, and this possibly caused the river to take up its new direction.

One important aspect of the structure of the area which has not yet been mentioned, is the large Tertiary fault, with a throw of nearly 2,000 feet (north side down), which has been projected into the Black Hills square from the Dromedary square, where it has been mapped for a considerable distance by McDougall (1959). This fault presumably enters the Black Hills square in a north-westerly direction, but it cannot be traced on the ground because just before it leaves the Dromedary square it enters a region in which there is dolerite on both sides. There is, however, a linear on the aerial photographs, which probably represents the continuation of this fault, and it is this which has been plotted on the map. This fault is probably offset to the north by the fault striking north-north-east across the northern boundary of the square. The only limit on the throw of this fault is that it is less than the thickness of the Knocklofty with the east side downthrown. Thus, it is probably well over 1,000 feet and it is possible that this fault takes up the whole of the throw of the north-west striking fault, although it is more likely that the throw is in part taken up by some smaller faults which, being entirely in dolerite, cannot be found.

BIBLIOGRAPHY

BANKS, M. R., 1952.—Permian, Triassic and Jurassic Rocks of Tasmania. *XIX International Geological Congress, Algiers*, pp. 63-86.

BANKS, M. R., & HALE G. E. A., 1957.—Type Section of the Permian System in the Hobart Area. *Pap. Proc. Roy. Soc. Tasm.*, Vol. 91, pp. 41-64.

EDWARDS, A.B., 1942.—Differentiation in the Dolerites of Tasmania. *Jour. Geol.*, Vol. 50, pp. 451-480 and 579-610.

FAIRBRIDGE, R. W., 1948.—The Geology of the Country around Waddamana, Central Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, Vol. 82, pp. 111-149.

FORD, R. J., 1956.—Geology of the Upper Huon—Arve River Area. *Pap. Proc. Roy. Soc. Tasm.*, Vol. 90, pp. 147-156.

KRUMBEIN, W. C., AND SLOSS, L.L., 1953.—Stratigraphy and Sedimentation. (Freeman, San Francisco.)

LEWIS, A. N., AND MURRAY, J. F., 1935.—Glacial Features in D'Entrecasteaux Valley. *Pap. Proc. Roy. Soc. Tasm.* (1934), pp. 87-90.

LEWIS, A. N., 1955.—Pleistocene Glaciation in Tasmania. *Pap. Proc. Roy. Soc. Tasm.* (1944), pp. 41-56.

McDOUGALL, I., 1959(A)—Geology of the Pontville-Dromedary Area, Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, Vol. 93 pp. 59-70.

————, 1959(B)—The Brighton Basalts, Tasmania. *Pap. Proc. Roy. Soc. Tasm.*, Vol. 93, pp. 17-28.

PETTIJOHN, F. J., 1949.—Sedimentary Rocks (Harper, New York).

SELWYN, A. R. C., 1855.—On the Geological Relations of Some of the Coalseams of Van Diemen's Land. *Pap. Proc. Roy. Soc. Van Diemen's Land*, 1855, Vol. 3, Part 1, pp. 116-141.

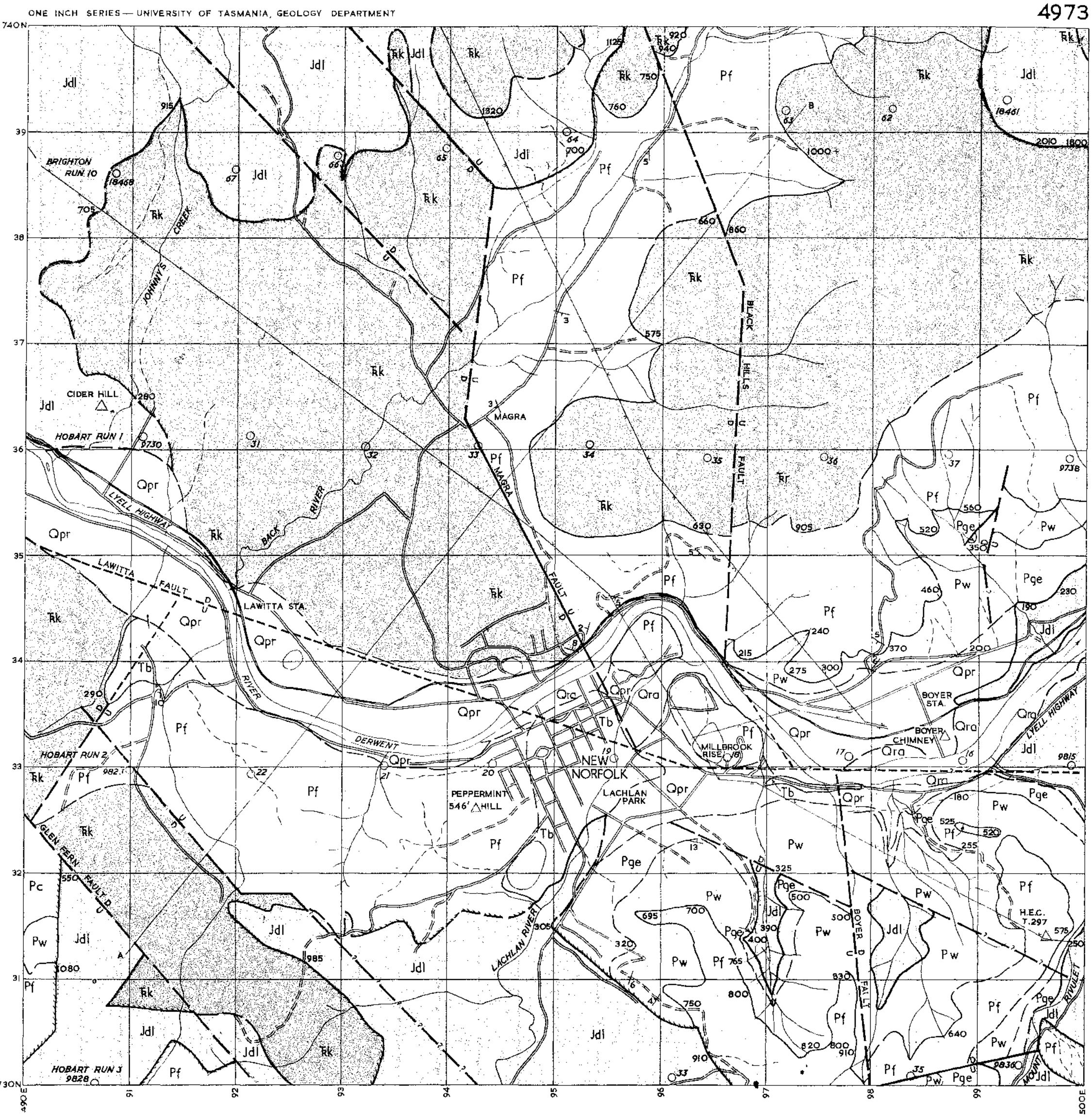
SPRY, A. H., 1955.—Tertiary Volcanic Rocks at Lower Sandy Bay, Hobart. *Pap. Proc. Roy Soc. Tasm.*, Vol. 89, pp. 153-168.

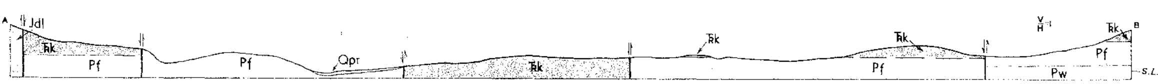
GEOLOGY OF TASMANIA

NEW NORFOLK

ONE INCH SERIES— UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT

4973





LEGEND

FAULT CONCEALED

FAULT WITH DOWNTHROWN SIDE INDICATED

FAULT—POSITION APPROXIMATE

FAULT INFERRED

FORMATION BOUNDARY

FORMATION BOUNDARY—POSITION APPROXIMATE

Dolerite Boundaries

CONCORDANT SILL

DISCORDANT INTRUSIVE BOUNDARY

26 STRIKE AND DIP OF STRATA

ROAD

VEHICULAR TRACK

FOOT TRACK

RAILWAY LINE

TRANSMISSION LINE

NUMBERS ON FORMATION BOUNDARIES ARE TOPOGRAPHIC HEIGHTS

Quaternary System

RECENT SERIES

Qra ALLUVIUM

PLEISTOCENE(?)SERIES

Qpr RIVER SEDIMENTS

Triassic System

Ŧk KNOCKLOFTY FORMATION

Permian System

Pf FERNTREE FORMATION

Pw WOODBRIDGE GLACIAL FORMATION

Pge GRANGE MUDSTONE

Pb BERRIEDALE LIMESTONE

CASCADES GROUP Pc

IGNEOUS ROCKS

Tertiary System

Tb BASALT

Jurassic(?) System

Jdl DOLERITE

MAPPED AND COMPILED BY D. WOOLLEY 1956

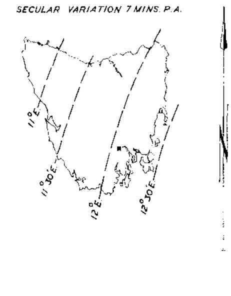
Compilation from Aerial Photographs
Trigonometric Station Control by
courtesy of the Department of
Lands and Surveys Hobart, and the
Australian Army Survey Service
Origin of co-ordinates 400,000 yds.
West and 1800,000 yds. South of
True Origin of Zone 7 of the
International Grid.

SCALE

0 — 1 — 2 MILES

0 1 2 3 4 5000 10,000 FEET

KEY MAP SHOWING MAGNETIC DECLINATIONS 1957
SECULAR VARIATION 7 MINS. P.A.



GEOLOGY OF NEW NORFOLK
SHEET 4973

PHYSIOGRAPHY

Drainage is dominated by the Derwent River which has eroded a wide flat valley, with extensive fluviatile deposits in some places. Tertiary faulting has exerted some structural control on the course of the river. To the north and south, the country rises to high hills, which have been eroded from sill-like dolerite bodies by streams having steep gradients, and which are still in the mountain tract.

STRATIGRAPHY

Age	Formation	Lithology	Thickness (in feet)
Recent		River deposits	?
Pleistocene		River sediments (sand and gravel)	?
Tertiary		Basalt flows	30+
		Erosion Interval	
Triassic	Knocklofty Sandstone and Shale	Basal fine conglomerate. Sandstone.	1000+
		Disconformity ?	
Permian	Ferntree Mudstone	Siltstone and sandstone.	600
	Risdon Sandstone	Sandstone	20+
	"Woodbridge Glacial" Formation	Sandstone and siltstone	260
	Grange Mudstone	Mudstone	100 approx.
	Berriedale Limestone	Foetid grey limestone, sometimes sandy	?

STRUCTURE

The main structural feature in this area is the system of Tertiary faults, most of which have a south-easterly trend, down the valley of the Derwent. Most of these have a throw of a few hundred feet, but one (Glen Fern Fault), has a throw of 1,200 feet. The dolerite intrusions are generally sill-like, but the contacts are often transgressive.

REFERENCES

Banks, M. R., and Hale, G. E. A., 1957—Type Section of the Permian System in the Hobart Area. **Pap. Proc. Roy. Soc. Tasm.,** vol. 91, pp. 41-64.

Lewis, A. N., 1945—Pleistocene Glaciation in Tasmania. **Pap. Proc. Roy. Soc. Tasm.** (1944), pp. 41-56.

McDougall, I., 1959—The Geology of the Pontville-Dromedary Area. **Pap. Proc. Roy. Soc. Tasm.,** Vol. 93.

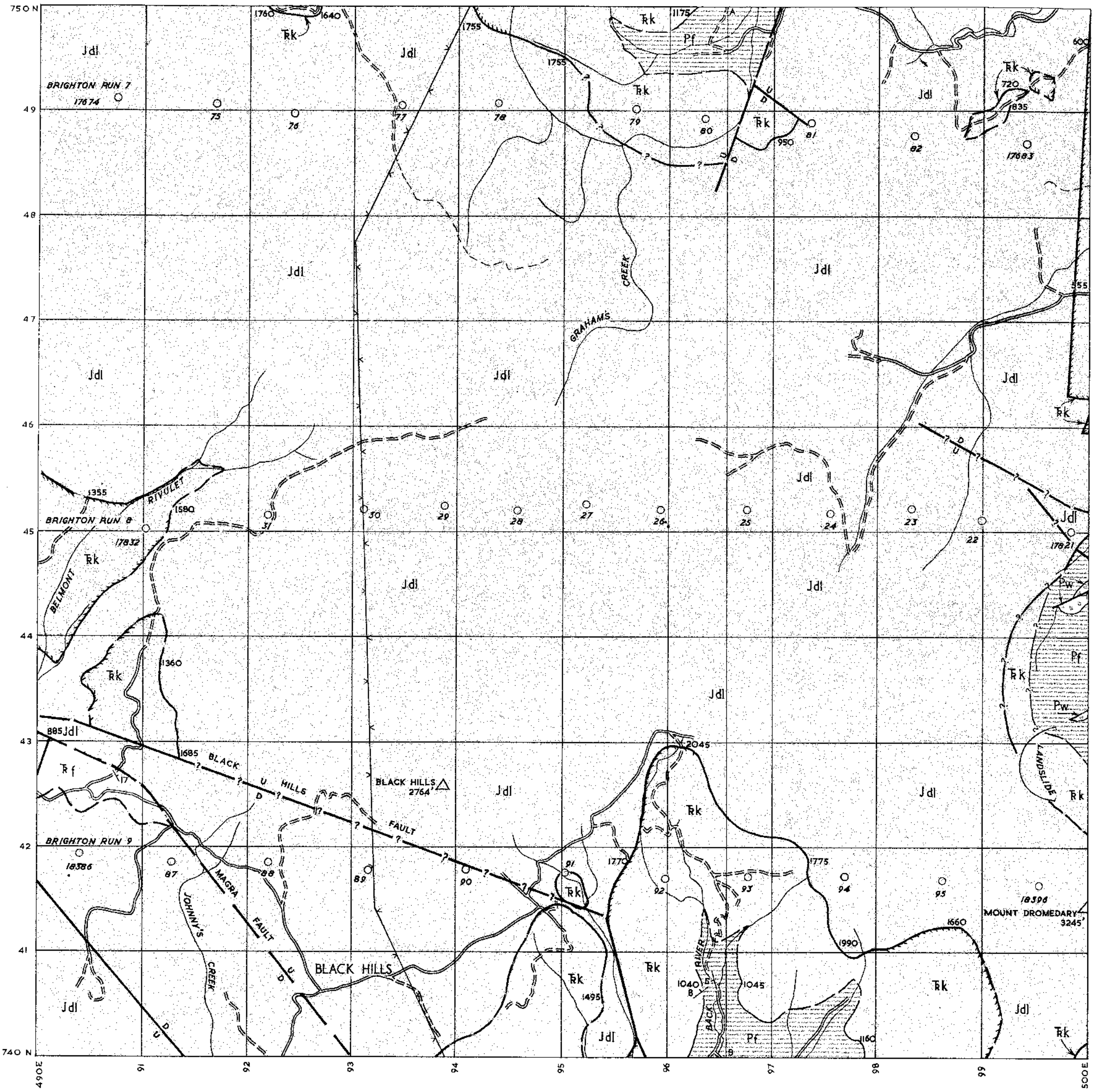
Woolley, D. R., 1959—The Geology of New Norfolk-Black Hills District. **Pap. Proc. Roy. Soc. Tasm.,** Vol. 93.

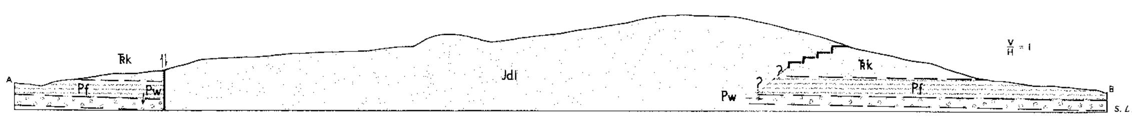
GEOLOGY OF TASMANIA

ONE INCH SERIES — UNIVERSITY OF TASMANIA, GEOLOGY DEPARTMENT.

BLACK HILLS

4974





LEGEND

FAULT WITH DOWNTHROWN SIDE INDICATED

FAULT — POSITION APPROXIMATE

FAULT INFERRED

FORMATION BOUNDARY

FORMATION BOUNDARY — POSITION APPROX.

Dolerite Boundaries

CONCORDANT SILL

DISCORDANT INTRUSIVE BOUNDARY

STRIKE AND DIP OF STRATA

ROADS

VEHICULAR TRACK

TRACK

TRANSMISSION LINE

NUMBERS ON BOUNDARIES INDICATE TOPOGRAPHIC HEIGHTS

Triassic System

Ҭf FELDSPATHIC SANDSTONE

Ҭk KNOCKLOFTY FORMATION

Permian System

Pf FERNTREE FORMATION

Pw WOODBRIDGE GLACIAL FORMATION

IGNEOUS ROCKS

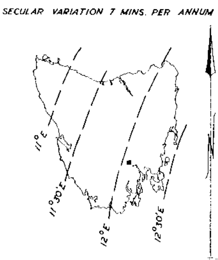
Jurassic (?) System

Jdl DOLERITE

Compilation from Aerial Photographs. Trigonometric Station Control by courtesy of the Department of Lands and Surveys, Hobart, and the Australian Army Survey Service. Origin of co-ordinates 400,000 yds. West and 1,800,000 yds. South of True Origin of Zone 7 of the International Grid.

KEY MAP SHOWING MAGNETIC DECLINATIONS

SECULAR VARIATION 7 MINS. PER ANNUM



MAPPED AND COMPILED BY D. WOOLLEY 1956

SCALE

0 1 2 MILES

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

GEOLOGY OF THE BLACK HILLS AREA

SHEET 4974

PHYSIOGRAPHY

The main part of the area is covered by a high dolerite plateau, which is being dissected by streams in the mountain tract. The main drainage is to the south into the Derwent River, but some streams flow north into the Jordan River.

STRATIGRAPHY

System	Formation	Lithology	Thickness (in feet)
Triassic	"Feldspathic Sandstone"	Sandstone with feldspar and ferromagnesians	?
	Knocklofty Sandstone and Shale	Basal fine conglomerates Sandstone	1000'+
		? Disconformity	
Permian	Ferntree Mudstone	Siltstones and sandstones.	600

STRUCTURE

There are a few small Tertiary faults in this area, most being on the noithern fringe of the faults running down the Derwent Valley to the south. Most of the area is occupied by a dolerite body whose base varies from high in the Ferntree Formation to high in the Knocklofty Formation. The top of this body is not exposed.

REFERENCES

Banks, M. R., and Hale, G. E. A., 1957—Type Section of the Permian System in the Hobart Area. **Pap. Proc. Roy. Soc. Tasm.,** Vol. 91, pp. 41-64.

McDougall, I., 1959—The Geology of the Pontville-Dromedary Area. **Pap. Proc. Roy. Soc. Tasm.,** Vol. 93.

Woolley, D. R., 1959—The Geology of the New Norfolk-Black Hills District. **Pap. Proc. Roy. Soc. Tasm.,** Vol. 93.