THE PERMIAN SYSTEM IN WESTERN TASMANIA

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(With 12 text figures.)

ABSTRACT

Permian rocks occur at Mount Read, Mount Dundas, Mount Sedgwick, Zeehan, Firewood Siding, Strahan and Point Hibbs in Western Tasmania. The basal formation is exposed at Mount Read, Mount Sedgwick, Zeehan and Point Hibbs and consists of tillite. Striations on the basement at Mount Sedgwick indicate ice moving from the west. Sections up to and including the Golden Valley Group (Lower Artinskian) occur at Mount Sedgwick and Point Hibbs and a section from the Mersey Group up to and including the Cygnet Formation is found in the Firewood Siding Area near the mouth of the Henty River. The sections at Mount Sedgwick and Firewood Siding are much thinner than corresponding ones in north-western and south-eastern Tasmania but that at Point Hibbs is as thick as or thicker than corresponding sections.

INTRODUCTION

The first record of Permian rocks in the area studied seems to be that of Montgomery (1891) who made brief reference to coal on the Henty River (see map, fig. 1). Johnston (1892) recorded some fossil plants from the Henty River area and correlated the coal measure there with the Mersey Coal Measures. In 1894 Dunn noted the tillite near Mount Read and commented on its similarity to the Dwyka of South Africa and to the conglomerates at Wild Duck Creek (Derrinal), Victoria. In the same year Moore noted the Permian fossiliferous and glacial beds on Mount Sedgwick and those at Zeehan (Zeehan Tillite) which he also described as Permian. The fluvio-glacial beds near Strahan were first described by Officer, Balfour and Hogg (1895). Several later workers dealt with the deposits mentioned above but no new work was added until Hills (1914) dealt with the Point Hibbs section. In 1925 Reid noted the probable presence of Permian rocks on Mount Dundas. Voisey (1938) included references to this area, particularly to the Point Hibbs and Malanna sections in his work on the Permian of Tasmania. Edwards (1941) noted the exhumed Permian surface on Mount Sedgwick and the Permian of

OCCURRENCES of PERMIAN ROCKS in WESTERN TASMANIA

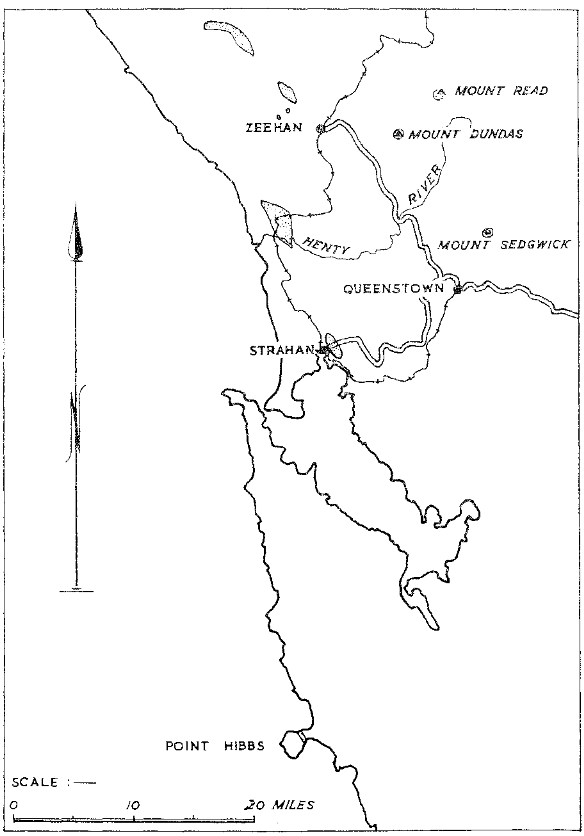


FIGURE 1

R.S.—2.

Mount Sedgwick was mentioned by Bradley (1954). Some of the Permian rocks at Firewood Siding, near Malanna, were described by Gill and Banks (1950). Campana *et al* (1958) and Spry (1958) re-established the Permian age of the Zeehan Tillite. Others have also commented on the Permian rocks considered in this paper but only as repetitions of earlier work.

Serious investigation of the Permian sections in this area began in November, 1953, when Professor K. G. Brill, Visiting Professor at the University of Tasmania, G. E. Hale and M. R. Banks spent a week measuring sections in the Malanna area. In January, 1957, the authors measured sections in the Malanna area, at Point Hibbs and on Mount Sedgwick and made observations on the Permian rocks on Mount Read and at Strahan. During the 1953 trip to Malanna sections were measured in railway cuttings and creek beds using a steel tape and abney level. The Mount Sedgwick section was measured by using a Brunton compass as a level and measuring cliff sections. The Point Hibbs section was measured by laying a steel tape along the dip of the vertical beds and reading off thicknesses directly until the fault zone was met and then by using the abney level. Thicknesses in the section in Geologists Creek, near Malanna, studied in 1957, were only estimates due to thick undergrowth.

During the work the authors were aided by the explicit directions on the route to Mount Sedgwick given by geologists of the Mount Lyell Company. This company also made available the services of Mr. Jock Gilfillan who was of considerable assistance. The Lyell-E.Z. Exploration Company made the work at Point Hibbs possible by making available to the authors one trip each way in a helicopter and later made aerial photographs available. The Electrolytic Zinc Company kindly allowed us to use their facilities and made Mr. John Druett available as a guide. The authors acknowledge with gratitude the assistance of these companies and their officers. The authors are also indebted to Mr. M. Longman, Geologist at the Tasmanian Museum for access to plant bearing shales from which Johnston had described fossil plants from the Henty River.

All bearings are related to true north.

MOUNT READ.

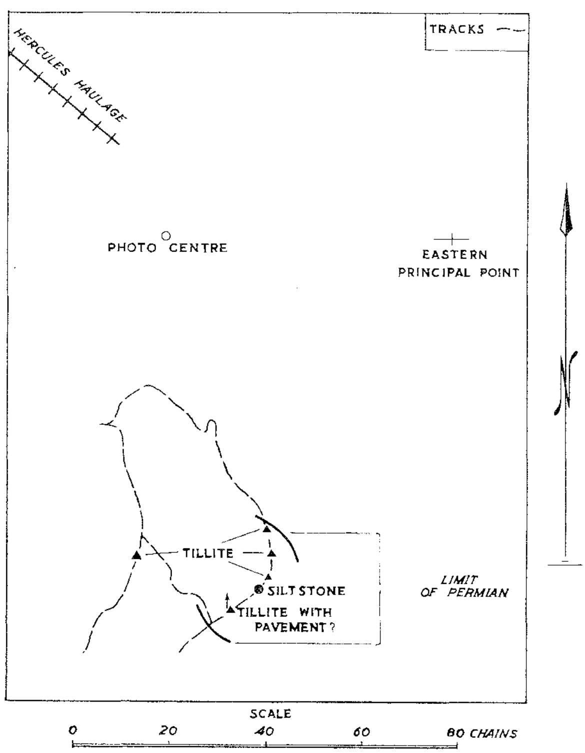
The earliest mention of Permian rocks near Mount Read is that of Dunn (1894) who mentioned a conglomerate with a great variety of pebbles on the south side of the track half way from Mount Read to Moore's Pimple. He remarked on its similarity to the Dwyka of South Africa and the conglomerate on Wild Duck Creek (Derrinal), Victoria, both considered as Permian. Hills (1915) gave further details. He considered that it was Permian as it contained fragments of undoubted "Silurian" rocks (now known to be Ordovician). Bradley (1954, p. 199) also mentioned this occurrence as showing that the Carboniferous peneplain in this area has an undulating surface with variations up to 80 feet in height.

A complete survey was not made by the present authors but two areas of Permian rocks were examined. On the track from Mount Read to Zeehan about half a mile south of the "L" Lode open cut on the south-west side of Mount Hamilton, tillite was found in a small depression (co-ordinates 8.5 cms. S.S.W. by S. of C.P., Zeehan 8, 23627) (see map, fig. 2).

The Permian rests on "sheared pyroclastics" of probable Cambrian age which have a steep easterly dip and the Permian has a horizontal fissility although no bedding could be seen. The rock is greenish grey. It is very poorly sorted with boulders up to 18 inches long in a fine-grained (clay and silt grade) matrix. The boulders are angular and sub-angular and are grey Owen Conglomerate, pink Owen Conglomerate, Eldon Group quartzites, green sandstone, black slate, quartz and rare feldspar porphyry. The rock is fairly well lithified. The tillite is probably not more than two feet thick and is a small remnant preserved in a hollow between hills of "sheared pyroclastics" which rise locally to more than 50 feet above the level of the Permian. There is no internal evidence in this exposure of a Permian age. The lithology and degree of lithification are very similar to known Permian tillites elsewhere in the State and quite dissimilar from those of the Pleistocene till in

SOME PERMIAN DEPOSITS

ON MOUNT READ



Based on air photo Zeehan Run 8 no. 23627

FIGURE 2

the West Coast area. The top of the plateau at Mount Read shows no sign of Pleistocene glaciation so that all available evidence from this outcrop suggests a Permian age.

The Permian age is confirmed by the other exposure of tillite and associated rocks. In a depression between hills of " sheared pyroclastics " about three-quarters of a mile south-west of " L " Lode Open Cut, tillite is found, resting on the pyroclastics (at point 10 cms. S.S.E. by S. of C.P. Zeehan 8, 23627) and in a runnel of an old track a surface of the pyroclastics shows a polished surface with striations trending 0° approximately. This may be part of the pavement beneath the Permian but this could not be established beyond doubt as the striations may be due to log hauling. Erratics in this vicinity reached a length of 33 inches and in addition to the types reported from the first locality include a black fine-grained quarzite. Otherwise the tillite at this second locality is very like that from the first. About 100 yards north-east along this track (at point with co-ordinates 9.7 cms. S.S.E. of C.P. Zeehan 8, 23627) olive-grey siltstones are exposed dipping at a moderate angle to the west off a small hillock of " sheared pyroclastics ". These are well-sorted in that erratics are rare and small. They are poorly bedded. These siltstones contain articulated crinoid columns and attached cirri of a type common in the Permian System in Tasmania. The siltstones are overlain by tillitic material and similar siltstones occur, apparently above the tillitic material, further north along the track and are again overlain by tillitic material. On topographic grounds it seems probable that the section is basal tillite, siltstone with crinoids, tillite, siltstone, tillite, but in view of the poor exposure the succession cannot be regarded as established. The presence of the crinoid of Permian type established the age of the succession.

The surface of the plateau north and eact of these occurrences was not examined and there may be further outcrops. The two areas of Permian rocks found occupied small depressions in the surface of the " sheared pyroclastics " which rises perhaps as much as a hundred feet above the base of the Permian. To some extent the present topography on this part of Mount Read is a slightly subdued expression of the pre-Permian topography.

SECTION AT MOUNT DUNDAS.

This section was not visited due to inaccessibility. Reid (1925) postulated that Permian sediments on the south-western fall of Mount Dundas on the evidence of fossiliferous boulders in some of the creek systems near Dundas. Elliston (1954, p. 172) stated that a thin layer of mudstone occurs between dolerite sills on Mount Dundas.

SECTION AT ZEEHAN.

In 1894, Moore discovered the tillite north-west of Zeehan and considered it (1896a, p. 60) to be Permian in age on lithological grounds as also did Twelvetrees and Ward (1910). It has also been regarded as Precambrian (Hills and Carey, 1949; Carey, 1953), and Cambrian (Carey and Scott, 1952, p. 70; Elliston, 1954, p. 177) but Banks (1956, p. 193) regarded the age of the Zeehan Tillite as not then established. More recently Spry (1958) has suggested that the Zeehan Tillite is Permian on structural grounds and because it contains fragments of Dundas Group and Eldon Group rocks. He has also found a further occurrence of it north of the Pieman River and describes the rock from the different areas in some detail. The authors did not visit these areas. Campana and King (1958) give detailed evidence for a Permian age for the Zeehan Tillite.

SECTION AT MALANNA (MOUTH OF HENTY RIVER).

The Permian rocks here were first noted by Montgomery (1891, p. 42) who gave the section as coal bearing beds overlain by sandstones and limestones with marine fossils and by white grit or sandstone. Johnston (1892) recorded *Glossopteris browniana, Gangamopteris spatula, G. obliqua* and *Noeggerathiopsis hislopi* associated with curious botryoidal concretions from the coal bearing beds and correlated them with the Mersey Coal Measures. Twelvetrees (1902a) noted that the impure limestones and mudstones overlie the coal measures. Twelvetrees (1902b, 1903) recorded details of two bores put down near Malanna in a search for coal and suggested (1902, p. lxxii) that the coal occurred on two horizons, one exposed near Malanna and the other below the limestone. Voisey (1938, p. 322) considered that only one formation containing coal was present, that above the beds with marine fossils. In this he was possibly influenced by the undoubted presence of coal bearing or carbonaceous beds above the marine beds in the railway sections. However, investigations by the authors suggest that there are two coal bearing formations separated by marine beds. The authors were unable to find any of the " curious botryoidal concretions " in the railway cuttings nor any *Noeggerathiopsis* and it is clear from Montgomery's statement (1891, p. 43) that the coal being investigated was on the flats just north of the Henty River, not as far north as the railway cutting. This has been checked in conversation with local residents. Specimens of the shale containing the plant fossils described by Johnston are in the Tasmanian Museum. The rock is a micaceous siltstone containing decomposed concretions probably of pyrite, now in the form of melanterite. It is thinly bedded with beds of dark-grey and medium-grey siltstone alternating from 0.1 inches to 0.25 inches thick. It is well lithified and shows some curved slickensided surfaces. No fossil seeds, nor sphenopsids, nor *Vertebraria* are present in the Museum specimens but large specimens of *Glossopteris* are present. One of the " botryoidal concretions " referred to by Johnston may be present but this is not certain. This material is much more lithified than any of the plant bearing siltstones seen in the railway cuttings and described later and the types of fossils are somewhat different in the two formations. The specimens in the Museum are characterised by extraordinarily large specimens of *Glossopteris* while specimens from the railway cutting contain numerous seeds, *Vertebraria* and sphenopsids. On the grounds of difference in degree of lithification and in the overall aspect of the plant assemblages it is considered that John-

MAP OF HENTY RIVER (MALANNA) AREA
SHOWING PERMIAN LOCALITIES

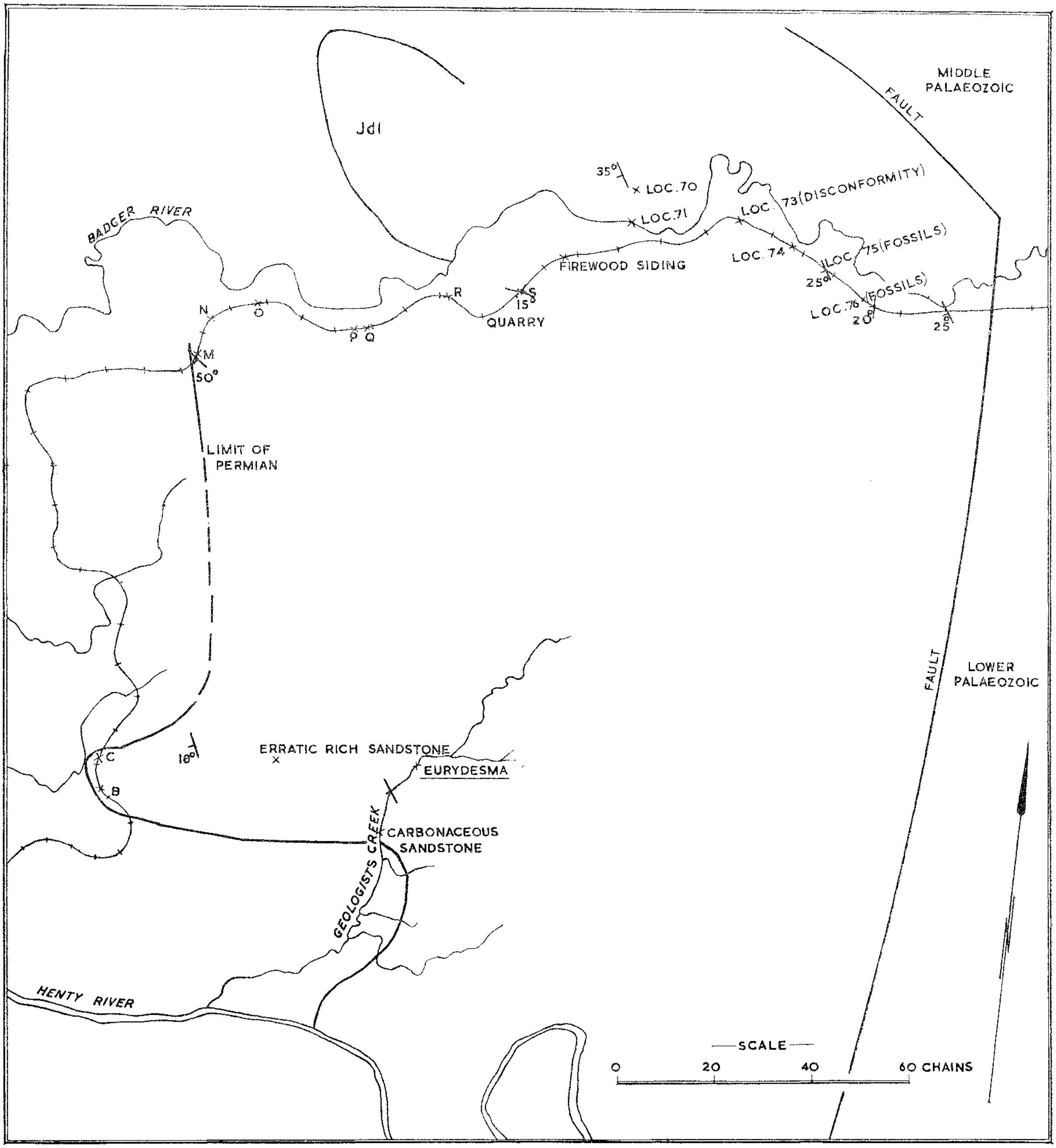


FIGURE 3

ston's specimens did not come from the railway cuttings, and on the grounds of Montgomery's description and Johnston's description, further supported by conversation with local residents, it is considered that they come from the flat ground on the north side of the Henty River, probably between Geologists Creek and the railway bridge. Thus, the coal measures referred to by Johnston as equivalent to the Mersey Coal Measures are thought to be below the marine beds but there are further coal measure beds above these marine beds and the present authors suggest that these are equivalent approximately to the Cygnet Coal Measures. Gill and Banks (1950, p. 266-7) described rocks from two formations close to Firewood Siding and suggested that the marine ones might be equivalent to the "Granton Formation" (= Cascades Group).

The present study was made in a traverse down Geologists Creek, in cuttings along the railway line and in a section along a creek flowing north into the Badger River just west of Firewood Siding (see map, figure 3).

Due to thick vegetation and flooding of Geologists Creek no measurements of thickness were possible. Sections of the upper coal measure beds in railway cuttings and a creek were made with a steel tape but due to faulting and irregularities in dip correlation between them is poor. Exposures of the marine beds in the railway cuttings were too discontinuous for measurement and the thickness is calculated trigonometrically. Localities mentioned are shown in the map (fig. 3).

The lowest formation in the section consists of carbonaceous, micaceous, quartz-rich sandstones which are well sorted. These occur in the lower part of geologists Creek where they are apparently associated with black shale containing *Glossopteris browniana, Gangamopteris spatula, G. obliqua* and *Noeggerathiopsis hislopi* (Montgomery, 1891, and Johnston, 1892).

This is followed after an interval with no obvious outcrop by alternating sandstone and fissile siltstone containing some fossils and a few erratics. In one place this shows north-west trending jointing planes less than a foot apart suggesting some faulting but there is no obvious displacement of beds and no change of dip. There follows a sandstone and siltstone alternation in which fenestellids, stenoporids, spiriferids and one specimen of *Eurydesma cordatum* were seen.

This is overlain by a fissile, calcareous siltstone containing spirifireds, stenoporids and predominant fenestellids. This is perhaps one of Montgomery's impure limestone beds.

After a further gap in the section the next unit is a buff sandstone with rare small erratics which forms small flats above creek level. This is richly fossiliferous with fenestellids, *Stenopora, Strophalosia* (?), *Terrakea, Dielasma,* spiriferids (including *Neospirifer*), *Spiriferellina, Ingelerella* and pelecypods. Of particular interest is the occurrence in bands of numerous small, inarticulate brachiopods.

A few feet above this and also forming a small flat area is a greyish feldspathic pebbly sandstone.

This is followed by a considerable thickness of greyish, feldspathic sandstone with numerous pebbles and small cobbles occurring in bands. The bedding in this sandstone is thick and the unit forms several large waterfalls. The final unit, exposed in the uppermost waterfall in the gorge of Geologists Creek, is a white, quartz-rich, well sorted sandstone with a few pebbles of white

Columnar Section of Permian Rocks in Geologists Creek

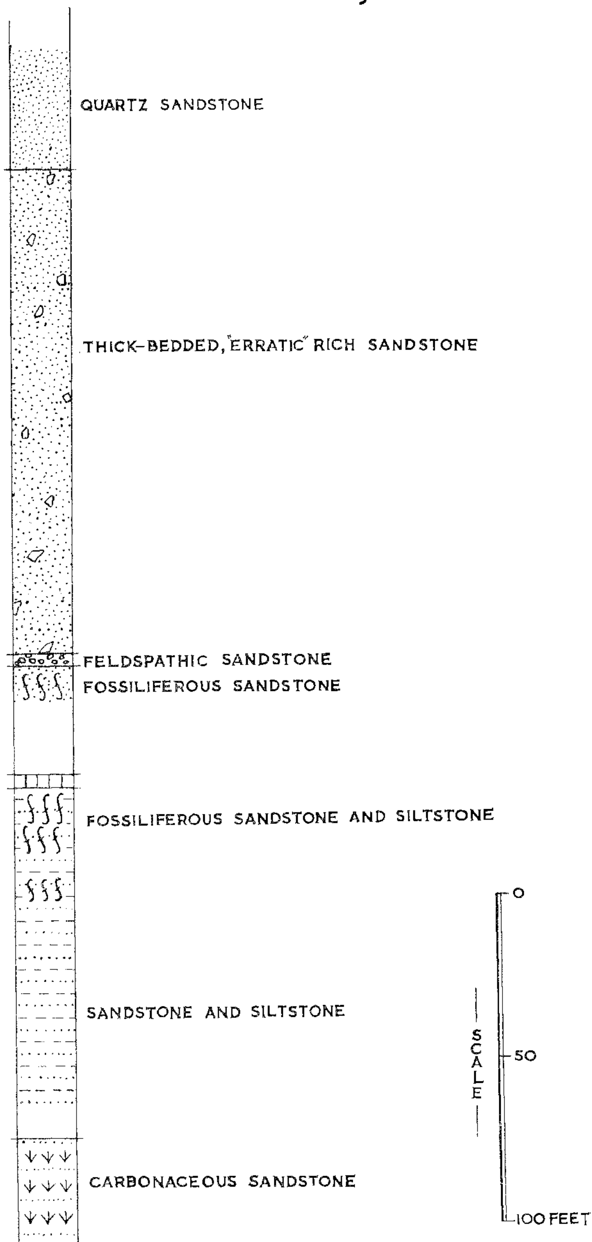


FIGURE 4

quartzite and this type of rock covers much of the surface between the Henty River and the railway line west of Firewood Siding. The basal sandstone and the plant-bearing shale formation is of the order of 40 feet thick and the marine sequence between the two formations of siliceous sandstone is of the order of 300 feet thick based on measurements of height of the top of the plateau cut in the Permian (525 feet above the level of the Henty River at the railway bridge) and on estimated heights in the gorge of Geologists Creek. The beds in the creek section are essentially horizontal. The thickness given is considerably in excess of that given by Montgomery which is thought to be much too small. The section in Geologists Creek is summarized in fig. 4.

In a railway cutting ("B") (Strahan 11, 3292, 1", E.N.E. of C.P. and see map, fig. 3) a section of Permian rocks is exposed. This shows:

Top—

20 feet: medium to fine grained feldspathic sandstone with occasional "erratics" or lenses of "erratics".

1 foot 8 inches: greenish-grey, medium-coarse grained sandstone with many erratics (up to 15 inches long) including quartzite, quartz schist, mica schist, chlorite schist and granite, very angular, un-oriented, unsorted; large (4" wide) *Ingelarella* (?) *subradiata* and other spiriferids.

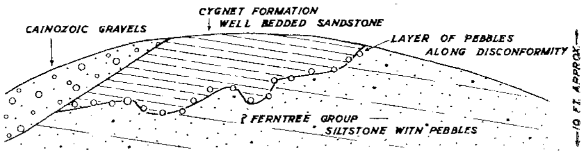
3 feet: dark-grey, medium-fine grained sandstone with pebbles and cylindrical bodies outlined by carbonaceous matter (? worm tubes).

4 feet: dark-greenish yellow sandstone with a few "erratics".

4 feet: greenish-yellow, fine-grained sandstone with occasional small angular and rounded "erratics".

The next cutting to the north ("C") also contains "erratic"-bearing sandstones but fossils are commoner and occur in lenses. The fossils include *Stenopora* (massive type like *crinita*, and ramose types), fenestellids, *Strophalosia*, spiriferids, including *Ingelarella subradiata, Spiriferellina, Aviculopecten,* other pelecypods, and calcareous worm tubes.

East of Firewood Siding a series of railway cuttings expose Permian beds. The easternmost one (co-ordinates 3.5 cms. S. CP. Zeehan 1,23435) contains alternating thick-bedded impure sandstone and fissile siltstone with sandstone predominating in thickness in the alternations. Pebbles up to an inch long are present but no fossils have been found. The boundaries between the members of the alternating beds are gradational. The next cutting west (Locality 76 of Gill and Banks, 1950, p. 267 and pl. III) contains fissile, grey, fossiliferous siltstone with a few pebbles interbedded with thin beds of feldspathic sandstone containing ostracodes and fenestellids. The fossils from these beds include *Fenestella, Polypora, Protoretepora, Stenopora, Ingelarella subradiata,* other spiriferids, *Schuchertella, Strophalosia, Merismopteria macroptera, Eurydesma cordatum, Edmondia, Chaenomya, Aviculopecten,* other pectinaceans. "*Platyschisma*" *oculus, Camptocrinus* and other crinoids and *Conularia inornata.* The pebbles include quartzite, schists and hornfels.



SKETCH OF DISCONFORMITY (Locality 73)

FIGURE 5

About forty yards from the eastern end of the cutting the fissile fossiliferous siltstones are overlain with a sharp contact by a bed of sandstone about a foot thick which grades up into a non-fissile siltstone, with a few "erratics" and no obvious fossils. Bedding is not clear and if present is thick to very thick. "Erratics" are up to eight inches long. Towards the western end of the cutting some bands of pebble occur in the siltstone as also do some bands of very thinly bedded siltstone without pebbles. These, however, are only a minor part of the sequence. In the next cutting west (co-ordinates 3.8 cms. S.W. of C.P., Zeehan, 1,23435; Locality 75 of Gill and Banks, 1950) thickly-bedded, grey siltstones with pebbles of schist which are well rounded and ellipsoidal, are associated with greenish-grey sandstone. *Fenestella, Strophalosia, Dielasma, Ingelarella oviformis, Spiriferina duodecimcostata* and other spiriferids are present. A fine-grained greenish-brown siltstone occurs in the next cutting to the west (Loc. 74 of Gill and Banks, 1950) and contains slightly-rounded pebbles of quartzite, schist and one large faceted cobble of grey granite eight inches long. Similar rock types occur west of the cutting (co-ordinates 5.2 cms. W.S.W., C.P., Zeehan, 1,23435; Locality 73 of Gill and Banks, 1950) where the "erratic"-bearing siltstones are overlain disconformably by well-sorted, thickly-bedded siliceous sandstone with carbonaceous fragments. The disconformity is marked by a narrow band of small siliceous pebbles (see fig. 5).

The apparent thickness of marine or "erratic"-bearing beds exposed is of the order of 800 feet. The section east of Firewood Siding is summarized as fig. 6.

The total thickness shown is thought to be excessive. Dips are up to 25°, indicating proximity to faulting, and possible faulting within the section. The numerous long gaps in the section in addition render the overall thickness quite unreliable and even the section is doubtful. Similar pebbly beds occur in some of the depressions south-east of the railway line where they outcrop beneath the quartz-rich sandstones. One such outcrop occurs at a locality 1" N.N.E. C.P. Strahan 11, 3293 and consists of grey, poorly-sorted sandstone with angular to sub-angular boulders of schist, slate, phyllite and quartzite.

Above the disconformity the basal beds are quartz-rich sandstones with carbonaceous fragments. These are thickly bedded and well sorted but have a few sub-rounded to rounded pebbles of quartz and quartzite. Between this cutting and Firewood Siding sandstone and fine-grained carbonaceous sandstone occur in the cuttings. At the

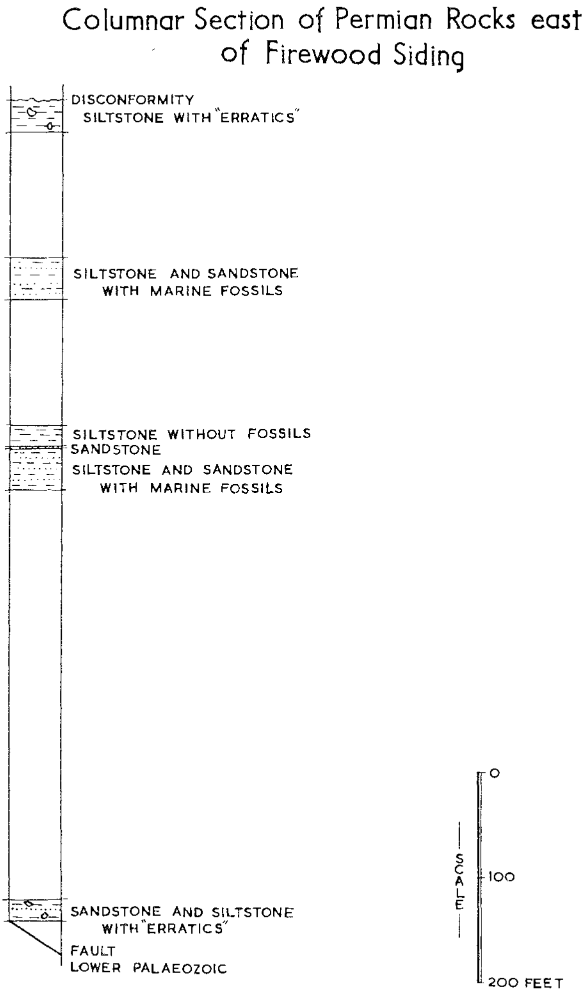


FIGURE 6

eastern end of the Firewood Siding cutting brown to gray micaceous sandstone outcrops. This is medium-grained and thinly-bedded with some cross-bedding in the thinner beds which have carbonaceous laminae. Plant fragments are present but not common. The rocks outcropping in the Badger River and on the cuesta to the north have been described earlier (Gill and Banks, 1950, pp. 266-67).

In the first cutting ("S") west of Firewood Siding (co-ordinates 3.4 cms. S.S.E. C.P. Zeehan Run 1, 23437) sandstone and pebbly sandstone are the main rock types with rare beds of carbonaceous siltstone. Cross-bedding dipping west or north-west is present.

In a small quarry south of the railway line about a hundred yards south-west of this cutting sandstone overlies a bed of grey, carbonaceous micaceous siltstone which is very rich in plant remains including *Glossopteris, Gangamopteris* and *Verterbraria.* Pyrite occurs associated with the carbonaceous siltstones.

The next cutting to the west ("R") (co-ordinates 3.5 cm. S.S.W. C.P. Zeehan Run 1, 23437) is thought to be that figured by David (1926, p. 102). At the eastern end of the figured cutting a bed of brecciated siltstone underlies a strongly-jointed sandstone in a small syncline. Just to the west in an anticline is sandstone with pebble bands and thin carbonaceous bands. Beyond a fault is a sandstone with a few thin carbonaceous siltstone bands, one of which shows circular, approximately horizontal sand-filled tubes, overlain by interbedded thin beds of sandstone and carbonaceous siltstone. To the west of another fault the basal section of the cut is in carbonaceous siltstone with the thin beds of sandstone overlain by two feet of sandstone, carbonaceous siltstone and finally 11 feet of thinly-bedded sandstone. In the basal siltstone unit there are worm tubes, current ripple marks (currents from west) and cross-bedding occurs in the sandstone layers indicating mostly currents from the east or south-east but some from the west. Next to the west is a fault zone in sandstone and carbonaceous siltstone. In the western section of the cut the basal portion consists of an alternation of thin beds of sandstone with very thinly interbedded sandstone and carbonaceous siltstone. This is overlain by a brecciated sequence of carbonaceous siltstone and thin sandstone bands. This is followed by several thick beds of sandstone which shows no brecciation or faulting like that in the underlying bed. The top unit in this part of the cutting is a thinly-bedded sandstone sequence.

Sandstone occurs in low cuttings further west in the axis of a flat anticline. The sandstone is medium-grained at the base and finer-grained and thinly-bedded above. In the next major cutting ("Q"), (co-ordinates 5.3 cm. S.W. C.P. Zeehan 1, 23437) a fault divides the cutting. At the eastern end there is a thickness of nine feet of medium-grained sandstone with thin bedding and cross-bedding mainly dipping south-west and overlain by nine feet of thinly-bedded fine-grained sandstone. Some cross-bedding dipping to the west and more rarely to the east occurs in the basal part. West of the fault the following section was measured:—

Top—

2 feet: Sandstone, white, micaceous, feldspathic, with clayey and carbonaceous partings producing flaggy breaks.

5 feet 6 inches: Brown and black carbonaceous and micaceous with minor superimposed on major rhythms. i.e., carbonaceous siltstone and siltstone alternate and each member consists of alternations of carbonaceous siltstone and siltstone; there are 8 cycles, the carbonaceous siltstone members being the thinner; a prominent sandstone band from 3′ 6″ to 4′ above the base.

3 feet: White, micaceous, feldspathic sandstone with thin bedding.

The basal sandstone contains bodies of concentric laminae of carbonaceous matter, the exact nature of which is unknown. The siltstones of the second unit contain worm tubes and ripple marks and the top is brecciated and crumpled. This unit is very reminiscent of the brecciated beds in the previous cutting ("R").

Another section is exposed in the next cutting to the west ("P", co-ordinates 5.6 cms. S.W. C.P., Zeehan 1, 23437) and is as follows:—

Top—

1 foot 6 inches: Thickly bedded. medium-coarse grained feldspathic sandstone.

2 feet: Fine-grained, feldspathic, micaceous sandstone; quartz grains angular; cross bedding rare; flaggy splitting.

1 foot: Medium to coarse grained quartz sandstone with angular grains; thickness to 6 feet at east end of cutting.

3 feet: Black to brown, carbonaceous, micaceous, feldspathic siltstone, very thinly bedded with irregular bedding and some worm tubes.

3 feet 6 inches: White, friable, thinly bedded, flaggy-platy, feldspathic, micaceous sandstone becoming carbonaceous near the top; some bedding planes show rippling.

20 feet: (Top 4 feet in cut, bottom 16 feet in cliff to north) white, medium grained feldspathic sandstone.

Cross bedding in this cutting dips south-west, west and north-west.

A section was measured up the bed of a creek tributary to the Badger River, with the co-ordinates 4.6 cms. S.S.E. C.P. Zeehan 1, 23438 (on railway line). This section is given in detail below:—

Top—

Interbedded carbonaceous and non-carbonaceous siltstones with shattering, overthrusting, and normal faulting (as in section figured by David).

30 feet: Fine to medium grained, cross-bedded sandstone with quartz, feldspar, muscovite; thickly-bedded.

40 feet 2 inches: Medium to coarse-grained sandstone, with quartz, feldspar and a few quartz pebbles up to 30 feet above the base then some pebble bands, thickly bedded.

5 feet 9 inches: Coarse sandstone to fine conglomerate with large pebbles (up to 25 mms.) of quartz, red chert and quartzite; angular to sub-rounded pebbles; thickly bedded.

4 feet 9 inches: Fine to medium-grained quartz sandstone with a few pebbles of quartz and quartzite sub-angular to sub-rounded; thickly-bedded; flaggy to massive.

10 feet 9 inches: Brown-yellow, fine-grained quartz, mica, feldspar sandstone with very thin to thick bedding and some carbonaceous partings, flaggy and platy.

11 feet: Interbedded black micaceous siltstones with disseminated carbonaceous matter, and brown micaceous siliceous siltstones; very thinly bedded; distinct band of quartz pebbles 8 feet above base; some distinct plant fragments.

1 foot 3 inches: White to pink, medium-grained sandstone with conglomeratic bands with pebbles of quartz, quartzite and some schist; quartz, pink feldspar and muscovite in matrix; some carbonaceous partings.

2 feet: Greenish-grey sandstone with muscovite and biotite; fine-grained, angular grains; "erratics" present, especially about 18″ above base, consist of quartz, quartzite, slate, argillite and pink granite.

The first unit is lithologically very like the beds below the disconformity east of Firewood Siding and distinct from those higher up. The higher units may be considered as parts of two cycles as under:—

8. Siltstone.
7. Fine to medium-grained sandstone.
6. Medium to coarse-grained sandstone.
5. Coarse sandstone to fine conglomerate.
4. Fine to medium-grained sandstone.
3. Fine-grained sandstone.
2. Siltstone.
1. Medium-grained sandstone.

The grain-size decreases upwards to unit 2 then increases upwards to unit 5 with higher decrease to unit 8. This latter is overlain by sandstones in the railway cuttings but the succession is broken. From the top of unit 8 to the highest point on the hills to the south on which the quartz-rich sandstones occur, is well over 50 feet so that a minimum thickness for this formation is 150 feet.

Further to the west (cutting "O", co-ordinates, 4.2 cms. S. C.P. Zeehan 1, 23438) white, siliceous sandstones outcrop. Some of these are pebbly and there are beds of siliceous and carbonaceous siltstones. Small limonitic concretions are present and there are also curved cylindrical worm burrows in it. Cross-bedding dips north-west to south-west with some dipping east, and ripple marks and slump structures are also present.

In the next cutting west ("N", co-ordinates 4.7 cms. S.S.W. C.P., Zeehan 1, 23438) a fault divides the cutting. At the eastern end of the cutting a cross-bedded sandstone is overlain by a micaceous sandstone containing plant fragments, a siltstone containing a sphenopsid, *Glossopteris*, both small and large species, and *Vertebraria*, and finally by a coarse sandstone with rare boulders up to four inches long. At the western end of the cutting the following section was measured:—

Top—

4 feet: White quartz sandstone, with much feldspar.

6 feet: Alternating fine micaceous sandstone and carbonaceous siltstone; sandstone beds ¼″ to 2″ thick, siltstone bands up to ¼″ thick.

4 feet: White to brown carbonaceous, micaceous, feldspathic sandstone; carbonaceous partings and bands, thick bedding.

2 feet: Carbonaceous, micaceous, siltstone; thinly bedded.

4 feet 8 inches: Brown-yellow sandstone; fine to medium-grained; few quartz pebbles at 1′ 6″ above base sub-angular to sub-rounded; above this bed becomes more carbonaceous and micaceous with some plant remains.

6 inches: Carbonaceous ,micaceous brown-black siltstone with *Glossopteris, Gangamopteris, Vertebraria, Phyllotheca, Schizoneura,* and seeds.

5 feet: White, thick bedded sandstone, with fine conglomeratic bands of angular to sub-rounded quartz pebbles; cross bedding dipping south-west.

This section shows an alternation of sandstone and siltstone with some of the siltstone units themselves composed of alternating sandstone and siltstone beds. The sandstone units are consistently thicker than those of siltstone.

The final cutting in Permian rocks ("M", co-ordinates 5.5 cms. S.S.W. C.P. Zeehan 1, 23438) consists mainly of sandstone as shown in the following section.

Top—

1 foot: Cross-bedded, white, medium-grained sandstone.

2 ins.: Sandstone.

6 ins.: Clayey sandstone.

9 ins.: Sandstone.

1½ ins.: Clayey sandstone.

6 ins.: Sandstone, top surface ripple marked.

1 in.: Clay.

2 ins.: Sandstone.

4 ins.: Yellow clay.

9 ins.: Sandstone.

9 ins.: Micaceous, feldspathic sandstone with 1 in. clay seam.

1 foot 8 ins.: Yellow-brown limonitic, clayey sandstone.

6 ft. 8ins.: Yellow quartz sandstone with cross-bedding; muscovite and feldspar present, grains angular; bedding planes about 1 inch apart.

5 feet 1 in.: Conglomeratic sandstone; pebbles of quartz, quartz schist up to 1½ inches long, sub-rounded to sub-angular; matrix coarse sandstone to fine conglomerate, mainly quartz with some feldspar, very angular; lower surface uneven.

1 in.: White sandy micaceous clay.

2 feet 6 ins.: Medium-grained, micaceous (muscovite), feldspathic sandstone with occasional pebbles of quartz; grains angular; thickly bedded.

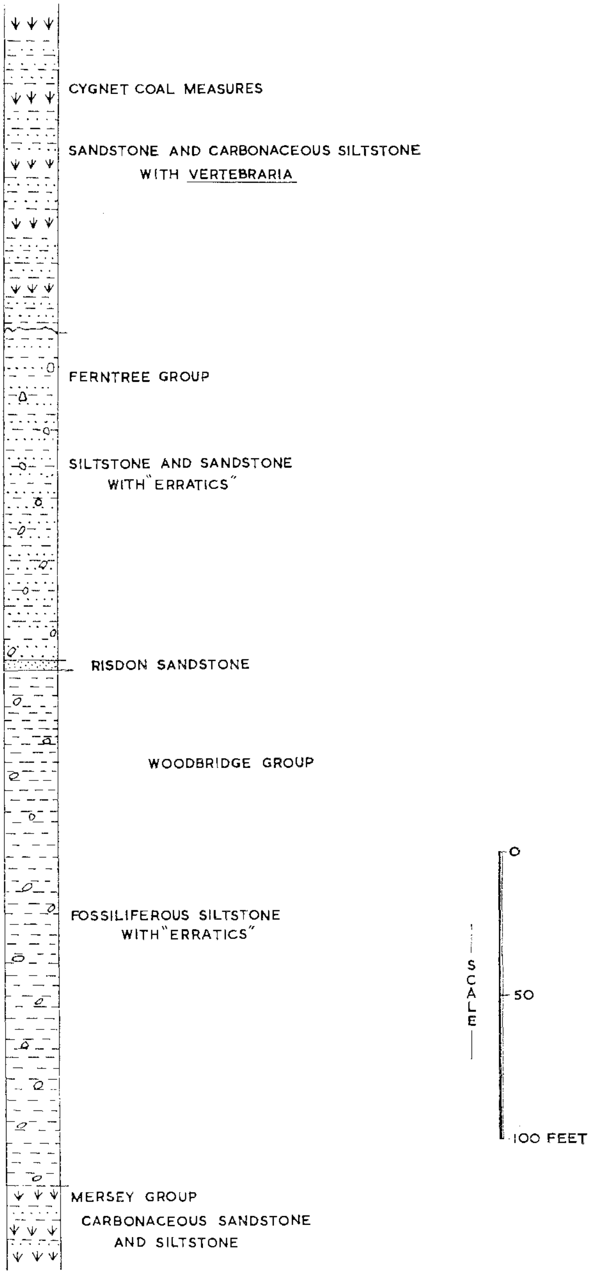
The prevalence of faulting, lack of distinctive marker beds, and common occurrence of cyclic sedimentation makes correlation between all these sections virtually impossible without very detailed work. On dip the last section ("M") should overlie the second last ("N") and this latter should overlie the creek section and due to lack of any possible correlation between them may well do so. However, the presence of faults is such that this superposition cannot yet be proved.

This, the highest formation in the Permian section in this area, consists of siliceous sandstones dominantly but with some minor conglomerates, mainly quartz-rich with some muscovite and feldspar, well-sorted, with some rounded pebbles of resistant types in a matrix of angular grains. Bedding varies from thin to thick and cross-bedding on a fairly fine scale is common. No consistent current direction is shown but currents from the eastern quarter seem to have been somewhat commoner than those from the west with very few from north or south. As exposed the sandstones are mainly white. Cyclic sedimentation is well shown in several sections with a major sandstone-siltstone alternation on which is superimposed finer alternations of fine-grained white siliceous sandstones with carbonaceous siltstones. These cycles represent changes in competency of the streams in the depositional area with perhaps the development of peaty swamps during times of low competence. The causes of the variations in competence may have been climatic or tectonic but more regional work is needed to establish the cause of the variation. There were at least three major cycles and many minor ones. The siltstones commonly show slumping, cross-bedding and ripple marking as well as the presence of worm tubes of several types. On at least one horizon plant remains are common and include *Glossopteris* spp., *Gangamopteris, Vertebraria, Phyllotheca, Schizoneura* and seeds.

The bores described by Twelvetrees (1902a, b, 1903) are of some interest although neither can now be located accurately. Eden Bore No. 1 was placed north of the railway line (and probably south of the Badger River) fifteen and a half miles from Strahan probably somewhere near cuttings M, N, O, as Eden Bore No. 2 was stated to be 1¼ miles further north-east on the Eden Coal Company's section (probably 4210, 43 M on the West Coast Mineral Chart) and must certainly have been south-west of the fault north of Firewood Siding. This means that Bore No. 1 was almost certainly not east of Cutting Q nor west of Cutting M. In Bore No. 1 it seems likely that the sandstones, shales and coal markings down to 115 feet belong to the topmost formation of the present authors. The beds from 115 feet down to 291 feet consisting of pebbly sandstone and mudstone may be the equivalent of the Ferntree Formation in the Geologists Creek section, the conglomerate between 291' and 309' to the Risdon Sandstone and the underlying pebbly and calcareous mudstones to the marine beds low in the Geologists Creek section. The order of thickness of the marine beds under this correlation is the same as that found in Geologists Creek. The correlations must, however, be regarded as very tentative only, in view of the lack of detailed information about the rocks in the bore. Eden Bore No. 2 passed through 108 feet of sandstone before entering a hard, indurated, broken-up slate which may well belong to the Eldon Group.

The Permian section in this area could be considered as consisting of five formations, a basal carbonaceous, micaceous well-sorted sandstone associated with plant-bearing shales, followed by poorly-sorted sandstones and siltstones with marine fossils, then an "erratic"-rich sandstone, a thick-bedded impure sandstone and finally a well-sorted siliceous sandstone with plant-bearing siltstones. The sequence is summarized in fig. 7.

The lowest formation, in addition to *Glossopteris* and *Gangamopteris*, contains *Noeggerathiopsis hislopi* which is known elsewhere in Tasmania from the lower or Mersey Coal Measures, now roughly correlated with the Liffey Group of McKellar (1957) and the Faulkner Group of Banks and Hale (1957) The succeeding formation contains *Stenopora crinita* which occurse in formations above the Faulkner Group in the Hobart area and at Locality 76, *Schuchertella* and *Camptocrinus* not yet recognized above the Cascades Group in eastern Tasmania. Thus the Cascades Group may be represented here by sediments lithologically like the Malbina Siltstone and Sandstone in the Hobart area. A similar situation probably also occurs at Deloraine and in the Central Highlands.



Composite section of Permian System in Malanna Area

FIGURE 7

The thin, pebbly sandstone may be correlated on lithological and stratigraphical ground with the Risdon Sandstone but this is not at all certain. The thickly-bedded impure sandstones are in the stratigraphical position of the Ferntree Mudstone but are coarser and contain more pebbles. The uppermost formation has in addition to sphenopsids, *Glossopteris* and *Gangamopteris,* many specimens of *Vertebraria* which is known elsewhere in Tasmania from terrestrial sediments correlated with the Cygnet Coal Measures. Thus on the occurrence of *Vertebraria* this formation is correlated with the Cygnet Coal Measures in the south-east. In addition carbonaceous siltstone from this formation is considered (Balme, letter 18.6.1959) to be Upper Permian on palynological grounds.

In this area the marine beds and the correlates of the Cygnet Coal Measures all show signs suggesting closer proximity to the shoreline or source than those near Hobart. The " Woodbridge " correlate is rather coarser than its Hobart equivalent and in addition contains inarticulate brachiopods indicative of shallow water, perhaps shoreline conditions. The correlates of the Ferntree Mudstone are much coarser and contain more pebbles than that formation. The equivalent of the Cygnet Coal Measures has generally much coarser sand grains and a greater preponderance of pebbles and boulders than in the south-east. Of interest also is the fact that the marine beds estimated at 300+ feet thick, are thinner than at Hobart where corresponding beds total at least 885 feet thick.

SECTION ON MT. SEDGWICK.

This seems to have been first noticed by Moore (1894, p. 148) who assigned a coal measure age (= Permian) to it. He became involved in a contoversy with Montgomery (1894, p. 161) who suggested that the beds observed by Moore were due to Pleistocene redistribution of Permian material. Edwards (1941, pp. 19-22) also dealt with the area as part of an exhumed Permian or pre-Permian surface and correlated the beds on Mt. Sedgwick with Voisey's (1938) Achilles Stage on the grounds of the presence of *Spirifer* and *Aviculopecten.* Bradley (1954, p. 199) mentioned the Permian rocks briefly.

On the southern side of Mount Sedgwick (fig. 8) a section of Permian rocks is exposed in creek and cliff sections overlying quartz feldspar porphyries with slate fragments and overlain by dolerite which has baked the Permian. The dolerite contact is irregular and where best exposed is dipping west at a steep angle and cutting across the bedding. The Permian beds have a very low dip to the west. The basement on which the Permian rests varies considerably in height. Just east of Mount Sedgwick Owen Conglomerate occurs at least 200 feet

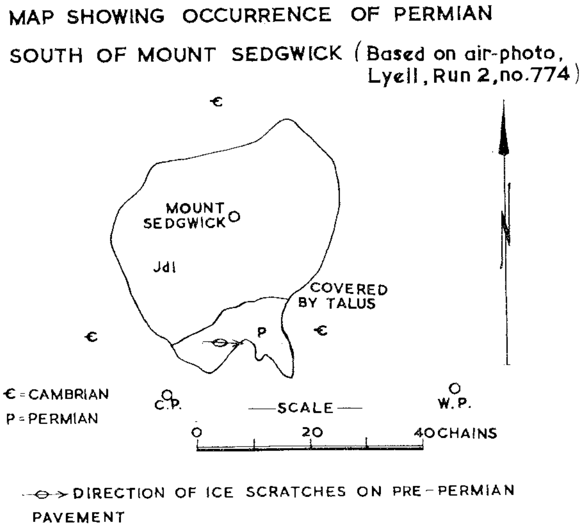


FIGURE 8

above the base of the Permian and has no Permian on it. Just to the west dolerite rests on porphyry about 20 feet above the base of the Permian and the Permian is absent. Thus it seems that there is either a valley in the pre-Permian surface at least 20 feet deep or a post-Permian graben. No evidence can be advanced as yet to favour either hypothesis. The depression occupied by the Permian is no more than 1,500 feet across (i.e., in an east-west direction).

On the southern side of Mount Sedgwick two streams flow south in the Comstock Valley. The section measured began on basement about 100 feet west of the easternmost and bigger stream. The section was carried to the north along cliff sections on the western side of the creek until a narrow shelf was reached which ran back to the foot of the dolerite cliffs. The section was carried north-westerly across this shelf and to the foot of a cliff in Permian then up this cliff to the dolerite contact. The total thickness measured between basement and dolerite was 210 feet approximately.

The contact between the Permian and the underlying rocks is exposed in a cliff section west of the creek mentioned above (1.8 cm., E.N.E., C.P., Lyell Run 2, No. 774). The contact is smooth and striated in some places but is jagged and irregular in other places within ten feet of the smoothed areas. Striations occur on both the slate fragments in the porphyry and on the porphyry itself but are clearer on the slate. The striations trend 106° and are deepest on the west side and shallowest towards the east thus indicating movement of the ice from west to east approximately. The contact is somewhat curved in section suggesting a *roche moutonnée* and it is perhaps significant that the surface is smoothed to the west and jagged to the east. Thus if the contact locally is the surface of a *roche moutonnée*, which cannot be positively established, the smooth upstream surface is to the west, the jagged plucked downstream surface is to the east, this agreeing with the evidence of the striations.

The basal Permian unit which is 39 feet thick (see text fig. 9) consists of well-striated boulders up to four feet in length consisting of porphyry, Owen Conglomerate, slates, quartzites and other rock types, in a poorly-sorted. dark-grey clayey matrix with poorly-marked horizontal fissility. No bedding was apparent. About six inches above the base at one place where the basement is jagged, there is a lense-like body of varved siltstone which is about six inches thick and about 30 inches wide. This lenticular body is slumped along the north-south axis. There is a slight disconformity just above the varved siltstone body. The basal unit is a tillite.

The second unit is a well-sorted pebbly tillite which is six feet thick. Much of the smaller material is lacking and the pebbles are well rounded. Faceting and striations are rare. No bedding is present. It is possibly an outwash deposit of supra-glacial material. This is followed by 14 feet of silicified conglomerate, rather resembling Owen Conglomerate, which differs from the underlying unit only in degree of silification. The next unit consists of six feet of compact conglomerate with small, rounded, mainly siliceous pebbles. This is well sorted. It tends to form the lip of a cliff. It is probably an outwash deposit. A thickness of 50 feet of unfossiliferous thickly-bedded, erratic-rich siltstone follows the conglomerate. The pebbles and boulders show some faceting and striations. This rock was possibly deposited by a floating ice sheet in very shallow water. There follows a thickness of 11 feet of conglomerate with somewhat rounded pebbles and few large boulders. This is possibly an outwash deposit.

The next unit represents a marked change in lithology. It is 11 feet thick and consists of dark-grey, fissile siltstone with a few small pebbles. Near the base this is unfossiliferous but higher up becomes fossiliferous, the main fossils being ramose stenoporids (*S. tasmaniensis*) but with some spiriferids and crinoids.

A limestone, 21 inches thick, succeeds the siltstone. It is medium to dark-grey in colour and fine-grained with a few rather rounded pebbles. Fossils are common and are dominantly stenoperids (*S. tasmaniensis*) although *Eurydesma cordatum* is common and crinoid plates are present. The *Eurydesma* shells are disarticulated and usually convex side up. The stenoporid colonies are broken and the crinoids fragmented.

The succeeding unit is about 63 feet thick and consists of a thickly-bedded, grey, pebbly siltstone with numerous fossils of which *Eurydesma cordatum* is prominent. However, spiriferids and stenoporids also occur in considerable numbers. The last unit is at least 11 feet thick and is a richly fossiliferous siltstone containing some erratics. Close to the dolerite contact it is baked and assumes a light-grey to creamy colour. It is thinly-bedded and rests on the underlying unit with a sharp contact. The fossils are dominantly ramose stenoporids (*S. tasmaniensis*) some of which show

Columnar Section of Permian Rocks on Mount Sedgwick

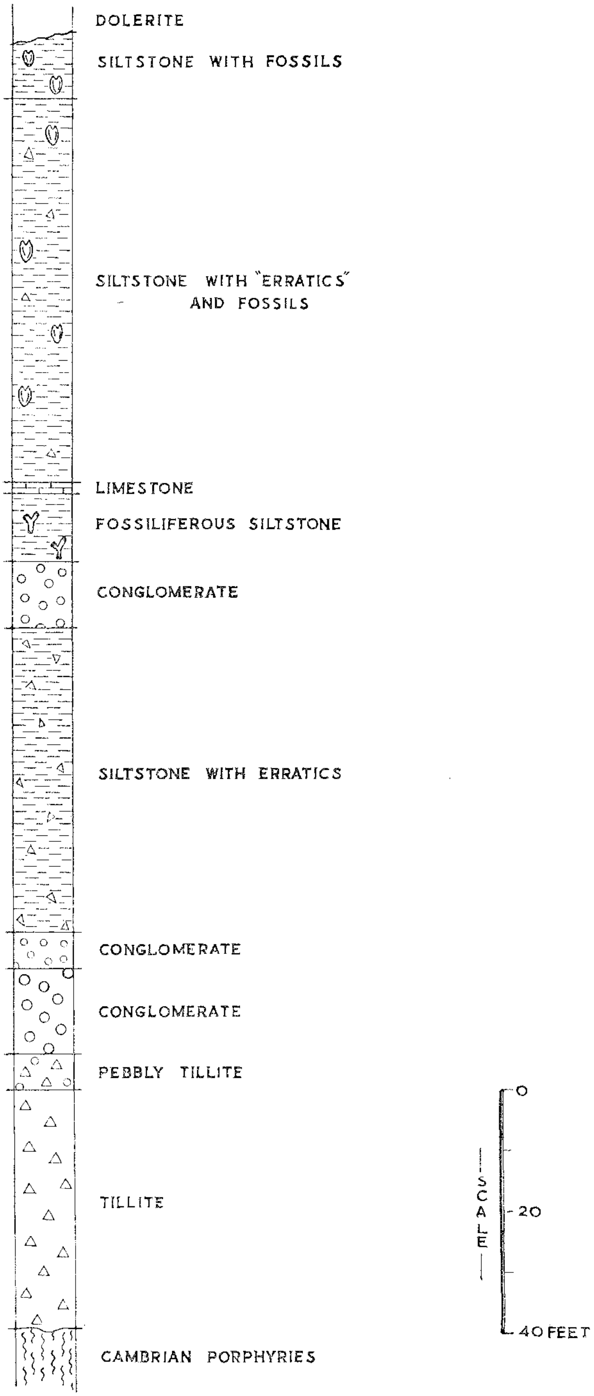


FIGURE 9

marked current orientation. Other fossils however are common and include fenestellids, spiriferids (including *Neospirifer*), *Eurydesma cordatum*, aviculopectinids and other pelecypods, *Peruvispira* and other gasteropods, and *Camptocrinus* and other crinoids (as disarticulated plates).

The succession consists of a basal formation of tillite and outwash conglomerate, then another similar formation differing from the lower one particularly in possessing bedding. The lower one is correlated on lithological and stratigraphical grounds with the Wynyard (= Stockers) Tillite and the higher one with the erratic-rich beds at the base of the Quamby Mudstone at Deloraine. The fissile siltstone which follows this is lithologically like the Quamby Mudstone. The succeeding limestone unit can be correlated with the basal limestone of the Golden Valley Limestone and Shale and with the Darlington Limestone as it is lithologically similar, occupies a similar stratigraphical position and contains *Eurydesma cordatum* and *Stenopora tasmaniensis*. The Darlington Limestone correlate is followed by a pebbly fossiliferous siltstone and this by a fossiliferous siltstone. These are correlated on stratigraphical and palaeontological grounds with the higher parts of the Golden Valley Group near Deloraine and the formations above the Darlington Limestone at Darlington (Banks, 1957). The section does not go high enough to include the Liffey Sandstone and its correlates.

The basal formation indicates initial terrestrial glaciation followed by an ice retreat (units 2, 3, 4). The next formation marks a second advance of the ice sheet which was possibly not grounded and was floating in a shallow water, possibly a marine basin. This second advance was less intense than the earlier one and the sheet thinner. This was followed by further retreat leading to the development of outwash. Shallow marine conditions succeeded the formation of outwash, in which the icebergs deposited small erratics in the silt. Then the limestone unit represents reduction in the amount of clastic material supplied to the site of deposition and rich marine life. Some icebergs were still present. The next formation indicated a third ice advance but in a deeper sea with icebergs depositing erratics. This third phase of the glaciation was less intense than either of the earlier phases. The topmost formation shows a decreased intensity of glaciation, possibly marking the retreat from the third phase maximum. Lack of outwash deposits also supports the idea of floating ice.

SECTION AT STRAHAN.

This deposit was probably first noted by Moore (1896b, p. 74) in a paper read before the Royal Society of Tasmania in August, 1895, and by Officer, Balfour and Hogg (1895) who noted a "deposit of unstratified or faintly stratified clay of great hardness . . . " which contained some boulders which bore striae. They remarked that similar deposits occurred on Mount Sedgwick and Mount Tyndall. The Strahan deposits were considered to be Pleistocene by Moore because they contained no erratics "foreign to the country". Moore (1896b, p. 75) also noted another outcrop of a similar sort of rock two miles north-east of the outcrop being discussed on "Gould's old track". Lewis (1939, p. 165) commented on these deposits which he considered to be a Pleistocene moraine, associated with the "fluvio-glacial" terraces at Strahan.

Road cuttings on the Queenstown-Strahan Road between 3 miles and 1½ miles from Strahan expose a tillitic conglomerate. It shows some fissility and rough bedding which dips south-east at a low angle. This rock contains boulders up to two feet in length of greenish quartzite. quartz, very fine-grained black quartzite, slate, greywacke conglomerate like those of the Dundas Group and a biotite rich granite. Despite careful search no boulders of Owen Conglomerate or dolerite were seen. Some of the boulders are faceted and striated. The rock shows marked fracture planes and in places both matrix and boulders are badly shattered. There are a few beds of sandstone with rare rounded boulders and good bedding. On the whole sorting is very poor but there are lenses of comparatively well-sorted material which may be buried ice deposits or deposits of melt water streams. Boulders in the main body of the rock are more rounded than might be expected in a sub-glacial terrestrial till, and this rounding may have been produced by water transport.

On the first cutting south of the S 2 milepost steep faces trending 76° show slickensides which are either horizontal or dip slightly south and indicate north side west movement.

The present authors regard these beds as Permian because of their degree of lithification reflected in the fracturing of matrix and boulders, the jointing and the slickensiding. They have the same degree of lithification as is common in the known Permian beds in this region (e.g., the Firewood Siding and Geologists Creek area and on Mount Sedgwick) and considerably greater than that of the alleged Pleistocene beds at Strahan and Malanna. Lack of dolerite boulders and of Permian boulders also points to a Permian age but this lack can also be explained on the assumption of a Pleistocene age with a source in the West Coast Range just east of Strahan where neither Permian sediments nor dolerite are known. However. if the source was in this area the lack of Owen Conglomerate boulders is very difficult to understand. The slickensiding and movement implied by it are in keeping with slickensides and movements in the Permian near Firewood Siding. Thus the bulk of evidence suggests a Permian rather than Pleistocene age but no Permian fossils were found in it. This, however, is common in the glacial beds near the base of the Permian System in Tasmania.

The poor sorting of the bulk of the material together with faceting and striation of some boulders indicate some glacial transport. Increase in percentage of smaller boulders and clay and silt grades indicates some sorting, although of a low order, which is confirmed by crude bedding and sandstone layers. On the whole the deposit indicates the possibility of deposition in aqueous conditions of some of the sediment. Possibly these deposits were laid down by an ice sheet which was not thick enough all the time to remain grounded but when the ice sheet was grounded the meltwater lenses may have been deposited whereas when floating, the tillitic conglomerate was formed.

Lithologically, these beds resemble those between 65 and 115 feet above the base of the section on Mount Sedgwick (see fig. 9) and beds near the top of the Stockers Tillite and the base of the Quamby Mudstone in the Deloraine area.

SECTION AT POINT HIBBS.

The only previous work on Permian rocks at Point Hibbs is that of Hills (1914) who noted the presence of fossiliferous mudstone conglomerate which he regarded as equivalent to the basal beds of the Permian System in other parts of Tasmania. His work was later quoted by Voisey (1938). The authors have examined the Permian section both north and south of Point Hibbs (see map, fig. 10).

On the northern shore the Permian is faulted against a Devonian limestone at the eastern end. Near the contact the limestone is sheared but the Permian is affected by the fault only to the extent of a shearing trending north-westerly in some of the finer beds near the contact. The Permian at the contact dips 275° at 85° and maintains this steep westerly dip for nearly a thousand feet. At this point it is affected by another fault and after a belt of variable strikes and dips some 20 yards wide maintains a dip of 38° to the south-west (237° to 255°) for about a hundred yards before dipping under dolerite. Almost at the dolerite contact the dip is 255° at 38° and the contact although irregular in detail, trends 318° over the length of its exposure on the shoreline. This trend would carry the contact west of Hibbs Pyramid, which is reported to be dolerite, so that there is probably either a marked swing in the trend or a fault. The dolerite has produced intense contact metamorphism in the Permian sediments for a hundred yards from the contact.

Because of the faulted contact with the Devonian limestone, the lower part of the Permian section may be missing. The lowest bed exposed is a conglomerate about two feet thick composed of numerous small angular rock fragments in a matrix of angular, coarse sand. The grains in the matrix are equant. There is no bedding within the unit but there is a north-west trending fissibility, probably due to shearing. The rock is medium-grey in

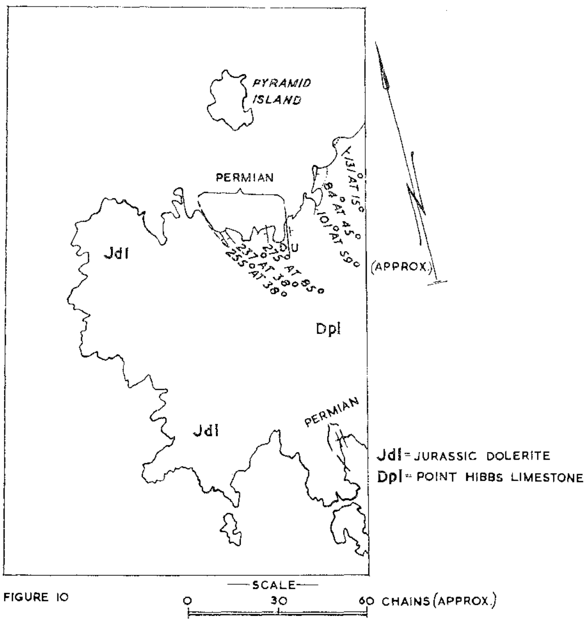


FIGURE 10

N.B.—The island shown as Pyramid Island should be called Hibbs Pyramid.

colour. Some of the boulders in it are striated and reach a length of one foot. One remarkable feature noticed was the lack of boulders of the adjacent limestone. This bed is overlain by 11 feet of conglomerate, interpreted as an outwash, which is relatively well sorted and contains somewhat rounded pebbles and boulders up to a foot long and lenses of tillitic material. The boulders include many of granite, some of a feldspar porphyry and quartzite including a green quartzite.

The outwash conglomerate is followed by 93 feet of tillite containing several thin beds of outwash conglomerate near the base. After a gap of 30 feet, siltstone outcrops for a thickness of 85 feet. This contains a lense of pyritic limestone twelve feet above the base and pyrite nodules at higher levels. It is a dark-grey, somewhat fissile rock with wavy laminations in places. A few pebbles which tend to be rounded occur near the base. A thinly-bedded siltstone unit 84 feet thick follows. The bedding is usually less than an inch thick but may reach two inches in thickness. Some of the siltstone is calcareous and there are a few cross-bedded sandy bands. Erratics are rare but pyrite nodules are common. The only fossils present are some worm burrows.

The next unit is 205 feet thick and consists of twenty alternations of fine-grained sandstone (or coarse siltstone) and "erratic"-rich sandstone in which the fine-grained sandstone is dominant as far as thickness is concerned. The fine-grained sandstone consists of angular, equant fragments of quartz, feldspar, rare white mica and carbonaceous material with a few erratics. It is medium-grey in colour and bedding planes are four inches to eight feet apart. It is brittle rather than fissile. Fossils are absent or rare in this rock type in the lower part of the unit but a little more common higher up. They include *Stenopora, Fenestella,* spiriferids, *Strophalosia, Eurydesma cordatum,* aviculopectinids, a euomphalid gastropod and crinoid columnals. Cross-bedded sets up to eight inches thick are present and the currents came from a southerly direction. One sandstone band about 10 feet thick above the base showed ripple marks with a trend of 340° when restored and cross-bedding formed by a current flowing from 225°. This sandstone contains plant fragments. Associated with the fine sandstone are at least twenty-one beds of "erratic"-rich sandstone which stands up several inches to two feet above the platform cut in the fine sandstone. These bands vary from six inches to nine feet thick. They are composed of the same minerals as the fine sandstone but they are perhaps a little coarser. In places the cement is calcareous. Bedding varies in thickness from six inches up to several feet. Their characteristic feature is that they contain numerous "erratics" up to four feet long which are angular to sub-angular and include granites, porphyries, quartzites, quartz, quartz schist, gneiss, green quartzite and rarely limestone like that immediately to the east. These "erratic"-rich bands are not tillites as they appear to contain little if any clay matrix and within any one band there is some sorting, although it is only middling good. Another feature of these bands is their richness in fossils especially *Eurydesma cordatum* and gastropods such as *Keeneia* but spiriferids, *Stenopora* and gastropods like *Peruvispira* also occur. The *Eurydesma* is articulated, disarticulated, or fragmented, the fragments lacking orientation. About 110 feet above the base the fine sandstone contains large limestone lenses with *Stenopora, Fenestella, Strophalosia,* spiriferids, *Eurydesma, Aviculopecten* and *Calcitornella.*

This unit of alternating sandstone and "erratic"-rich bands is followed by fifty-six feet of siltstone with rare erratics up to six inches long and numerous fossils. It is very dark grey. The siltstone contains rare small calcareous concretions which contain *Calcitornella* and numerous glendonites which are commonly single crystals up to six inches long and only rarely rosettes with up to three crystals. One glendonite grew around a specimen of *Eurydesma,* Fossils are very common and include numerous *Stenopora tasmaniensis,* fenestellids (very common in some bands), spiriferids including *Grantonia, Neospirifer* and *Ingelarella, Eurydesma cordatum, Notomya,* aviculopectinids and *Keeneia.* The numerous extensive colonies of *Stenopora tasmaniensis* are preferentially oriented in many places suggesting currents from the north-west, north or north-east.

The next unit, which is 430 feet thick consists of four cycles, each cycle consisting of a basal member of banded conglomeratic siltstone and siltstone and the higher one of siltstone. The lowest cycle is 65 feet thick and of this 59 feet are conglomeratic siltstone and siltstone and six feet of silstone. In the second cycle there are nine feet of siltstone and conglomeratic siltstone and then 37 feet of siltstone. The next cycle is 125 feet thick with the basal member 103 feet thick and the upper one 22 feet thick. The final cycle is 295 feet thick with a basal member only five feet thick. There is a further major cycle in that in the first and third cycles the basal member is the thicker one while in the second and fourth the upper member is the thicker.

The lowest cycle contains numerous fossils, especially in the pebbly bands, and these include *Eurydesma cordatum, Keeneia platyschismoides, Stenopora tasmaniensis,* spiriferids, *Peruvispira* and fenestellids. The siltstones have wavy laminations. In the basal member of the third cycle fossils are again very abundant on some horizons and in the top member an 18-inch-thick limestone bed occurs. This is very impure and contains numerous "erratics". Fossils are not common in the limestone but include worm burrows and a bilaminar *Stenopora* very like *S. johnstoni.* The higher member of the fourth cycle is fossiliferous and the fossils include *Stenopora* and *Eurydesma.* Erratics up to 18 inches long occur in the siltstone member and a band of "erratics" occurs 146 feet above the base of the member. Erratics again become common near the top of the formation.

The belt of shattering and variable strike interrupts the section at this level. Beyond it at least 200 feet of alternating sandstone and siltstone occur in which the beds are usually two to three feet thick but one more than 20 feet thick is present. Bands of pebbles are present in the sandstone and erratics are present in the siltstone. The erratics are dominantly quartzite and are up to six inches long. Fossils are abundant on some horizons. They include gastropods, fenestellids, *Stenopora Aviculo-*

SECTION OF PERMIAN ROCKS ON NORTH SIDE OF POINT HIBBS

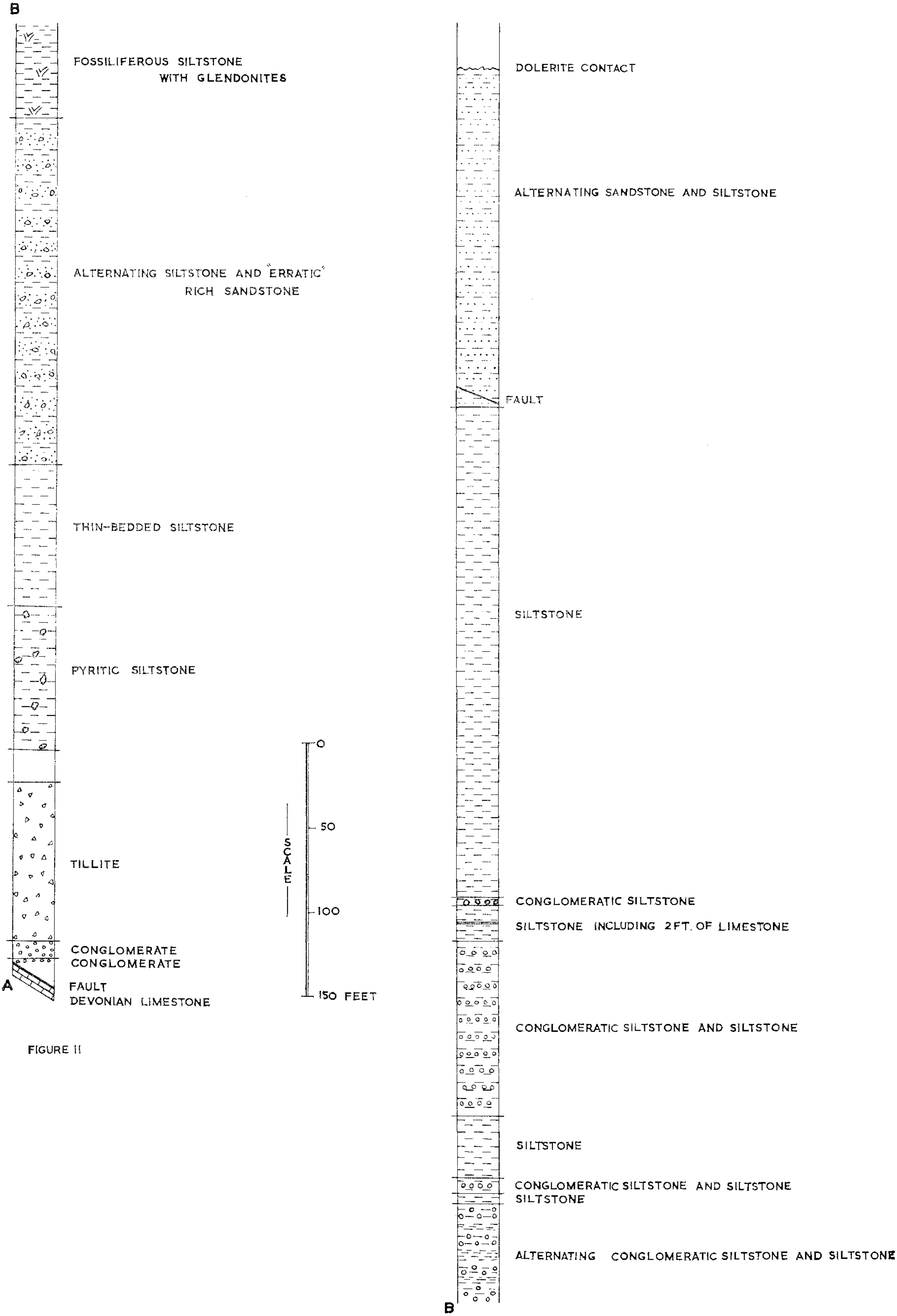


FIGURE 11

pecten subquinquelineatus, Eurydesma cordatum, E. cordatum var. *sacculum* and spiriferids including *Ingelarella.* The section is terminated by a dolerite intrusion.

The Permian section on the north shore of Point Hibbs is summarized here as fig. 11.

It will be seen that at least 1,200 feet of clastic sediments are present. The lowest 106 feet of dominantly glacial origin, might be correlated with the Wynyard Tillite. The next major unit could be considered as composed dominantly of pyritic siltstone with some calcareous concretions and rare sandstone bands. It is at least 174 feet thick but there is a 20-feet gap between it and the underlying formation. This might be considered on lithological and stratigraphical grounds as equivalent to the lower part of the Quamby Group (= Quamby Mudstone of Wells, 1957) and the Woody Island Siltstone. The next major lithological break is at the top of the alternating sandstone and pebbly sandstone, 205 feet thick. Fossils become abundant in the next unit, 56 feet thick, which consists of siltstone with glendonites. The fossils indicate a position low in the Permian sequence in Tasmania and the presence of glendonites strongly suggests correlation with part of the Woody Island Siltstone as these pseudomorphs are known from this formation and its correlates in eastern and northern Tasmania. The formation showing the four cycles follows this and is 430 feet thick. The thin limestone bed in the third member may be the Darlington Limestone as it is roughly in the correct stratigraphic position and contains some of the fossils from that formation. However, this cannot be regarded as established. It occurs within a unit 20 feet thick of siltstone much more richly fossiliferous than the adjacent beds and this strengthens the correlation with the Darlington Limestone. If the richly fossiliferous beds elsewhere are accepted as being at or near the base of the Golden Valley Group (= Formation of Wells, 1957), the base of the correlate of this group in the Point Hibbs area might well be considered as the base of the 20 feet of richly fossiliferous beds. The beds above this 20-feet unit consiting of at least 44 feet of alternating siltstone and conglomerate then sandstone and siltstone might then be considered equivalent to the higher units of the Golden Valley Group such as the Macrae Mudstone and Billop Sandstone of McKellar (1957) and the Bundella Mudstone of Banks and Hale (1957). The Mersey Group of fresh-water beds does not seem to be present but it is not impossible that they are represented here by marine sediments.

Permian rocks also occur on the south side of Point Hibbs (see fig. 10). They are faulted on the east against Devonian limestone which dips steeply east, and are intruded on the west by dolerite. The total thickness would not exceed 300 feet of which 250 feet are exposed in the shore section at the head of the bay. The Permian itself dips steeply to the east near the limestone and is apparently overturned and on the west side of the bay dips west at about 80°. The lowest (i.e., easternmost) exposed bed is a pebbly sandstone with fragmentary fossils. Higher up are siltstones with erratics and some beds of limestone. *Stenopora tasmaniensis* is particularly common in these. The topmost unit consists of interbedded pebbly sandstones and siltstones. The sandstones are richly fossiliferous . The dolerite has highly indurated the sandstone. Fossils in the Permian rocks in this bay include *Stenopora tasmaniensis, S. johnstoni* and a fine ramose stenoporid, fenestellids, *Strophalosia*, spiriferids including a large *Ingelarella*, pelecypods including numerous large *Eurydesma cordatum* and aviculopectinids and gastropods . The beds close to the western side of the bay where limestone is commonest are probably close to the Darlington Limestone in age judging from the presence of *S. johnstoni* and the lowest beds exposed would be about the level of the "Erratic Zone" on Maria Island.

One feature of the Point Hibbs section is the cyclic sedimentation. On a fine scale there are alternations of siltstone and sandstone, siltstone and conglomerate or sandstone and pebbly sandstone. In many cases fossils are much commoner in the pebbly beds but this is not invariable as some of the siltstones with few erratics are also fossiliferous. These alternations are themselves grouped into larger cycles with the banded sediments alternating with siltstone. On an even greater scale the succession may be considered as glacial beds, followed by siltstone, banded sandstones, siltstone, and then five cycles of alternating banded siltstone and siltstone. Explanation of these cycles requires more regional data than it is appropriate to present here.

SUMMARY AND CONCLUSIONS.

Permian tillite and fossiliferous siltstone occurs on the western end of Mount Read occupying depressions in a partly exhumed pre-Permian surface of Dundas Group rocks. The section is not clear but the Wynyard Tillite and Quamby Group are thought to be represented. At Mount Sedgwick the Permian rests on a striated surface of Dundas Group rocks. The striations indicate movement of ice from west to east. The section includes a basal tillite then rocks of the Quamby and Golden Valley Groups but these are considerably thinner than in eastern and north-western Tasmania. Near the mouth of the Henty River Permian rocks are faulted against older Palaeozoic sediments. The oldest Permian rocks recognized are correlated with the Mersey Group and include some coal. These are followed by the "Woodbridge" Group, Ferntree Group and Cygnet Coal Measures. All these groups are thinner than in south-eastern Tasmania and generally of coarser grainsize. Near Strahan a fluvio-glacial conglomerate occurs and is correlated with the top part of the Wynyard Tillite. At Point Hibbs a section from somewhere within the Wynyard Tillite up to at least into the Golden Valley Group is well exposed. The Quamby and Golden Valley Groups are comparable in thickness with their equivalents near Deloraine and Cressy and perhaps thicker than the sections in south-eastern Tasmania (see fig. 12).

Evaluation of these variations in thickness must await more regional data.

GEOLOGICAL HISTORY.

It would appear from the evidence quoted earlier that early in the Permian Period, Western Tasmania was covered by an ice sheet which in places moved

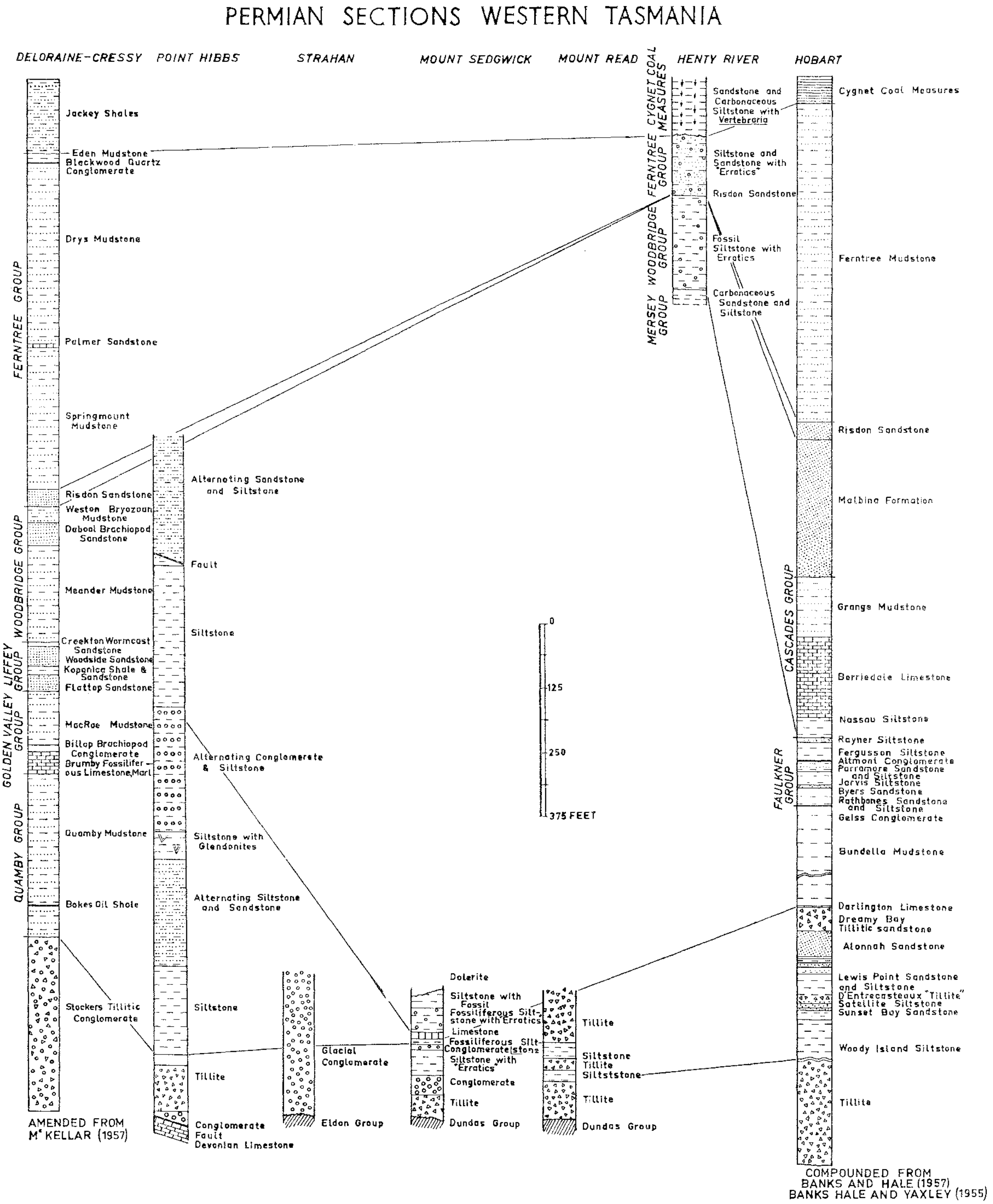

PERMIAN SECTIONS WESTERN TASMANIA
DELORAINE-CRESSY
POINT HIBBS
STRAHAN
MOUNT SEDGWICK
MOUNT READ
HENTY RIVER
HOBART
Jackey Shales
Eden Mudstone
Blackwood Quartz Conglomerate
Drys Mudstone
Palmer Sandstone
Springmount Mudstone
Risdon Sandstone
Weston Bryozoan Mudstone
Dubool Brachiopod Sandstone
Meander Mudstone
Creekton Wormcast Sandstone
Woodside Sandstone
Kopanica Shale & Sandstone
Flattop Sandstone
MacRae Mudstone
Billop Brachiopod Conglomerate
Brumby Fossiliferous Limestone, Marl
Quamby Mudstone
Bokes Oil Shale
Stockers Tillitic Conglomerate
FERNTREE GROUP
WOODBRIDGE GROUP
LIFFEY GROUP
GOLDEN VALLEY GROUP
QUAMBY GROUP
AMENDED FROM M^c KELLAR (1957)
Alternating Sandstone and Siltstone
Fault
Siltstone
Alternating Conglomerate & Siltstone
Siltstone with Glendonites
Alternating Siltstone and Sandstone
Siltstone
Tillite
Conglomerate
Fault
Devonian Limestone
Glacial Conglomerate
Eldon Group
Dolerite
Siltstone with Fossil
Fossiliferous Siltstone with Erratics
Limestone
Fossiliferous Siltstone
Conglomerate
Siltstone with "Erratics"
Conglomerate
Tillite
Dundas Group
Tillite
Siltstone
Tillite
Siltststone
Tillite
Dundas Group
0
125
250
375 FEET
CYGNET COAL MEASURES
FERNTREE GROUP
WOODBRIDGE GROUP
MERSEY GROUP
Sandstone and Carbonaceous Siltstone with Vertebraria
Siltstone and Sandstone with "Erratics"
Risdon Sandstone
Fossil Siltstone with Erratics
Carbonaceous Sandstone and Siltstone
Cygnet Coal Measures
Ferntree Mudstone
Risdon Sandstone
Malbina Formation
Grange Mudstone
Berriedale Limestone
Nassau Siltstone
Rayner Siltstone
Fergusson Siltstone
Altmont Conglomerate
Parramore Sandstone and Siltstone
Jarvis Siltstone
Byers Sandstone
Rathbones Sandstone and Siltstone
Geiss Conglomerate
Bundella Mudstone
Darlington Limestone
Dreamy Bay Tillitic sandstone
Alonnah Sandstone
Lewis Point Sandstone and Siltstone
D'Entrecasteaux "Tillite"
Satellite Siltstone
Sunset Bay Sandstone
Woody Island Siltstone
Tillite
CASCADES GROUP
FAULKNER GROUP
COMPOUNDED FROM BANKS AND HALE (1957) BANKS HALE AND YAXLEY (1955)

FIGURE 12.

from west to east over a surface with a relief of possibly a couple of hundred feet. On the evidence of the boulders present in the basal tillite and overlying fluvio-glacial or glacial beds the area overridden by the ice included conglomerates like the Owen Conglomerate, grewacke conglomerates like those in the Dundas Group, quartzites like those in the Eldon Group, some of them with fossils, black quartzites, green sandstone, slates including black slates, porphyries of several types including feldspar porphyries and a biotite rich granite. The lack of erratics similar to local Precambrian rocks is remarkable.

The ice later retreated depositing a sequence of glacial and fluvio-glacial beds. At least one readvance of the ice sheet is recorded in the section on Mount Sedgwick. Following retreat of the ice, sands and pebbly sands were deposited in a cyclic fashion, the cycle representing perhaps minor retreats and advances of the glacial front or influx of turbidity currents into the area from time to time. At Point Hibbs at least these sands were marine. "Erratics" of quartz schists and gneiss of a local Precambrian type occur at this level. Perhaps contemporaneously at Mount Sedgwick pebbly silts were being deposited.

Further retreat of the ice front led to deposition of siltstones containing few erratics, calcareous concretions and glendonites. This type of rock is much thicker at Point Hibbs than at Mount Sedgwick where it also lacks the glendonites, and concretions. These siltstones are marine and were probably formed under conditions of poor circulation. .They contain no structures or fossils characteristic of deep water but at the same time contain no clear evidence of shallow water deposition.

There is a break in the record of Permian sedimentation in Western Tasmania in the next rocks exposed being the lacustrine and paludal beds of the Mersey Coal Measures. These terrestrial conditions were followed by an inundation of the land by the sea. Pebbly siltstone, sandstone and impure limestone were deposited and at times marine life was abundant . It was mainly of shallow water benthonic forms. Some evidence suggests that this area was closer to the source and that the sea was shallower than at Hobart. After retreat of the sea erosion occurred before deposition of pebbly sands, silts and carbonaceous silts in lakes and swamps. There were several variations in the competency of the currents in the area of deposition. Plant life was abundant and included pteridosperms and equisetales.

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LOCALITY INDEX.

Badger River	Strahan	41°	59′	145°	14′
Comstock Valley	Lyell	42°	02′	145°	39′
Darlington	Maria Is.	42°	35′	148°	04′
Deloraine	Quamby	41°	31′	146°	22′
Derrinal, Victoria	—	36°	53′	144°	36′
Firewood Siding	Zeehan	41°	59′	145°	16′
Geologists Creek	Strahan	42°	00′	145°	16′
Henty River	Strahan	42°	02′	145°	18′
Hobart	Hobart	42°	52′	147°	20′
Malanna	Zeehan	41°	59′	145°	13′
Maria Island	Maria Is.	42°	37′	148°	06′
Moores Pimple	Zeehan	41°	02′	145°	28′
Mount Dundas	Zeehan	41°	52′	145°	29′
Mount Hamilton	Murchison	41°	50′	145°	30′
Mount Read	Zeehan	41°	50′	145°	30′
Mount Sedgwick	Lyell	42°	00′	145°	35′
Mount Tyndall	Murchison	41°	57′	145°	3′4
Pieman River	Pieman River	41°	40′	145°	02′
Point Hibbs	Pt. Hibbs	42°	43′	145°	15′
Strahan	Strahan	42°	10′	145°	20′
Zeehan	Zeehan	41°	53′	145°	17′