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1. CHIEF PHYSIOGRAPHIC UNITS

The chief physiographic units of Tasmania are

1. The Central Plateau
2. The Southern Highlands
3. The Ben Lomond Highlands
4. The North-western Peneplain,
5. The Eastern Peneplain
6. The Western Coastal Plain
7. The Launceston Tertiary Plain
8. The Northern Coastal Tract.

1. The Central Plateau occupies the central portion of the State. The surface is not uniformly level but ranges in height from 2500 to 5000 feet above the sea. The general slope is to the south especially of the eastern half, which corresponds to the drainage being effected by south flowing streams. The western boundary is represented by the West Coast Range which presents a steep face to the west. The northern and eastern boundaries are represented by the Western Tiers which present very steep slopes to the north and east. The steep face disappears to the south and west of Lake Sorrell, but its continuation to the south is suggested by Woods Quoin, Mt. Dromedary, Mt. Wellington &c. The lower altitude of the southern part of the Plateau is due largely to the erosion by the Derwent and its numerous tributaries.

11. The Southern Highlands represent the southern continuation of the Central Plateau. Only a small portion now remains above 3000 feet above sea level, but this appears to have been due largely to the erosion of the Derwent, Huon and Gordon river systems.

The eastern boundary is represented by the highly dissected continuation of the Western Tiers south from Lake Sorrell and Crescent as indicated above in the discussion of the Central Plateau. The western boundary is represented by the high ranges which trend parallel to the south-west coast. The north-western portion is continuous with that of the western portion of the Central Plateau. To the south, the highlands extend as far as the south coast.

111. The Ben Lomond Highlands represent the elevated regions in north-eastern Tasmania with elevations between 2500 and 5000 feet. They are separated from the Central Plateau by the Launceston Tertiary Basin. To the north, east and south they are surrounded by the Eastern peneplain.

1V. The North-Western Peneplain was first recognised by J.W. Gregory. It extends generally between the Pieman and Arthur Rivers with an eastward extension towards Moina. It is particularly noticeable around Waratah and Middlesex, where its surface is covered by basalt flows. Towards the west, its surface is largely dissected and Norfolk Range

represents its westerly extent. Mts. Heemskirk, Zeehan &c. probably represent dissected remnants of its southern extension. Its western boundary is formed by the Western coastal plain. Its eastern boundary is formed by the West Coast Range and the western and north western edges of the Central Plateau. To the east it cannot be traced further than the Moina district. The northern boundary is indefinite, due largely to the erosion of the north flowing streams entering Bass Strait, and probably to other causes such as downwarping &c.

V. The Eastern Peneplain The region east of the Western Tiers - Mt. Wellington line, with the exception of the Ben Lomond highlands and the Launceston Basin, represents a dissected peneplain with an elevation of 2000 to 2500 feet above the sea. The northern portion includes the Pre-Permo-Carboniferous peneplain which has been almost completely re-exposed by denudation. A number of monad-rocks rise above the general level of this portion of the peneplain, which surrounds the Ben Lomond highlands on the northern, eastern and southern sides.

VI. The Western Coastal Plain consists of a narrow tract, ranging in width up to 12 miles, which fringes the west coast from Arthur River on the north to Low Rocky Point in the south. It may extend further north than the Arthur River and also east along the north coast, but has not been definitely recognised. It is generally found to extend to the present west coast and to be terminated by cliffs averaging 100 to 200 feet in height. Inland its surface (now partly dissected) rises gradually to heights of 700 to 900 feet above the sea. Numerous portions of this plain have been recognised and named by investigators such as Western peneplain and Henty peneplain (Gregory, 1904) (), Pieman peneplain (Ward, 1909), Little Henty peneplain (Twelvetrees and Ward, 1908), and Coastal peneplain (Ward, 1910) and Darwin (Hills, 1913) (). It has also been described at other places in unpublished geological reports of the Mines Department. In some portions and particularly in the Low Rocky Point district, shallow layers of gravel occur on its surface. In the North Dundas, Strahan, and Low Rocky Point districts, glacial or fluvio-glacial deposits occupy portion of its surface, such deposits being most extensive in the Strahan district.

Though referred to as a coastal plain, there is no evidence of marine deposits upon it, unless the Miocene limestones &c. at Temma occupy such a position. Its age however is probably later than Miocene and the limestones at Temma may be incorporated as part of the surface of the plain.

It must be noted that Ward (1909) connected the Pieman peneplain with the North-Western peneplain and that Waterhouse (1913) also connected the Western Coastal plain with the North-Western peneplain. Hills (1913) correlated all the peneplains and in 1921 (1) referred to them as the Darwin Peneplain.

However, the Coastal plain is so definitely a coastal feature with a seaward slope and as its surface inland does not exceed 1000 feet above the sea, that it appears to be distinct from the North Western peneplain

(2000 feet) and should be separated therefrom. The possibility of it forming a warped or tilted portion of the North-western plain cannot, however, be entirely overlooked.

VII. The Launceston Tertiary Basin is a tract of country not exceeding 1000 feet above sea level and representing the greater part of the drainage system of the Tamar and South Esk Rivers. It lies between the Central Plateau on the west and the Ben Lomond highland and Eastern peneplain on the east and has a general trend from south-east to north-west.

VIII. The Northern Coastal Tract. This tract is not definitely a physiographic unit as are the above and it may be composite in origin. Hills () considered the Western Coastal plain to extend easterly to Wynyard. Later he () correlated the Coastal plain and the North-Western (or Darwin) peneplain as one and considered it to extend to the Mersey River. The North-Western peneplain certainly extends as far as the Forth River, but the evidence of the coastal plain is not so definite. There may be a tilted block between the peneplain and the coast, but its recognition has been obscured by basalt flows and subsequent erosion.

The Launceston basin crosses the coastal tract further east. East of the Launceston basin, there is more definite evidence of a coastal plain extending to the north-eastern corner of the island. In the Lilydale district there is definite evidence of tilting towards Bass Strait from the level of the Eastern peneplain down to 500 feet above sea-level.

2. COASTAL PHYSIOGRAPHY.

1. Features due to Submergence

Drowned Valleys are a common feature around the coasts of Tasmania, and many fine examples are present at the mouths of the principal rivers. The most prominent are those of the Tamar River, Derwent River, Huon River, Port Davey, and Macquarie Harbour, but many other rivers also exhibit the same feature. On the north coast, Duck Bay represents the drowned portion of Duck River, and Port Sorell that of the Rubicon River, while the lower portions of the Flowerdale, Leven, Forth, Mersey, and Ringarooma Rivers have also been drowned. On the east coast Ansons Bay represents the drowned portion of the Anson River, St. Georges Bay that of the George River, parts of the Moulting Lagoon and Oyster Bay, that of the Swan River, while the mouths of the Swan Port and Prosser Rivers have also been

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() Tas. Geol. Surv. Bull. Nos. 6, 8, 10 and 16.

() Hills, Loftus, Progress of Geological Research in Tasmania since 1902. Proc. Roy. Soc. Tas. 1921

drowned. On the south coast the mouths of the Dover, Lune, Catamaran and New Rivers have been flooded. On the west coast, the mouths of the Pieman, Lewis and probably other streams have been flooded.

The effect of submergence is especially prominent in the south-eastern districts. The drowned valleys of the Derwent and Huon have already been referred to above. D'Entrecasteaux Channel represents the flooded portions of either the lower part of the Derwent River or what is more likely of tributaries of the Derwent and Huon Rivers. Frederick Henry and Norfolk Bays (or portions thereof) represent the flooding of the lower parts of Coal and other rivers. Many of the tied islands now joined to the mainland or to one another such as those of South Arm, Tasman's Peninsular, Bruni Island &c. were also formed by submergence. Coastal Islands are fairly common. Bruni Island is one of the best examples of a coastal island, and was isolated by the formation of D'Entrecasteaux Channel as described above. The Furneaux group of islands (including Flinders, Cape Barren &c.) have also been formed by submergence) that involved in the formation of Bass Strait).

The Hunter group (including Hunter, Robbins &c) on the north-west coast are also coastal islands. Maria and Schouten Islands on the east coast are possibly also coastal islands formed by submergence. The numerous rocks and islands in Macquarie Harbour, Port Davey, and around the coasts of Storm Bay and in Frederick Henry and Norfolk Bays are obviously coastal islands.

11. Features due to Emergence. Several features due to emergence are recognisable around the coasts. While these are generally of Recent emergence, some are geological older, possibly extending back to the Pleistocene epoch or slightly older.

Coastal Plains. The Coastal Plain of the west coast has been described above. While it is not claimed that all of this plain is of marine origin, it is possible that some portions may be. If this is so the emergence occurred before the Pleistocene glacial epoch.

Old Raised Beaches &c. On Flinders Island and probably other islands of the same group, marine Werrikoonian beds have been elevated above sea level. At Mowbray Swamp, marine (and freshwater) Pleistocene beds have been similarly elevated. The sands, gravels and clay of the Gladstone district, the clays and gravels of St. Helens, and the sands of Five and Seven Mile Beaches (Frederick Henry Bay) are generally of similar age. The two latter represent extensive raised beaches, but the others are still more extensive and are included here for descriptive purposes and because of their part in determining the present coast line.

Raised Beaches. Raised beaches of Recent age are fairly common features around the coasts, but very few have been described. Generally they occur at the mouths of streams

() Tas. Geol. Surv. Bull. No. 13., 1913.

() Hills, Loftus, Progress of Geological Research in Tasmania since 1902, Proc. Roy. Soc. Tas., 1921.

and more or less merge into alluvial deposits further inland. The amount of elevation represented by these beaches is 10 to 15 feet. Such beaches are known to occur at Sandy Bay, Kingston, Snug, Cox Bight Narracoopa and numerous localities along the northern coast.

An interesting raised beach, some 30 to 40 feet above present sea-level occurs in the township of Stanley. The beach deposits consists of boulders of basalt up to one foot in diameter with internal casts of a large limpet (probably *Cellana limbata*) adhering to the boulders.

Rock-benches appear to be absent from the Tasmanian coasts.

Tied Islands are common in the southeastern and also to a less extent in the north-western districts. Bruni Island consists of two tied islands, as also does Maria Island. Tasman Peninsula is a tied island joined to Forestier Peninsula by Eaglehawk Neck, Forestier Peninsula is itself joined to the mainland by East Bay Neck. The South Arm peninsula is joined to the mainland by Ralph Bay Neck, while another neck connects South Arm with the remainder of the peninsula, which is therefore formed by two tied islands. Parts of Freycinet Peninsula are probably tied islands.

On the north-west coast, the Nut is probably a tied island forming part of the Stanley Peninsula.

111.

Coastal Faulting. The problem of coastal faulting has not been investigated to any extent. In general it would appear that the Tasmanian coasts have been largely determined by faulting and possibly warping. The East Coast between Eddystone on the north, and Freycinet Peninsula on the south with its remarkably straight line, short coastal streams and the central drainage rising within a few miles of the coast is strongly suggestive of faulting. If this line is continued to the south it would pass to the east of Schouten and Maria Islands. A long and narrow trough fault runs parallel to the southern portion of this coastal fault and a few miles inland therefrom, from a point near Seymour on the north to Oyster Bay on the south. This trough was the determining factor in the formation of the valleys of the Swan (or portion thereof) and Apsley Rivers, and of Oyster Bay. This trough probably continues to the south between Maria Island and the mainland. Between Schouten and Maria Islands, the narrow ridge between the trough and the coastal fault has been destroyed by erosion or cross-faulting, or both.

The south coast between S.E. & S.W. Capes has probably been largely caused by faulting. The fairly straight line of the west coast is suggestive, but no definite conclusion can be reached.

The problem of the north coast is involved in that of the formation of Bass Strait which is discussed elsewhere. It is possible that either faulting and (or warping) played a prominent part in its formation.

1V

Erosion The greater part of the coast is high and rocky and erosion is particularly active in such parts. The main effect is the wearing away of the land and the production of steep cliffs. The period during which the present relations of land and sea have prevailed, has been too short to permit of the formation of the extensive rock-benches at sea-level. It is possible that narrow benches have been formed at a number of places around the south east coast such as the Tessellated Pavement at Eaglehawk Neck.

The "blow-holes" in south-eastern districts e.g. (Tasman Arch, Remarkable Cave and Blow-hole), Tasman Peninsula, Blackman's Bay are of particular interest and have been formed by erosion in combination with the bedding and joint planes of the Permo-Carboniferous rocks.

The low-lying parts of the coast are found chiefly in bays. The bays have of course been formed by coastal erosion combined with that of the streams entering them.

V

Deposition. Sand dunes occur on all the coasts but are most common on the south-east, east, north-east and north-west parts. They are not high and seldom exceed 50 feet. In only a few places on the north-west coast are the dunes found to extend beyond a few yards from the coast.

Deltas do not occur, due mainly to the short time during which the present relations of land and sea have existed. Deposition is most marked in the shallow bays and inlets, where mudflats appear at low tide.

3. RIVER SYSTEMS

1. General Description. The main river systems are those of the Derwent, Tamar (South and North Esk), Gordon, Huon, Pieman and Arthur Rivers.

The Derwent River drains the greater portion of the Central Plateau, the north-eastern portion of the Southern Highlands and the southern portion of the Eastern peneplain and enters Storm Bay through its flooded lower valley. The majority of its tributaries are south-flowing streams and enter it from the north, the main stream having a general course from north-west to south-east. The main stream and most of these tributaries rise in lakes on the Central Plateau.

The Tamar River system includes a number of streams of which the South Esk is the most important, the Tamar River being a flooded valley. Its watershed includes the Launceston Tertiary Basin, the greater part of the Ben Lomond Highlands and the central part of the Eastern peneplain. The South Esk river rises on the eastern side of Ben Lomond Highlands and flows round the southern and western sides of them. A number of tributaries rise along the Western Tiers and flow north and north-east to join the main stream.

The Gordon River system drains the western parts of the Central Plateau and Southern Highlands. The main stream flows south and then west to enter the west coast through Macquarie Harbour - a drowned portion of its valley. Its main tributaries including the Franklin River are south-flowing and enter it from the north.

The Huon River drains the southern part of the Southern Highlands and enters D'Entrecasteaux Channel through the flooded portion of its valley. Tributaries enter it both from the north and south.

The Arthur River drains the northern part of the Western peneplain. The main stream has a general west-north westerly course, and receives all its tributaries from the south.

Apart from the above systems, all the drainage is more or less coastal and is effected by short streams flowing directly into the sea by the shortest route. The drainage of the north coast is typically of this type, excepting the Tamar River and possibly the Ringarooma River, the Forth and Mersey Rivers being the principal streams. The drainage of the east coast is also typically coastal and is also that of the south and west coasts not drained by the Huon, Gordon, Pieman and Arthur Rivers.

11. Development. The production of the present drainage system began after the close of the Triassic or Jurassic (?) sedimentation and the intrusion of the dolerite. The streams began to establish themselves on the Triassic or Jurassic sediments, or if these were absent over the western part of the island, on the Permo-Carboniferous rocks. One, or two, cycles of erosion were completed and resulted in the formation of a peneplain at the close of the Eocene or beginning of the Miocene period. During these cycles the Triassic and Jurassic (?) rocks were largely denuded and the dolerite intrusions exposed. In some areas the Permo-Carboniferous rocks were denuded and the underlying basement of Proterozoic and Lower Palaeozoic rocks exposed. Thus the streams were largely super-imposed ones as regards the dolerite, Permo-Carboniferous rocks and the basement rocks.

The peneplain was uplifted and deformed in early Miocene time and the streams rejuvenated in part at least. It is now difficult to trace the former drainage system, but probably the present system developed largely from it. At any rate, the present drainage began after the deformation of the peneplain. Before the Tertiary (Pliocene) sedimentation and the Newer basalt it had dissected the peneplain in places to a depth of over 1000 feet.

The Newer basalt flows were extruded in valleys differing little from the existing ones and the general effect was merely an alteration of the course of the streams within the confines of their own valleys. The post-basaltic stream in any one valley flowed along one side of the basalt for a certain distance and then turned across the basalt and flowed along the other side, and twin streams appear to be absent.

In several cases, however, the post-basaltic stream left its old valley for a greater or less part of its length. The most notable example is that of the Ringarooma River which left its former valley near Herrick and passed to the east of Mt. Cameron whereas formerly it passed to the west thereof. Another example is the Macquarie River which left its former valley near Ross and assumed a parallel course several miles to the west. Similar changes appear to have taken place in the north-west coastal districts, but they have not been properly investigated.

The Pleistocene glaciation also affected the drainage, filling old valleys with moraines &c. Some of the present streams in glaciated regions show an absence of glacial deposits and prove vigorous post-glacial erosion.

The present drainage has therefore reached its present development through many stages and its normal development has been affected by the basalt flows and the Pleistocene glaciation.

It still remains largely a superimposed system on the dolerite, Permo-Carboniferous rocks and Proterozoic and Lower Palaeozoic rocks. In the latter rocks the development has of course been partly influenced by the meridional draining of them but not to any marked extent.

The drainage is still in a comparatively youthful stage of development.

Rejuvenation. Rejuvenation has probably occurred several times in the development of the present drainage system. The earliest rejuvenation took place when the peneplain or peneplains were uplifted to form the present plateau or plateaux. Little information exists in connection with the drainage systems of the peneplains, due solely to lack of investigation. The depths to which gorges have been cut in the plateaux bear witness to the amount of uplift and consequent rejuvenation. The streams draining the northern part of the Eastern peneplain have cut gorges to depths of 1000 feet. Where the streams have cut through the edges of the Central Plateau, the gorges are much deeper and attain a maximum of 3000 feet e.g. Lake River, Mersey River, Forth River &c. The Gordon and other streams have cut similar gorges in the South-Western Highlands.

It cannot be stated whether the whole of the uplift occurred at once, or in a number of stages at different periods. It is certain, however that the greatest portion of the uplift occurred between the Older and Newer basalt epochs, as in the Ringarooma Valley, over 1000 feet of erosion occurred after the Older basalt epoch and before the pre-Newer basalt sedimentation (freshwater).

A later period of rejuvenation, but a less amount, followed the extrusion of the Newer basalts. This was probably the result of a slight uplift of the land, and not merely to the filling of the valleys by basalt, because the present streams have cut their courses below the basalt and into the underlying freshwater sediments.

Lewis () reports considerable post-glacial river erosion at the southern end of the Central Plateau. This may represent rejuvenation due to a Pleistocene or Post Pleistocene uplift, or possibly the cutting of gorges by the headward erosion of the streams as a result of an earlier uplift.

() Lewis, A.N., M.C. L.L.D. M.H.A. Note on the Origin of the Great Lake and other Lakes on the Central Plateau, Proc. Roy. Soc. Tas. 1932, p. 15.

There has been a rejuvenation of the West Coast streams, as the streams crossing the Western Coastal plain have dissected it to depths of at least 200 feet and possibly greater in certain parts. This rejuvenation is not recognisable in other parts of the State unless it be connected with the post-Pleistocene uplift which at Smithton, Flinders Island, and probably Gladstone raised the marine Pleistocene sediments to their present positions.

The rejuvenation following the recent uplift of 10 to 15 feet is only noticeable where the streams have cut through their alluvial flats near the coast.

- IV. Capture There are only a few cases of stream capture known in Tasmania, which is due probably to the youthful nature of the drainage, and partly to the limited amount of physiographic investigation carried out.

One possible capture that has been described is that of the upper portions of the former Henty River by the King River (Gregory, (),). It was considered that the headwaters of the present King River flowed westerly through the Sedgwick Gap and continued as an ancient Henty River, before being captured by the lower portion of the King River. It must be pointed out, however, that the valley of the Comstock Creek flowing easterly from Sedgwick Gap into the King River was already in existence in Pleistocene time, as it is a typical glacial valley and was filled with a considerable thickness of glacial deposits (morainal material, clays &c.) The headwaters of the Queen River west of Sedgwick Gap contain no glacial deposits and have been developed since the glacial epoch, thus proving a certain amount of erosion since Pleistocene time which may have been partly responsible for the formation of the Sedgwick Gap. In any case, if the above capture did take place it must have occurred some time before the glacial epoch.

An obvious capture is that of the upper part of the Jordon River by the Coal River. Between Richmond and Colebrook the valley of the Coal River is fairly wide and open, but upstream from Colebrook it consists of a deep narrow gorge for a distance of eight miles.

This gorge is 600 feet deep at its southern end, but approaching Baden its depth becomes less until finally a much more mature valley is represented. Near the head of this gorge the river which was flowing westerly makes a right angle bend and flows southerly. This sharp bend occurs immediately east of the Lake Tiberias and the head waters of the present Gordon River. The explanation is that the Coal River by headwater erosion along a fault, captured the headwaters of the west-flowing Jordon River which was established in a fairly mature valley on the Eastern peneplain.

Another probable capture is that of the Arthur River. There is a low gap at the head of the Duck River which may indicate that the Arthur River flowed through it and entered Bass Strait along the valley of either the present Duck River or Montagu River. The capture, if it occurred

was made by a small coastal stream now represented by the lower part of the Arthur River. Support is given to this view by the presence of blackfish (*Gadopsis marmoratus*) in the Arthur River, as it is stated that this is the only stream entering the West Coast with these fish in it, and that the blackfish only occur in the southern rivers of Victoria and the northern ones of Tasmania i.e. in streams entering Bass Strait.

An impending capture worthy of mention is that of the South Esk River by the North Esk River near Evandale. The South Esk River having been superimposed on the large body of diabase to the south-west of Launceston has cut a steep and narrow course (the Launceston Gorge) through it, the grade of the stream being high. The North Esk which flows mainly over soft Tertiary clays &c. has naturally been able to excavate its valley with a lower grade. Thus near Evandale where the streams are comparatively close, the valley of the North Esk is several hundred feet lower than that of the South Esk. The headwaters of a tributary stream (Rose Rivulet) have cut their valleys back to within a short distance of the South Esk near Evandale and in the course of time will capture the latter stream. It is probably, however, than an extraordinarily large flood in the South Esk will bring this about. If the 1929 flood had risen several feet higher, the water would have flowed through a gap into the valley of Rose Rivulet and thence into the North Esk.

It is probable that numerous captures have occurred in the drainage of the Central Plateau Lewis () refers to the following captures - the Ouse and the Shannon capturing the drainage of adjacent streams, the Ouse having captured much of the drainage of the Nive River and may shortly capture the Little Pine River: the Lake River capturing that of Arthur's Lakes which was formerly part of the Derwent drainage system.

Relations of Valleys to Glacial Features. These relations cannot be definitely decided at present owing largely to lack of investigation. Moreover the relations will probably be different in different parts of the State.

In the eastern, midland and adjacent regions there is a general absence of features due to glaciation and the streams apparently continued their development through the Pleistocene epoch without any noticeable change.

In the less elevated portions of the southern and western regions, the present valleys often contain glacial and fluvio-glacial deposits. This strongly suggests that the present valleys existed generally in their present form in pre-glacial times and that the glaciers occupied these inherited valleys. Further, in general, the present valleys coincide with their pre-glacial ancestors, being modified only by the filling of glacial deposits and the subsequent erosion. However, valleys (chiefly small and tributary to the main ones) exist which contain no glacial deposits.

() Lewis, A.N. MC., L.L.D., M.H.A. Note on the Origin of the Great Lake and Other Lakes on the Central Plateau. Proc. Roy. Soc. Tas., 1932.

These have undoubtedly been formed by vigorous post-glacial erosion, and for examples there may be quoted the upper part of the Ring River, near Williamsford and Ringville, the Stitt River valley and the branch of queen River rising near Comstock Gap, all of which are in close proximity to glacial filled valleys.

The relations on the more elevated regions of the State are not definitely known. On the Central Plateau, Lewis () states "I cannot at present throw any light on the pre-glacial drainage" He reports extensive extensive post-glacial erosion, glacial-filled valleys, and to the capture of the drainage of the main drainage course of pre-glacial times by streams in adjacent small valleys. Thus in general it may be stated that the present valleys may agree in some cases with their glacial-filled ancestors. while in other cases subsequent erosion, capture &c have considerably altered the valleys and the drainage compared with their pre-glacial ancestors.

4. L A K E S

A large number of lakes exist throughout the State, the majority being on the Central Plateau and include the largest such as Great Lake, Sorell and Crescent, St. Clair, Arthur's Lakes, Echo and Woods Lakes. In addition to the above mentioned ones there are innumerable smaller lakes, lagoons &c. Lewis () has shown recently that practically the whole of the Central Plateau down to an altitude of feet was glaciated during the Pleistocene and that the lakes are largely, if not wholly of glacial origin. The innumerable lakes &c. are indeed typical of the drainage of glaciated area of fairly low relief. Of the larger lakes only St. Clair (Clemes, 1924) () and possible Arthur's Lakes () have been formed by damming due to terminal moraines. Lakes Sorell, Crescent and the Great Lake are shallow and occupy shallow depressions on the dolerite ridges occupy the outlets from the lakes. In the case of the Great Lake, Lewis reports glacial deposits at other places than the outlet and it appears that the glacial action may have produced the depression and that the present outlet is due to later drainage capture. A similar origin for Lake Echo is possible, the subsequent erosion having removed the glacial deposits.

In the cases of the smaller lakes and particularly the tarns on the Plateau, there is usually terminal morainal material present and definitely establishing the glacial origin.

The lakes are smaller and less numerous on the western side of the Central Plateau and in the South-Western Highlands, which is probably to be explained by the greater amount of denudation which has occurred there. In every case where the lakes have been examined morainal material occurs and the glacial origin is established.

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- () Ibid. p.32
 () Ibid.
 () Clemes, W.H. Notes on a Geological Reconnaissance of the Lake St. Clair District, Proc. Roy. Soc. Tas., 1924.
 () Lewis, A.N. Ibid.
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Only four lakes exist in the Midlands and Eastern districts. Lake Dulverton occupies a shallow depression in sandstone with a sandstone bar at its outlet. Lake Tiberias occupies a shallow depression in felspathic sandstones with dolerite at the outlet retarding the action of the Jordon River. The capture of the head of the Jordon by the Coal River has also affected the action of the Jordon River. Lake Tooms is an artificial lake formed by a dam. Lake Leake.

In the case of the above four lakes, evidence of glacial origin is absent, as is also evidence of glacial action in the vicinity.

5. GLACIAL PHYSIOGRAPHIC FEATURES

As the Pleistocene glaciation is described in detail elsewhere, only the briefest mention of the land forms produced will be made here.

The glaciation was most extensive on the Central Plateau and ice covered a large portion of it, although nowhere was the ice thick. The mountains and hills protruded as nunataks and the glaciers filled the valleys and coalesced to form extensive glaciers. Valleys filled with morainal deposits were the chief land forms produced. Striated pavements are rare but "roche mounonnees" are plentiful. At the head of the glaciers and particularly during the lost phase of the glaciation, cirques, tarns and attendant phenomena were produced.

On the western side of the Central Plateau and in the south Western Highlands, the glaciers were of the mountain type which entered inherited valleys. These produced the typical U-shaped glacial valleys and filled them with morainal deposits. Piedmont glaciers may have been formed to a slight extent. Outwash fans were formed at a few places.

The most extensive glaciation of the cirque-cutting type progressed on some mountains until comb ridges, monuments, horns &c were produced.

Many of the button grass plains in the valleys appear to be of fluvio-glacial origin and to be formed by beds of gravel &c.

I. GEOLOGICAL STRUCTURE AS AFFECTING THE EVOLUTION OF THE TOPOGRAPHY

As the evolution of the topography is determined by the geological structure, a brief description of the latter is necessary in considering the former.

(a) General.

The basement consists of Proterozoic and Lower Palaeozoic sedimentary rocks (metamorphosed in the case of the former) intruded by granite, the sedimentary rocks being folded and faulted. Upon this basement rest horizontal or slightly tilted sedimentary rocks of the Permo-Carboniferous and Triassic systems ranging in thickness up to 3500 feet. The latter two systems have been intruded on an extensive scale by Mesozoic dolerite in the forms of irregular sills and large dyke-like bodies. Large scale faulting has occurred in Permo-Carboniferous and Triassic rocks.

(b) Rocks.

From the viewpoint of evolution of the topography the rocks may be considered as follows:-

- (i) Hard structures of the basement rocks. These include the Proterozoic schists and quartzites, the Lower Palaeozoic conglomerates, quartzites, sandstones, slates, limestones etc., and the Devonian granite and porphyries. These are strong structures which have developed a more or less marked meridional "graining".
- (ii) Soft. The relatively soft mudstones etc. of the Permo-Carboniferous system occupy large areas in the south-eastern districts, and also occur in the north-eastern and north-central districts and may underlie the eastern portion of the Central Plateau.
- (iii) The hard structures (though not as hard as those of (i) above) of the Triassic Ross or Knocklofty sandstones, ranging up to 700 feet in thickness.
- (iv) Mixed hard and soft. The Triassic or Jurassic felspathic sandstones with coal seams and mudstones occur throughout the eastern districts and range in thickness up to 1000 feet.
- (v) Hard and very resistant. The irregular sills of dolerite range in thickness up to 1000 feet or more and occur throughout the eastern and central regions.

As the dolerite intrusions are probably pre-tertiary in age the dismantling of them by natural forces of erosion must have commenced a very long way back in geological time, probably in at least a third cycle of erosion from the present.

Footnote

It is not yet known at what date the dolerite sheets were injected, but it is clear that they have a wonderfully close analogue in the dolerite sills

forming the kopjes of the Great Karroo in South Africa. They have also the closest possible resemblance to the huge dolerite sills first described by H.T. Ferrar of the First Scott National Antarctic Expedition in the Ross Sea Area of Antarctica. The Antarctic Andes of Victoria Land are largely built up of similar great sheets of dolerite, which have thicknesses of considerably over 1000 feet in places. In South Africa these newer dolerites intersect the Stormberg volcanic series of which latter the Drakenberg Range is so largely built. The Stormberg lavas and tuffs range from probably Rhaetic into Jurassic. It is considered by Drs. A.W. Rogers and A.L. du Toit that the dolerite sills of South Africa are of pre-Cretaceous and probably of late Jurassic age.

(c) Faulting.

A consideration of the structure of the island reveals the extensive faulting in the Permo-Carboniferous and Triassic rocks. The Permo-Carboniferous rocks were deposited on a fairly level, if not a peneplained, surface of the older basement rocks, and as the former have not been folded and only slightly tilted, their base gives a fairly accurate estimate of the faulting of the basement. It is found that along sections in nearly every direction from the western part of the Central Plateau, downthrow faulting of the Permo-Carboniferous and the basement rocks occur. One of the largest of such faults is that extending approximately from Ulverstone on the North Coast to Caçamaran on the south-east coast with a downthrow of 2000-3000 feet to the east. A similar fault of like magnitude probably trends parallel west of the West Coast Range and extends to the north coast. Similar faults probably surround the Ben Lomond highlands.

In addition to the above faulting affecting the basement, there are numerous faults in the Permo-Carboniferous and Triassic rocks which are intimately associated with the dolerite intrusions and which probably do not affect the basement, the displacement of the rocks being accounted for by the different thicknesses of the diabase sills.

II. CYCLES OF EROSION

The greater part of Tasmania has been a land surface since the close of the Triassic (or Trias-Jura) sedimentation, and the development of the present topography is therefore the result of the cycles of erosion which have operated since then, in conjunction with the various earth movements that have taken place. The evidence is not conclusive as to the number of cycles that have occurred during this development, but there is conspicuous evidence of two or less conclusive evidence of a third and older cycle. In addition to these two or three, brief reference must be made to a still older one viz. a Pre-Permo-Carboniferous cycle.

(a) Pre-Permo-Carboniferous Cycle.

In the north-eastern portion of the State, the basal Permo-Carboniferous beds overlie the basement of Cambro-Ordovician rocks and Devonian granite at a general elevation of approximately 2000 feet above sea level. The surface of this basement is generally level and strongly suggest a Pre-Permo-Carboniferous peneplain. This plain is also observable in the faulted and tilted blocks surrounding the main highland block.

Similar conditions exist in the Cradle Mt.-Lake St. Clair region, but the old basement is now at a higher level than the portion in the north-eastern region.

In the north eastern region portions of this old peneplain was re-exposed and incorporated in the later Miocene peneplain.

(b) Pre-Tertiary (?) Cycle.

Many of the higher mountains in the southern, western, north-western, and north-eastern districts have heights ranging from 3000 to 5000 feet above sea level, some of the most prominent being Hartz Mts. (4000), Arthur Range (3363), Wilmot Range (3483), Mt. Wellington (4166), Mt. Field West (4721), Frenchman's Cap (4756), Mt. Eldon (4789), Cradle Mt. (5059), Ironstone Mt. (4736), and Ben Lomond (5160). It is possible that these and numerous other mountains and highlands represent the remnants of a former peneplain. The Central Plateau, South-Western Highlands and Ben Lomond Highlands would represent more or less dissected portions of this peneplain. If this peneplain was formed, its formation must have been completed probably by the end of the Cretaceous period.

An alternative explanation is that these mountains etc. represent hard residuals or monadnocks of the peneplain formed at a later period (Miocene) than that which would be necessary for the formation of the above supposed peneplain.

(c) Pre-Miocene Cycle.

More than half of the surface of the State is situated at heights between 1000 and 3000 feet above sea level. At many places in the western, north-western, north-eastern, eastern and south-eastern, there are plains or remnants of dissected plateaux, the surfaces of which are 2000 - 2200 feet above sea level. These include the North-Western peneplain and the Eastern peneplain and it is probable that they form parts of a former extensive peneplain. It is to be noted that this peneplain is arranged concentrically around the Central Plateau, Ben Lomond Highlands and South-Western Highlands.

(d) Post-Miocene Cycle.

Following the earth movements which affected the probable peneplain formed by Miocene time, another cycle of erosion commenced and has continued with a considerable amount of interruption until the present time. The orderly development of this cycle has been interrupted by the outpourings of Newer basalt, earth-movements of the Kosciusko epoch, transgression of the Werrikoian or Pleistocene sea and numerous minor elevations and depressions of the land. Further, this cycle would include the very important glaciation of the Pleistocene epoch, which will be described separately to the remainder of this cycle.

III. CORRELATION OF THE PHYSIOGRAPHIC UNITS WITH THE CYCLES OF EROSION

The physiographic units naturally fall into several groups by virtue of their altitudes. The Central Plateau and its extension of the South-Western Highlands, together with the separated Ben Lomond Highlands represent more or less dissected regions ranging in height up to 5000 feet above sea-level. If the uniform height of the higher mountains in these units has any physiographic significance, it suggests an old peneplain. Such a peneplain would be the result of the first, post-Triassic cycle of erosion referred to above.

The North-Western and the Eastern peneplains with altitudes of 2200 feet above the sea form another group. These give definite evidence of peneplanation which would be the result of the second Post-Triassic cycle of erosion referred to above.

The Western Coastal Plain and the Launceston Tertiary Basin appear to have no connection with each other or either of the above groups.

Several questions arise in connection with the above. In the first place, as the evidence of the older cycle and peneplain is not definite, it might be thought that this and the younger peneplain are faulted portions of one and the same peneplain. This cannot be the case however with the Eastern peneplain and the Ben Lomond Highlands, as there are many mountains e.g. Mt. Victoria etc. rising to heights comparable with that of the Ben Lomond Highlands, which are clearly monadnocks rising above the Eastern peneplain. Thus two definite cycles appear to be present.

Secondly, the Western Coastal plain has been correlated by numerous writers with the North-Western peneplain. However, this plain is essentially a coastal feature and in places is distinct from the peneplain that it must be considered a separate feature.

There is a possibility though small, that the coastal plain may form a warped or tilted portion of the peneplain, but there is no direct evidence of this.

Account can only be taken here of the second of the above two cycles and so it and the peneplain produced will be discussed further, particularly from the point of view of age.

IV. AGE OF THE NORTH WESTERN AND EASTERN PENEPLAIN

The amount of direct evidence of the age of this peneplain is relatively small. The formations which would offer the best evidence are Tertiary marine rocks, Tertiary basalt flows and Tertiary freshwater sediments and these will be briefly reviewed.

Tertiary Marine Rocks.

These are very limited in extent and are restricted to the north-western coastal districts. One isolated area occurs at Table Cape and it is considered to be of Miocene age. The beds are overlain by basalt which is therefore post-Miocene in age.

Other areas include Cape Grim, Marrawah and Temma and suggest a more extensive development. The beds in these areas are mainly polyzoal limestones and their fossil content proves them to be Miocene in age. The limestone at Marrawah surrounds a low plateau of basalt and includes pieces of the latter rock. This proves the age of the basalt to be pre-Miocene.

The Miocene marine beds are not extensive and provide no direct evidence of the age of the peneplain as they do not come in contact with the recognised parts of the latter. However in providing proof of the age of the basalts they provide valuable evidence.

Basalt Flows

Basalt flows occur throughout the island, but are most extensively developed in the north-western coastal districts. Until recently there was no evidence to suggest that there were basalts of more than one age and they were regarded as being Upper Tertiary (the Table Cape section proved them to be post-Miocene) and probably the equivalents of the Newer Basalt of Victoria.

The discovery last year of the pre-Miocene basalt at Marrawah gave definite proof of an older basalt probably equivalent to the Older basalts of Victoria.

In the present state of our knowledge, the two basalts cannot always be separated but certain factors indicate generally which series any particular flow belongs. The Newer basalts occur generally as flows in valleys corresponding to those of the present streams, and subsequent dissection has been to shallow depths of only a few hundred feet. The Older basalts appear to occur mainly on elevated plateaus, and have been subjected to deeper weathering and to dissection amounting to 1000 feet.

The Newer basalts include those of the Ringarooma Valley, Launceston Basin, South Esk Valley, Derwent Valley (in part) and Smithton district.

The Older basalts include those of Marrawah, North-western peneplain (Waratah and Middlesex basalts), high level basalts of the Midlands, those of Bulman Bluff near Branxholm, and of Weldborough.

Fresh Water Sediments

These occur under the basalt flows and chiefly those of the Newer series. No recent age determinations have been made as regards the fossil leaves and fruit found in them, but the sediments are regarded as being of Pliocene and possibly Miocene age. The sub-basaltic beds at Waratah appear to be older than the others and this coincides with the Waratah basalt occupying an elevated plateau and being probably of the Older series.

Age of the Peneplain

Eastern. At Bulman Bluff near Branxholm Older basalt occurs at an elevation of 1700 feet or more corresponding to the general level of the peneplain. The Ringarooma valley has been eroded to depths of over 1000 feet below the peneplain and Older basalt level and has been flooded with Newer basalt. Thus it would appear that the Older basalt was extruded on the peneplain and that the peneplain was subsequently elevated (and perhaps faulted) and that it was dissected to a depth of at least 1000

feet before the fresh water beds were deposited and the Newer basalt extruded.

Similar dissection of the peneplain is evident in the upper portion of the South Esk Valley before the Newer Basalt flows.

The above suggests that the peneplain was formed in pre-Older basalt time and that it was elevated and perhaps faulted some considerable time before the Newer basalt series and probably not long after the Older basalt flows.

North Western Peneplain

This peneplain is covered with plateau basalts apparently of the Older basalt series. Near Waratah the plateau has been dissected to depths of 1000 feet.

In the valley of the Forth River, on the road from Sheffield to the Sheppard and Murphy Mine, valley in valley structure occurs as shown by the accompanying sketch. The excavation of at least two sheets of lava, which had successively filled the valley of the Forth to depths of fully 500 feet below the level of the old peneplain, shows that the Forth River had already deepened its channel to very nearly its present level before the latest streams of basalt flowed.

The above evidence suggests that the peneplain was formed in pre-Older basalt time and that the flows of this basalt were extruded over its surface. The peneplain was elevated and deformed between the Older and Newer basaltic flows and probably not long after the Older basalt. Assuming, as occurs in other regions in Australia, that the Miocene marine beds were formed on the peneplain surface, the limited extent of them in the island suggests that the deformation of the peneplain occurred before this marine transgression and that only small areas in the north-western districts (Temma, Marrawah and Table Cape) and possibly larger ones in Bass Strait (King Island) were left near sea level and were covered by the Miocene sea. The deformation of the peneplain therefore apparently occurred about the close of the Eocene or beginning of the Miocene period.

V. BASS STRAIT

It is not known at what particular epoch of geological time the east-west cross warping occurred, which defined the important lineament of Bass Strait.

As far as the evidence in Tasmania extends the formation of Bass Strait was pre-Miocene. Marine sands etc. of Pleistocene age occur at several places along the north coast, while marine sandstones, limestones, clays etc. of Werrikoian age occur extensively on Flinders Island and other islands of the Furneaux group. A strait slightly more extensive than the present one was therefore in existence in Late Pliocene to Pleistocene

() David, Prof. T.W.E., F.R.S., Sketch Section in Geol. Surv. Tas. Bull. No.14. 1913.

time. Miocene deposits occur on the north-west coast of the State, on King Island and most likely also on Flinders Island. It appears therefore that a strait similar to the present one was in existence in Miocene time.

In Victoria similar, but more extensive evidence points to the existence of Bass Strait in Lower Tertiary times. The evidence at Port Phillip and at the Sorrento bore near the south-east entrance to Port Phillip shows that, even as far back as Oligocene time (Balcombean), there was already a marine trough where Bass Strait is now situated, and even to the north of it. This marine trough followed on either lacustrine or terrestrial conditions, in as much as in the Altona area near Melbourne, extensive seams of brown coal are found underneath the marine Oligocene strata. Again, in early Miocene time there is evidence of an oscillatory movement, which converted the northern part, at any rate, of Bass Strait into a land or a fresh water lake, possibly a swampy plain area. Next we find that a widespread subsidence supervened, bringing the ocean waters not only over the original Oligocene fresh-water and marine beds, as well as over the Miocene lacustrine beds, but it spread some considerable distance to the north of the old boundary of Bass Strait. At this time, the Great Valley of Victoria from East Gippsland to Robe (?) was more or less submerged and formed a northern replica of Bass Strait.

As regards the Mesozoic rocks there is in Tasmania the sandstones, felspathic sandstones, mudstones assigned to the Triassic system and in Victoria the felspathic sandstones, shales, mudstones etc. assigned to the Jurassic system, coal seams being present in both States. Though assigned to different systems, the felspathic sandstones are identical lithologically and being of rather unusual types it is by no means improbable that the two should be assigned to the one system. Moreover the fact that both are fresh water sedimentary series rather tends to suggest a land connection between Tasmania and Victoria. If this is the case then the formation of Bass Strait would be late Jurassic or post Jurassic and as shown above pre-Oligocene.

Support is given to this view as the Jurassic strata of Victoria (excluding those of the Great Valley) have been tilted so that, on the whole, they tend to dip towards Bass Strait. In Tasmania, it cannot be said that the Triassic strata have a similar relation, but the underlying Permo-Carboniferous strata (from above which the Triassic have been removed by erosion) along the north-coast and especially in the north-eastern districts, show a general dip towards Bass Strait. This indicates tilting towards the Strait, while faulting is also prevalent with the down faulted blocks on the Bass Strait side. It will be noticed on reference to the section, that Bass Strait, is on the whole, defined by very definite heavy, marginal faults. If these faults and the tilting, are connected, as seems likely from the above, with the formation of the Strait, then they are probably connected with the late Jurassic, widespread intrusions of dolerite into the Jurassic and older rocks. This does not necessarily imply that all the faults are of this age, and it is quite possible that many, including even the main faults, are of newer origin. Some may be connected with the uplift and deformation of the peneplain, which occurred in late Eocene or early Miocene time.

Others may be connected with the important tectonic movements of the Kosciusko epoch.

As regards the date of origin of Bass Strait the evidence is fairly definite that it is Lower Miocene or pre-Miocene, but is not conclusive as to whether it is late Eocene (or early Miocene) or late Jurassic.

VI. GENERAL SEQUENCE OF EVENTS IN THE EVOLUTION OF THE PRESENT PHYSIOGRAPHY

Without going into unnecessary details the following table gives the events (elevations and depressions of land, sedimentation, basalt flows, erosion cycles etc.) responsible for the present physiography of the State.

Triassic (or Jurassic) sedimentation ends.

Extensive intrusions of dolerite (probably late Jurassic).

Large scale faulting accompanying dolerite intrusions in the Permo-Carboniferous and Triassic rocks.

Pre-Miocene cycle of erosion and formation of peneplain.

Older basalt extrusions.

Deformation of peneplain by uplift, faulting and warping.

Miocene marine transgression on north-west coast, King Island and possibly Flinders Island.

Erosion with dissection of peneplain to depths of over 1,000 feet.

Present drainage system established.

Depression of land of at least 350 feet.

Accumulation of Fresh-water sediments (possibly Pliocene) in valleys coincident with or differing little from present ones.

Newer basalt extrusions.

Formation of Western Coastal Plain.

Pleistocene glacial epoch.

Werrikooian transgression on north-west and north-east coasts, Flinders Island etc.

Elevation of land of at least 250 feet and withdrawal of Werrikooian seas.

Rejuvenation of streams and slight gorge-cutting.

Depression of land of possibly 150 feet.

Formation of flooded valleys near coast, coastal islands etc.

Recent elevation of land of 10 to 15 feet with formation of raised beaches, tied islands etc.