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Time Scales in the Development of Tasmanian Physiography

By

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PLATES II-V

Of all branches of Geological research, Physiography has been the most neglected in Tasmania. With the exception of a few observations, such as those by Moore, Gregory, David, and Taylor, published accounts prior to 1920 deal with restricted localities. These are excellent and accomplish their objects, but they do not even together constitute a general survey of the structure of Tasmania as a geographical unit of the earth's crust. P. B. Nye (1921, 1924) geologically surveyed parts of the State on a regional basis. The work has been continued since by the Geological Survey, with contributions from other writers, but is, as yet, very far from complete.

The plain fact is that we have not the necessary data on which to build an accurate appreciation of the structural framework of our island. This paper is merely a record of the writer's observations and conclusions, space not permitting an analysis of previous accounts or the views of other observers.

From the point of view of world geography, Tasmania is important as the apex of the Australian continental mass. Physiographically, Bass Strait is merely a very shallow flooded portion of the south-eastern Australian peninsular wedge inserted between the Tasman Sea and Southern Indian Ocean, both of great depth. The Australian-Antarctic connexion passes through Tasmania-Mills Rise-Macquarie Island to Adelie Land. The recent structural history of Tasmania must reflect the measure of the influence of the southern oceanic basins on the Australian continental mass, and any relative pressures and movements must be reflected in Tasmanian physiography. From the purely Tasmanian point of view, a correct interpretation of physiographic structure is essential in every phase of investigation in which geology can be of assistance.

Nye and Blake (1938) summarize current ideas on all major problems of this subject, and the present paper amplifies certain aspects without materially differing from their conclusions. It is based on more detailed work by the writer along the boundary between blocks showing only Permian and more recent rocks, and which, in the Hobart district, shows the post-dolerite movements in great detail.

The major diastrophic periods must, of necessity, be taken as the primary time indices. These, individually, are all clear, but their mutual relationships and dates are often subjects of conflicting evidence. Confusion has been caused in the past by merely local observations, and errors will be possible until all factors are recorded for consideration in relation to all other factors.

The Tasmanian terrain is, for the purpose of this investigation, classified into divisions as follow (Plate II):—

Western Type

Country in which rocks from pre-Cambrian to Devonian appear on the surface.

This paper and the following paper were written by the late Dr. A. N. Lewis some years before his death and were prepared for publication by Dr. D. E. Thomas—Eds. P. & P.

(*a*) Areas by low relief from sea-level to 1000 ft. which are characterized by gentle slopes and are frequently covered by Tertiary sediments, or by basalt.

(*b*) Areas of high relief rising from sea-level to 5000 ft. marked by mountain ranges with sharp slopes which are sometimes capped with dolerite.

Midlands Type

Country in which Permian to Triassic rocks with intrusive dolerite appear on the surface, in a mosaic of faulted blocks all worn to a peneplain which has, in places, been subsequently elevated but seldom above 2000 ft.

(*a*) Low relief areas of gentle slopes frequently covered with Tertiary sediments, river terraces, or basalt.

(*b*) Hilly relief—an elevated and dissected peneplain, characterized now by low ridges.

Plateau Type

Country showing a Permian base passing upward into Triassic sandstone and usually a dolerite sill cap with one or more scarp faces and an average elevation of 4000 ft.

Bass Type

Areas of low relief with terraces and raised beach margins, and with flooded areas of relatively shallow water.

Dolerite Intrusions

(Plate III)

The age of these is uncertain from stratigraphical evidence in Tasmania, but may be assigned to the Jurassic period from analogy with the dolerites of South Africa. This may be tentatively accepted, as no Tasmanian evidence disproves this age determination.

These intrusions terminated an Upper Permian-Lower Triassic sedimentation, and were preceded by a volcanic phase (Lewis & Voisey, 1937). No subsequent sediments occur until Tertiary times.

Existing dolerite occurrences are hypabyssal and no eruptive phase persists for observation. No indication of the topography immediately following the dolerite intrusion, is now obtainable.

The only reliable datum for measuring the stratigraphical position of the igneous intrusion is the Permian-Triassic successional junction. This appears to be reasonably constant throughout Tasmania. The Permian base is obscured, except where pre-Permian 'islands' give an unusually high 'false' base, due to overlap, while the summit of Triassic rocks has been eroded.(1)

Dolerite is found as sills at every horizon. It is common between lower Palaeozoic rocks and the lowest observable Permian strata in many localities. Sills 400-700 ft. thick are common in the Permian series, particularly in or just above or below the Woodbridge glacial stage. The maximum occurrences are sills averaging 1600 ft. thick overlying the highest Triassic strata now existing in the vicinity. Chilled margin summits are to be found occasionally, and other mineralogical characters indicate that the erosion of these major sills in their thickest part has not been considerable (200-400 ft. as a rough estimate on the available, but imperfect, data).

(1) For actual measurements, see *Coal Resources of Tasmania*, 1922, pp. 5-6, and Plate II, but the thickness of the Ross sandstone in the vicinity of Hobart (1350 ft.) is based on an old error, and must be disregarded. 800 ft. is the maximum, and this is, in general terms, the average for all Tasmania.

The maximum height measured from the Permian-Triassic junction of immediately pre-dolerite sediments is 1700 ft. These sediments were terrestrial deposits of relatively soft rock. Resorting is apparent, and immediately prior to the dolerite intrusion the beds, which now stand 1500-1700 ft. above the Permian-Triassic junction, could not have been much above sea-level. Probably their deposition had been rapid, but Tasmania shows no marine transgression between the top of the Upper Marine (Lindisfarne stage) of Permian age and the dolerite intrusions.

Many areas now show little or no interference by dolerite and the thickness given above of the Triassic sediments have been measured in these areas. The strata in such areas correspond sufficiently closely with that in areas which were affected by maximum dolerite intrusion to postulate the following:—

(*a*) A considerable volcanic activity (all traces now removed by erosion) is highly probable. This may have given a measure of protection to pre-dolerite sedimentary rocks.

(*b*) The top of the existing dolerite, immediately after intrusion, could not have been more than 2500 ft. above sea-level and was probably considerably lower. In view of the preservation of unprotected sediments, it may not have been materially above sea-level.

(*c*) The thickest sills had their sedimentary coverings in the general order of only 200 ft.

It appears that the dolerite was not again covered by marine sediments, as no trace of any now remains, and in view of the wide-spread persistence of Triassic coal measures unprotected by overlying rock, it is improbable that all evidence of a depositional phase and a subsequent erosional phase should have been completely removed.

The dolerite was intruded into an area which had been gradually sinking since Upper Permian times and which had been subjected to erosion since Carboniferous or Devonian times. At most, the thickness of the new rock intruded, excluding any volcanic equivalents which may have been since removed, would be in the order of 2500 ft.

In view of the relatively small amount of erosion, not only of the dolerite sills, but also of soft coal measures standing at relatively the same height (e.g., at La Perouse, Lewis, 1925), I postulate that the tops of the dolerite sills, as we now see them, did not stand much above sea-level until the plateau uplifts, to be discussed later, and, in the absence of any protecting covering, the Jurassic rocks must have been protected from erosion by their low elevation.

Dislocations of Older Rocks associated with the Dolerite due to the Dolerite Intrusions

A mass of basic igneous rock 1600 ft. thick cannot 'penetrate' soft coal measures without causing disturbance. This does not seem to have occurred (Lewis, 1928, pp. 7-8).

In the Hobart area, evidence is accumulating which indicates the widespread faulting of the country, with the dolerite occupying spaces between the moving masses of rock and terminating in a long, straight wall of older rock. These faults often show metamorphic contact with the dolerite, and at the same time indicate vertical movements of about 1400 ft. and horizontal movements of the order of 5 miles. Some evidence, although not conclusive, is forthcoming of differential vertical movements at the same time as the intrusions. There are examples of small masses of sedimentary rocks 'floating' on the dolerite. Subsequent faulting and erosion complicate this field evidence, and much further checking is necessary before it is possible to give an accurate survey of the mechanism of the dolerite intrusions.

The problem of the mechanism of the intrusions must be solved before we can be certain what has happened since. This problem is difficult and we have not progressed very far towards its solution. In general terms, the explanation which best appears to fit the field evidence is that there was a considerable and rather rapid up-arching of surface rocks associated with an ascending normal basic magma. The earth movements caused splitting of the rocks, which became more pronounced upwards. The magma invaded the lower sedimentary series and the Devonian granites, as sills. In the higher elevations it occupied fractures with sharp edges against more massive blocks of sedimentary rocks and with extensive, but smaller, ramifications on the side opposite the fractures. The nature of the ensuing igneous rock mass was determined first by the quantity of the magma in the locality (this varied considerably) and, second, by the shape of the 'mould' into which it was forced. There were many local upward extensions in the nature of small sills and dykes. Lateral pressure by the magma was seldom exerted. The gravitational pressure of uplifted block varied considerably. The pressure of the causal earth movements cannot be estimated, nor can any movements of subsequent collapse be traced at present, but these cannot be neglected as factors.

I must briefly refer to the controversy between Mr. P. B. Nye and myself on the question of the origin of the dolerite plateaux. Nye's first statement (1921) was elaborated into a general principle by Loftus Hills (1922). The gist of this statement was that the dolerite masses are in the approximate position which they assumed when originally intruded. Mr. Nye has since informed me that he considers that Dr. Hills went too far in this generalization. In 1927 I published my reasons for disagreeing with this view as pronounced by Hills, based on Nye's observations, although not with Nye's record of the field evidence (Lewis, 1927). My suggestion of a possible foundering (p. 14) is obviously erroneous, but otherwise subsequent observations confirm my adherence to the general statements contained in that paper with certain further subdivisions. The conflict of ideas was further elaborated (Lewis, 1928). During the 12 years which have since elapsed, I have come to the conclusion from a continuous study of the problem that Nye was right as to the Midlands plain, but made too sweeping a generalization when he included the plateaux and mountains of the south and middle-west; but likewise, I generalized too widely as to the effects of post-dolerite faulting. In other words, Nye had gathered most of his data from an area not greatly affected by Tertiary block faulting, while my experience was almost confined to areas of great disturbance. The two types, it now appears, present essential differences not to be covered by a brief generalization, as will appear in more detail later. Some degree of post-dolerite disturbance is now recognized (Nye and Blake, 1938), but one of the problems to be solved is the extent and date of the dislocations.

From detailed observations around Hobart, I postulate that dislocations of older rock by earth movements associated with the dolerite intrusions were frequent, but relatively small, in horizontal measurement. I would be surprised if one such influence could be traced over a distance of 15 miles, but 5-10 miles is common. All the thick sills are very high in, or at the top of, the intruded sedimentary rock, and the lower sills can be easily measured in several places. The maximum vertical uplift by the dolerite of any bed is about 500 ft. All traces of such dislocation as physiographic features has long since disappeared and the only indication is given by stratigraphical correlation.

Subsequent faulting, some rotational and others normal, giving rise to horsts have destroyed the possibility of using the present horizons of the dolerite sills as a means to correlate present physiographic units. The only safe guide is the vertical distance between the chilled margin of either the floor or the roof of the sill as measured from the Permian-Triassic junction. This criterion applied round Hobart shows—

(*a*) There is a sill of widespread occurrence about 400-500 ft. thick some 700-900 ft. below the junction.

(*b*) The main Wellington sill occurs some 900 ft. above the junction.

(*c*) Dolerite occurs between these horizons, but is relatively rare.

(*d*) The sills mentioned do not cover large areas continuously. The lower appears to be most extensive and has been traced over some 250 sq. miles, but the upper appears to be very irregular in shape and distribution. Eastward from Mt. Wellington, dolerite is common as broken outcrops of varying thickness.

(*e*) In some areas where Permian rocks predominate and there has been considerable tilting of sub-blocks, the lower sill has been brought to the surface.

(*f*) The upper sill stands at all elevations from sea-level to 4200 ft. At lower altitudes, it is often covered, or partly so, by Triassic coal measures and sandstones. It is much faulted within the major physiographic blocks and is as frequently exposed by this faulting as by simple erosion.

(*g*) Occurrences of dolerite may be found faulted against a different sill or a different level of the same sill. Therefore, only the most detailed deciphering of the structure of the whole of Tasmania can provide an accurate knowledge of the nature and mechanism of the dolerite intrusions.

(*h*) In my opinion, the plains of the midlands, the coastal regions, and old mature valleys standing not very high above sea-level are physiographically similar to the country just after the dolerite intrusions with only some few hundred feet removed since Jurassic times, but the dolerite capped mountains and plateaux and areas where Permian or Lower Palaeozoic rocks predominate show marked effects of one or more post-dolerite uplifts.

Exposure of Area of Lower Palaeozoic Rocks—their Peneplaination and Origin of Western Type Country

Published reports show a fairly well developed peneplain at the base of the Permian series (see section measurements in Geol. Survey, 1922). Apparent contradictions (e.g., *ibid.*, pp. 33-34, 54, 85-88, and 221) do not detract from this statement. It is probable that low hills existed on this peneplain at the commencement of this sedimentation, but none such showing a relief exceeding 500 ft have been identified. However, this aspect has not yet been investigated.

It appears to me to be a reasonable assumption that Permian-Triassic sediments with some intrusive dolerite once covered the Western type landscapes. I have already discussed this at some length (Lewis, 1939). The reasons for this statement are as follows:—

(*a*) Along the junction zone between the Western type and the Plateau type landscapes there is a mosaic of blocks of Ordovician and Permian rocks in a faulted relationship. I have described the features at Junee. Similar features occur at the Snowy Mountains-Jubilee Range area, at the junction of the Weld, Arve, and Huon Rivers, Mt. Picton and New River area, Mt. King William and Cradle Mt.-Barn Bluff areas. Here, from north to south, blocks of rock lie alongside each other in such a way that the Lower Palaeozoic blocks must have been elevated in comparison with the Permian blocks, and subsequently each must have been reduced to the same general level prior to an uplift along different lines. This arrangement of adjacent blocks showing, on one hand, over a thousand feet of Permian-Triassic strata separated by a chess-board pattern of vertical faults, is too extensive to be explained by some fortuitous overthrusting or erosion effect.

(*b*) Along the whole north coast is a terrain of low-lying Western type. The relief is not generally high, and there is some evidence of Tertiary uplift. Nevertheless, the same mosaic pattern of older and newer rocks is apparent, although in rather more extensive blocks. The dolerite Triassic-Permian rocks and Ordovician-pre-Cambrian rocks all at the same general level form a basement for the Tertiary rocks.

(*c*) Dolerite occurs on many of the Western mountains. At Mt. Anne and Mt. Wedge it is extensively intruded into Cambrian or Ordovician quartzites. At Mt. Elder and Mts. Sedgewick and Dundas it is in association with Permian rocks overlying Silurian strata. At Cradle Mountain it is intrusive into Triassic and Permian rocks which are associated with pre-Cambrian schists. With the exception of Frenchman's Cap (4756 ft.), the dolerite-capped mountains are the highest in those areas of high-level Western type physiography, averaging about 400 ft. higher than those without dolerite. That represents approximately the thickness of the sub-Permian sill, which appears to be fairly constant where not removed by erosion. These dolerite residuals could not be part of a sill intruded in a physiography resembling that now existing, so that post-dolerite physiographic cycles must be postulated.

(*d*) On the coast west of the mountainous country (Western type (*b*)) there are at least two remnants of Permian rocks, one at Malanna and the other associated with intrusive dolerite at Point Hibbs. The central Permian-Triassic sedimentation or for the dolerite sills over the whole composed of Palaeozoic rocks extending to sea-level.

(*e*) The close association of the Devonian granite terrain with newer Permian-Triassic rocks down the east coast repeats the features described above for that area.

(*f*) Taking the Permian-Triassic junction as the datum line, reasonable evidence is forthcoming of a general pre-Permian peneplaination. There is no necessity to postulate any particular degree of regularity for the Permian-Triassic sedimentation or for the dolerites sills over the whole of Tasmania, although there is no evidence to the contrary as yet forthcoming. It is, however, justifiable to assume that newer rocks once covered to some extent the Western type country.

It is not yet possible to define what happened in immediate post-dolerite times. The evidence points to a lengthy period of quiescence, with the dolerite intruding a flat terrain which marked the end of an era of sedimentation. There is no evidence of subsequent submergence and no proof of marked erosion in immediate post-dolerite times. A low, flat terrain is therefore presumed. Taking the top of the sedimentary series as only slightly above sea-level at the time of the intrusions (coal swamps existed or had been in existence in the not very far distant past) and the maximum thickness of the dolerite as 2000 ft., it is unlikely that the original top of the sills was more than 2000 ft. above sea-level. As the base of the dolerite to which the above measurements were made is well below the top of the sedimentary series and as the dolerite was seldom, if anywhere, 2000 ft. in thickness, the elevations would probably be nearer 1000 ft.

The first major event after the dolerite intrusions of which we have clear evidence is the elevation of the Western type country. This includes the western third of Tasmania, with a strip along the whole of the north coast. As Tasmania has lost much area by more recent submergence, this Western type may have been the predominant portion at one time, with the Midlands and Plateau type areas as incidental intervening strips.

The reasons for the assumption that this elevation did not precede or accompany the dolerite intrusions are those given above. It is clear that the dolerite could not have occurred where it does in the Western type country under existing physiographic conditions. The only explanation which appears to fit all the evidence is that it occurred at the same level (one or more) all over Tasmania. The level of the occurrences mentioned is that of the Permian-Lower Palaeozoic junction, that is approximately 2000-2500 ft. below the Permian-Triassic datum, which datum now stands at the average height of 1500-2000 ft. above sea-level in the Plateau type area and sea-level to 5000 ft. below in the Midlands type areas, giving the average height of the lower sills at the pre-Permian uncomformity as about 0 to 500 ft. in the Plateau type area and 2000 to 2500 ft. below sea-level in the Midlands type area. The dolerite of Mt. Anne and Mt. Wedge at 4000-4500 ft., Mt. Sedgwick 3000-2000 ft. (approx.), Cradle Mt., Barn Bluff 4500-5100 ft. are correlated with this lower sill. This gives an average elevation of the Western type country as some 7000 ft. above the Midlands type and some 4000 ft. above the Plateau type countries.

The above conclusion is based on an assumed correlation of the dolerites which, although it holds good for all exposed areas of the Western type, may possibly not be universally applicable. That doubt, however, only goes to prove the validity of the proposed correlations of the vertical scale. The alternatives are (*a*) the Western type country was dry land during the Permian-Triassic sedimentation, or (*b*) that it was once covered with some thickness of sediment referable to those periods. The probabilities favouring (*b*) increase in direct ratio to the time from the commencement of the sedimentations, since the dolerite at the end of that time is found where it would be expected if, at the time of its occurrence, there was no differentation between the country types. If alternative (*a*) were correct, it would obviate the necessity of removing some 4000 ft. or so of sediments, but still not account for the existence of pre-Cambrian and Ordovician strata at 4000-5000 ft. elevation not far distant from Triassic strata at sea-level. Some differential movement clearly occurred since the end of the Triassic sedimentation, i.e., the date of the dolerite intrusion. This could not have been other than upward for the Western type country, as otherwise the Permian marine sedimentary rocks would have been deposited many thousands of feet above sea-level. The junction country is clearly faulted. The Ordovician-Permian relationship is not that of more recent deposition of the latter in channels of the former (see Lewis, 1939, for examples). Further, in many places Ordovician rocks now stand at the same elevation as all stages of the Permian-Triassic series. If the western country had been dry land in the early stages of the sedimentation and had gradually subsided, it would have been successively covered by later stages. This has not been the case, at least to any marked degree, and blocks of newer rocks lie against blocks of older rocks with clear fault breaks with displacements often as much as 3000 ft.

For these reasons, the next major event after the dolerite intrusion must have been the elevation of the Western type country into plateaux, followed by the removal of from 2000 to 6000 ft. of Permian-Triassic sediments and intrusive dolerite (if any) from these areas.

This resulted in a peneplain. It is probable that this presented a rather uneven surface, but was reduced by erosion until variations in elevation were not more than about 1000 ft. It covered the whole present surface of Tasmania. That involves the proposition that at general elevation not considerably above sea-level there existed by the end of the peneplaination the Western type country with granite, Silurian-Ordovician, or pre-Cambrian rocks on the surface and the Midlands plateaux types undifferentated between themselves and with predominant dolerite on the surface at about the same level as the older rocks. It also involves a long epoch of erosion, during which most of the Triassic-Permian covering of the Lower Palaeozoic rocks was eroded. It is not necessary to presume a uniform thickness of dolerite in these eroded beds, and, perhaps, they had little or no protection by this hard rock.

The Western type country may have been elevated to its present height by this series of movements, but it is only necessary, in order to fit in with the evidence available, to presume an elevation in the vicinity of 3000-4000 ft., that is, sufficient to bring the top of the Lower Palaeozoic rocks (bottom of the dolerite sill, if any, below the base of the Permian) on a level with the top of the upper dolerite sill above existing Triassic beds.

The evidence for the subsequent peneplaination is as follows:—

(*a*) There is a general accordance of the mountains of the Western type country with the plateaux. This involves a physiographic reason as the higher Western type mountains stand stratigraphically some 4000 ft. higher than the adjacent plateaux, while the two types are physiographically equal in elevation.

(*b*) For the reasons given above, these mountains did not protrude out of the early Permian sea, and did not escape the dolerite intrusions. It might be argued that the factor (*a*) above was due simply to an elevation in early post-dolerite times followed by normal erosion. However there are unelevated portions of the Western type country along the north coast, in association with the peneplain Midlands type country. Also, there are elevated tracts of Lower Palaeozoic rocks in association with the Plateau type country from Cradle Mountain to the Du Canes. In other words, the three types of country all show the same general level whatever rock type occurs on the surface.

(*c*) The mass of overlying Permian-Triassic sediments could not have been eroded from the Western type mountains as they now stand and left the physiography as we now know it.

(*d*) The western rivers are superimposed streams which do not conform to existing physiographic trends. Some of them must have originated in at a higher elevation.

(*e*) Considerable accumulations of pebbles of Lower Palaeozoic rocks are now to be found in valleys which do not contain any such rocks in their watersheds.

For the above reasons it is postulated that portions of the country were elevated into plateaux some 4000-5000 ft. above sea-level, while the other unaffected portions remained with elevations not exceeding 1000 ft. The mountains or plateaux formed by this elevation were all reduced to approximately the same level as the unaffected area, thus exposing the older rock. That the dolerite sills and soft Triassic sandstones of the Midlands plateaux type areas were not materially affected, while some 4000 ft. or more of these rocks were removed from the Western type country, is another argument for the assumption that the Midlands type country was not at this stage much above sea-level.

The next problem is the date of these happenings. On this matter, no exact evidence whatever is as yet forthcoming. Putting the date of the dolerite intrusions as Jurassic and the date of the north-western marine sedimentary rocks as Miocene, there is still an enormous time-gap, sufficient for all happenings of which we have any evidence. This western country unlift and its peneplaination occurred prior to the deposition of the Lower Tertiary sediments of the north coast and, although it may have taken place in Cretaceous times, it is considered more likely to have occurred in Lower Tertiary times, and, for reference purposes only, I term these the Lower Tertiary uplift and the Lower Tertiary peneplaination.

Exposure of Areas of Permian Rocks in Predominantly Triassic Localities

A somewhat similar movement, although less extensive, both in vertical thrust and area affected, is to be seen in the Plateaux and Midlands types of country which were not affected by the previously described movements which resulted in the exposure of Lower Palaeozoic rocks. In most cases, the Permian rocks are found at the base of areas of Plateau uplifts. I am not speaking of these occurrences here. There are several areas, the most extensive being in south-eastern Tasmania, south of Latrobe, round Lilydale, and at Preolenna, where Permian rocks outcrop on the surface. This involves the removal of the Triassic covering with any intrusive dolerite which may once have been associated with the Triassic sediments.

Some degree of differential uplift of the peneplained surface must have been responsible for this. Around Hobart, these uplifts are clearly in evidence and faults cut low hilly ridges showing Triassic rocks in juxtaposition to Permian rocks for a vertical height of 700 ft. in places. The only explanation which will fit all the evidence is a slight uplift (less than 1000 ft.) with a subsequent peneplaination, leaving areas of Permian rocks on the same general surface level as surrounding areas of Triassic rocks and dolerite.

The age of this series of movements is doubtful The effects were not nearly as marked as those which produced the Western type country. The movements were clearly post-dolerite in sufficient instances to warrant a general statement to this effect. In south-eastern Tasmania, where the Permian areas are most in evidence in a peneplained relationship with Triassic areas, there is no outcrop of Lower Palaeozoic rock. At Latrobe and Preolenna the Permian areas are included in Western type country, with neighbouring areas of Lower Palaeozoic rocks rising higher than the Permian areas, and the removal of the overlying Triassic sandstone was prior to the Plateau uplift and the peneplaination must have been effected before the Plateau uplifts and Miocene deposition phases, as areas of Permian rocks appear on the surface of the Central Plateau at the same level as Triassic areas, and Tertiary sediments cover both types in the midlands. Where observable, there is no sign in either case of any post-Miocene differential movements sufficient to account for the occurrence of the same level of beds of the two ages—one originally considerably below the other (0-1500 ft.).

There is no reason to differentiate these slighter uplifts from the major one which gave us the Western type country. At most, they can only be a final phase of those movements, and the whole of Tasmania was reduced to one peneplain in pre-Miocene times. In the areas now occupied by the Plateaux and Midlands types country, the surface rock at the end of this peneplaination was mostly dolerite of the upper sills, but considerable areas of Triassic sandstone and Permian mudstone also appeared on the surface. In any case, the original uplift produced very marked differences in elevation in close horizontal relationship. These differences were smoothed out by the peneplaination, giving areas of rocks of different ages alongside each other and divided by fault lines. This is seen everywhere, whatever the age of the rock may be. The general geological mapping is not yet completed in sufficient detail to bring this out. With a complete map, it might be possible to trace the mountains produced by this early uplift, and this might show either that the movement was long continued or proceeded in stages, with erosion proceeding at the same time to give the extremely varied pattern now exposed.

It may be asked whether the Western and Permian uplifts were due to the dolerite intrusions. I do not think that this is possible. Where dolerite occurs in the Western type country it occurs high in elevation (about 4000 ft.), with lower elevations occupied by Palaeozoic rocks, while the dolerite caps are peneplainal residuals with the neighbouring dolerite sills of the plateau country which overlie Triassic and Permian strata. This shows a differential uplift of the two types of country independently of the dolerite intrusion. I have already stated my reasons for the view that the western country had no Lower Palaeozoic rocks exposed as a land surface during the Permian-Triassic sedimentation. This leaves the bare possibility of an uplift subsequent to the termination of the sedimentation and earlier than the dolerite intrusions, giving us our highest surviving Triassic strata. Had this happened, we would have to explain why there is no deposit representing the erosion of some 3000-4000 ft. of strata. In view of the fact that in many places (e.g., Maria Island and Junee) sills of dolerite are to be seen between Lower Palaeozoic rocks and the lowest Permian rocks, it is probable that dolerite intruded widely at this horizon, and such residuals as are now to be seen on Western type mountains belong here. For these reasons, I date the uplift of the Western type country as subsequent to the dolerite intrusions (i.e., post-Jurassic).

In the areas where Permian rocks now occur at the surface in Midlands type country, dolerite sills are almost universally developed. It might be argued whether these dolerite sills did not raise the Triassic strata above them so that in the general erosion the Triassic strata was removed, until a general accordance between Permian and dolerite intrusive into Higher Triassic strata was attained. Some such factor is quite possible, but it is not the whole story. Round Hobart we see the same sill and sedimentary strata now standing at different levels showing some degree of post-dolerite faulting. In other places we see the section broken by small faults and the blocks, including the dolerite sills, tilted in repeating patterns or at angles to each other. Further, we see in a few localities, dolerite intrusive into Permian strata, but the latter passing upward with Triassic strata now standing at the same general level with adjacent Permian beds. For these reasons, I think that there is ample evidence of post-dolerite uplift of limited areas sufficient to have caused the removal of the overlying Triassic strata, while neighbouring blocks of soft Triassic coal measures were protected from erosion by their lower elevation.

THE PLATEAU UPLIFTS

The Plateaux are the second characteristic feature of the Tasmanian physiography. The Western type mountains are bare or saw-back ridges, in contradistinction to the plateaux which are flat-topped and clothed with vegetation. The dominant cause of the extreme difference—a difference which can be noticed fifty miles away—is the dolerite. The plateaux, as the term is used in this paper, stand at an average height of 4000 ft.—a thousand feet higher than the *average* elevation of the far more rugged western mountains. The Central Plateau is the most outstanding. Southward from this runs a chain of more or less isolated plateaux of smaller area but similar elevation, the King Williams, Wyld Craig, Mt. Field, Mueller, Styx, Snowy, Wellington group, and the Hartz, Picton, Adamson's Peak, and the La Perouse group. In the north-east is the Ben Lomond Plateau extending northwards to include Mt. Barrow and Mt. Arthur, Ben Nevis, and Mt. Victoria. Round the flanks of these plateaux are dissected remnants of lower elevations, called tiers and including the indeterminate 'Eastern Tiers'. These features will be discussed later, but they must be closely associated in origin with the higher plateaux.

Starting with the higher plateaux, we appear to be on safe ground in postulating an original peneplaination with the western country, followed by an uplift of both. Physiographic evidence to be discussed later confirms this. The primary problems relating to the plateaux are—

(*a*) Are they uplifts from the general elevation of the midland country or is the latter a rift valley or other subsidence?

(*b*) Are they of more recent date than the Western type mountains?

(*c*) Are the breaks and gaps due to uplifting movements or to normal river erosion?

(*d*) What is the relationship of the plateaux to the surrounding tiers? Has there been one uplift or several, and has any of the movement been subsidence?

These problems will be open for discussion until the whole State is adequately mapped. At present we know practically nothing of the actual structure of the plateaux or their morphology.

The stratigraphy of the plateaux is most regular. In most cases the platform rocks are obscured by faulted blocks, and the lower level of the actual plateaux are Upper Permian strata of or above the Granton stage. At about 1500 ft. this passes into Ross standstone, and from 2500 ft. to 4000 ft. there is a dolerite cap. When a height exceeding 4000 ft. is reached, the above sequence shows further uplift. In places the dolerite cap is thinner or does not exist. This does not appear to affect the general accordance materially nor the average stratigraphical sequence, the place of the missing rock usually being taken by coal measures which normally overlie the Ross sandstone and were predominately invaded by the dolerite.

I regard the plateaux as uplifts from a plain of general low elevation which was of more recent date than the uplift which exposed the Lower Palaeozoic rocks of the Western type country. The landscape and structure imparted by the plateau uplifts was much what we now see, that is, there were breaks and gaps in the plateaux from the first. There was also differential uplift imparting different levels to adjacent blocks.

As compared with the Western type country the Plateau type country stands some 3000-4000 ft. higher stratigraphically, but at approximately the same elevation. Along the junction of the west Plateau type country there is an intricate pattern of Lower Palaeozoic rocks and Permian-Triassic-dolerite series, all equally affected by the uplift pointing to the earlier western country uplift as already described, followed by a general peneplaination, and this, in turn, followed by a general uplift which includes both the Western type and the Plateau type areas.

Along the western section of Tasmania we have a number of rivers, particularly the Huon and the tributaries of the Derwent, which rise at low altitudes in the Western type country and cut through the plateaux. We also have the Gordon and Pieman, which rise in the plateau and cut through the western mountains. All these streams are antecedent at last in part of their courses.

Factors to be described in more detail later point to the conclusion that these rivers started their present life history in a since removed Permian-Triassic terrain above the Lower Palaeozoic rocks in which they flow. These rivers have worn gorges 1500 ft., nearly sheer, and often 3000 ft. from the top of the mountains without exposing Lower Palaeozoic rocks in the plateaux country. They rise in very mature western valleys and flow through gorges in the plateaux which show all the features of extreme youth. I postulate that they have been stable in the western country for a much longer period than that during which they have been eroding the gorges through the plateaux. Therefore the western uplift antecedes the plateau uplift. Since then there has been river erosion of normal development, accompanied by the removal of the more recent rocks over the Western type country and the erosion in performed courses through to the underlying Lower Palaeozoic rocks.

Along the north coast the Western type country forms a fringe to the plateaux, somewhat comparable, but lower than the wider area of the west coast type. The rivers here rise in the plateaux and flow northward. The general aspect of such rivers as the Forth, Mersey, and Ringarooma appear to have little reference to the Lower Palaeozoic rocks, but to indicate an origin in the plateaux and a subsequent development across the Western type country—again indicating the uplift of the plateaux at the date subsequent to the exposure of the Palaeozoic rocks. In other words, although the two systems show contrary features, one set of features is seen in rivers rising in Western type country and flowing through plateaux, the other set by rivers rising in the plateaux and flowing across Western type country. Both these sets show the features to be expected if the plateaux were of more recent origin than the Western type country.

For these reasons, as well as subsidiary ones to be mentioned later, I postulate that the elevation of the Western type country and the initiation of the present drainage over that portion of the State preceded the elevation of the plateaux.

Turning now to a comparison between the Plateaux areas and the Midland type country, the possibilities are either the subsidence of the Midland type after the initial elevation of the plateaux, or the elevation of the plateaux while the Midlands type country is more or less at a standstill. I favour the latter alternative for the following reasons:—

(*a*) The Midlands type country is largely covered by deposits approximately referred to the Miocene or later periods (but the earlier ones are the only ones that concern us here). Some of these extend below sea-level. If the Midlands type country was formed by sinking, this differentation must have taken place in pre-Miocene times. If the plateaux were due to uplifts, the period of elevation could have occupied a much more extended time (i.e., before and after the deposition of these sediments over the lower country). If the Midlands type country was a submergence the Western type country was first uplifted, then followed by the Plateaux and Midlands type uplift, before the sinking prior to the Miocene deposition. Such is possible. Evidence of the rivers which cut the plateaux indicate that these valleys were cut prior to the deposition of Miocene sediments. They must have been flowing in their present channels before, during, and after the plateaux uplift, and they emerge on the Midlands type country in their lower levels. Had the latter been due to sinking we would have thought that the rivers had cut an appreciable depth of their gorges through the plateaux previous to the Miocene times. Then, after the deposits were formed in the lower elevations, the river erosion and the deposition was very materially slowed down. In other words, such an interpretation involves a time spacing which does not seem to fit the facts. The Miocene and subsequent deposits only appear in lower elevations (except at Bischoff) and so could not have been deposited prior to the differentation of these physiographic blocks.

(*b*) Had the original level been that of the present plateaux tops the rivers would have cut out valleys from sea-level first. This should have involved gorges in the order of 4000 ft. deep at the then plateaux edges. The sinking of the Midlands type country would have submerged the gorges. There is no evidence of any such gorges. The Midlands type country is not simply due to normal river erosion, as is amply proved by the comparative stratigraphy of the two types, where adjacent. The plateaux show Permian rocks to an average height of 1500 ft., then Triassic and dolerite to 4000 ft. The Midlands types show at sea-level to 600 ft. the rocks which occur on the plateau at 4000 ft. Some faulting must have occurred at some time. Although the evidence is not very clear, I consider it to point to the fact that the faulting gave the upward differentation of the plateaux areas from a general peneplain, as the higher elevations show a peneplained surface which could not have originated *in situ* and the lower elevations show no evidence of a submerged topography of a previously elevated tract of country.

One of the problems of Tasmanian physiography is to decipher what do the 'plateaux' imply. These will be analyzed in some detail later, but here I indicate the view that their only constant factor is their 4000 ft. height. The Central Plateau is too broken to be regarded as a single, simple physiographic unit and probably consists of a number of inter-related blocks. The Mt. Field-Mt. Wellington-Picton-La Perouse group of plateaux show a general accordance at 4000 ft., but are separate physiographic entities. The Ben Lomond plateau shows some of the features of both the other types, but is not exactly in accordance. Even taking these major divisions it is difficult to fix boundaries. The Central Plateau merges south-eastward by a series of steps and shelves to lower plateaux with general levels about 2500 ft. and 1500 ft. The Eastern Tiers do not show the features of the 4000 ft. plateau levels, but correspond closely with the 2500 ft. and 1500 ft. features.

The 1500 ft. plateaux features connect the Mt. Wellington-Mt. Field group with the Eastern Tiers. In the western country the 2500 ft. plateau is much in evidence, but the 1500 ft. is not apparent. Bench marks at lower levels correspond with these of the Midlands type country. Outside the plateau country the 1500 ft. level is a constant factor.

It seems to me that the 1500 ft. level is reasonably universal and the 4000 ft. level is the usual elevation of the areas here called the Plateaux. Below 1500 ft.

we have a series of bench marks which indicate (or perhaps will provide data to indicate) earth movements during the later phase of one period, as the physiography at this level is primarily dependent on geological structure.

The Mechanism of the Uplifts

The possibilities presented by the field evidence are—

1. A relatively early uplift by differential sinking and considerable erosion.
2. A long, continual, gradual uplifting movement, probably in stages.
3. A series of differential movements, giving rise to more or less isolated mountain ranges, followed by a general uplift with some small negative movements.

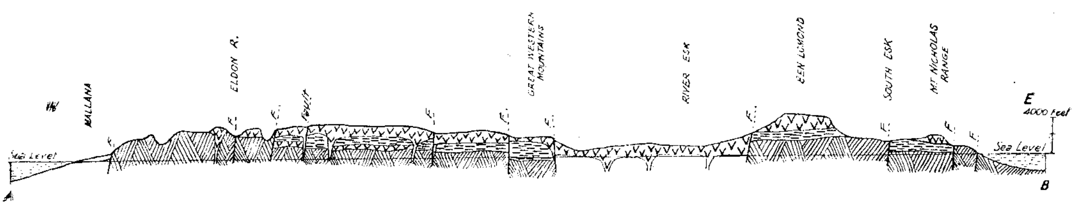
I favour the last alternative at present.

The mechanism of the plateaux uplifts is very much confused by the fact that the terrain upon which the impulses operated had already been faulted. It is now difficult to differentiate the faults caused by the more recent uplifts from those that were previously present on the peneplained surface. In general, the latter movements still leave visible physiographic fractures, and the effects of the earlier ones have been practically removed by the subsequent peneplaination.

From studies on Mt. Wellington, confirmed in a general way by more casual observations on Mt. Field and the Central Plateau, I postulate a series of roughly east-west compressional stresses. These broke the peneplain in roughly north and south directions and elevated long, narrow strips of country. These blocks in turn broke along east-west lines, leaving relatively narrow gaps in the elevated country, and an elevated strip along the line of junction with the Lower Palaeozoic rocks. Pressure was considerable here and some degree of overthrusting, high tilting, and crushing of the newer rocks is apparent.

The resultant elevations consisted of an assemblage of blocks shaped rather like great trichnic pinacoids with their long axis roughly north and south, welded into a physiographic whole but actually separated by major structural faults, now marked by the valleys of important rivers, while the plateaux edges are all marked by a complicated cross-fault pattern. In addition, there is clear evidence of a slight rotational movement imparting a westerly dip averaging 5-10° to each of these subsidiary blocks and a repeating physiographic and structural pattern from east to west through the whole plateau.

Ben Lomond Plateau, the only extensive area over 4000 ft. east of the midlands plains is an exception in that here the pressure appears to have come from the opposite direction from that which produced the other plateaux. Ben Lomond Plateau has Lower Palaeozoic rocks to the north and east, but the other plateaux have the older rocks to the west.



GENERALISED SECTION A-B
TO ILLUSTRATE RELATIONSHIP
OF ROCK GROUPS OF TASMANIA

Scale 10 0 10 20 30 Miles

Dolerite Permian Triassic Rocks Older Palaeozoic Rocks J.S.D

The directions of the pressure can only be assumed, but field evidence imparts the suggestion that this pressure which elevated the plateaux came from the areas now occupied by the lowest midlands country. This fact is significant and justifies the proposition that the pressure came from outside the present confines of Tasmania by a sinking of the sea floor. This pressure was exerted on areas of Lower Palaeozoic rocks now fringing the east and north and western coasts and was imparted to the Lower Palaeozoic platform of the central part of the island. This platform gave way and the areas now represented by the plateaux were elevated by a movement mainly vertical, but also slightly rotational away from the more stable areas which remained stationary or were slightly depressed and which now are seen as the Midland type country. In this process, Tasmania lost much land round its coast by direct depression.

What we can see to-day is the surface effect only of a slight shortening of the earth's crust under Tasmania. This may have been so deep seated as to cause folding at a depth, and the physiographic features we see now may only be the surface effects of such folding. On the other hand, the pressure may have been more superficial and have directly affected the surface. The results, however, are clearly the consequences of compressional movements. It is clear that these movements were very gradual and only produced their maximum effects on long, narrow blocks. General uplift or depression movements affecting the whole island produced minor effects. There appears to have been a rythmic result either from one side or the other, or more probably from the centre outward, and the field evidence points to the maximum effects having been produced early, with a gradual lessening.

An alternative possibility is that the whole island was raised by the first effects of this pressure to about 1500 ft. Later, as a final phase, certain blocks were more rapidly raised to 4000 ft. and certain other blocks depressed to about 600 ft. In view of the effects of erosion, to be discussed later, it is impossible to isolate any direct depression of large areas for an elevation of more than 100 or so feet, excepting the Bassian type off the coast which must have sunk.

However, although I regard the movement in general to have been upward, there is no reason to exclude the possibility of differential collapse of strips of country round the edges of the plateaux.

Valley Erosion, Dissection of Plateaux, Deposition of Tertiary Sediments, and Basalts

The next happening in chronological order was the moulding of the details of the landscape from the framework imparted by the tectonic movements already outlined. It is very difficult to determine, except in detail, how much of the present topography is due to either of these influences, but in certain places very considerable gorges have been cut into the plateaux edge. It is clear that—

(*a*) The uplift has been sufficiently gradual to permit most of the rivers to adjust their courses without serious diversion.

(*b*) The uplift took place in more than one stage.

(*c*) There has been a final stage of relatively small throw (600 ft. max.) in post-glacial times which has imparted recent rejuvenation to many rivers.

(*d*) The main valley features were excavated before the deposition of the Tertiary sediments.

Tasmania is a country of wide, flat, mature valleys flanked by precipitous residuals of the older peneplain, but this general statement must be qualified by noting that rejuvenation has interrupted the cycle in many places to such an extent that the erosion cycle is anything but mature in the valley troughs. The problem of this rejuvenation is closely associated with the problem of the 'tiers'—1500 ft. and 2500 ft. plateau residuals.

I postulate a fairly general uplift as already described, by section from west to east or from east and west alternately towards the centre. The western country is pre-eminently a land of mature drainage (interrupted by glaciation and slight uplift), and all the field evidence points to a far longer cycle of river erosion there than in the plateau country. The midlands country is likewise, in general, and subject to rejuvenation, an area of extreme maturity. The real problem arises in regard to the plateau areas. The midlands and western country all correspond approximately, and it is safe to postulate a cycle of approximate duration for both. Of course, maturity has been reached nowhere. The main valleys are wide and extremely flat, but are bounded by steep elevations, and many of the smaller tributaries are mere mountain torrents falling off the uneroded residuals. Speaking broadly, it can be reckoned that the cycle from the original peneplain to full maturity over the whole island was about one-half completed.

The real problem of the dissection of the plateaux is whether all or most of Tasmania was elevated and the midlands country was subsequently carved out to maturity by normal river erosion or whether the plateaux were elevated subsequently to the peneplaination of the midlands country and out of a mature peneplain. The difficulty of reconciling all the field evidence together has led to the violent swing of opinion traceable through Tasmanian geological literature.

My present view is that the truth lies between these alternatives. In brief—that the first uplift was to the 1500 ft. level, and out of the plateau this formed a normal course of river erosion and has produced the Midlands type country as we now see it. Subsequently, and after a considerable interval, the plateaux were elevated. This movement only affected a portion of the country elevated to the 1500 ft. level, and successive stages can be traced at 2500, 3000, 4000, 5000 ft. Each successive stage affected a progressively smaller area within the previous uplift. Usually the later uplifts elevated a block, two sides of which corresponded to portions of two sides of the earlier and more extensive block, so that the maximum elevation from Midlands or Western type country to the highest portion of any particular plateau is continuous on two sides of the highest segment, while elsewhere the successive stages are apparent. In some cases (only the smaller plateaux) the whole block was successively elevated over approximately the same area by each uplift and the earlier stages are apparent not as 'tiers' or subsidiary plateaux, but merely as shoulders on the spurs of the plateaux which we see to-day.

The reasons for this view will be given later in sections dealing in more detail with areas which supply useful data. As a general statement, it is here sufficient to say that the midlands areas do not show a disturbance exceeding 600 ft. since Tertiary sediments were deposited, and mature valleys were even then in existence.

The oldest basalts were younger than the oldest Tertiary deposits. The degree of erosion in basalt terrains on the edge of several plateaux indicates that there has been a considerable uplift (at least 1000 ft.) since the eruption of the oldest basalt, i.e., since the erosion of the mature valleys of the Midlands type country. In close juxtaposition there are plateaux showing sharp escarpments, and Midlands type country covered with Tertiary sediments. These escarpments occupy long stretches, and are hardly effected by river erosion, i.e., they are not the result of the cycle of river erosion which has produced the mature valley alongside, and so must be the result of a more recent uplift.

But very deep and long entrenchments into the plateaux have been cut by the main tributaries of the larger rivers. The gorges in many places merge into the Midland type country and show very long-continued erosion. It appears to me that this is quite natural. The rivers excavated valleys in the 1500 ft. plateau, and what are now the main rivers continued to excavate their valleys while certain sections of the watershed suffered further gradual elevation. Pre-existing rivers cut into this giving a rejuvenated gorge. Thus we see the sharp interruption occurring often in the middle of a mature river valley (although now at different elevations) and the tributary system persisting, notwithstanding the remarkable gorges met in places. This view also explains the tiers, the lower plateaux, and the topography of south-eastern Tasmania, where the 1500 ft. plateau is very much in evidence, but no higher plateaux have been produced.

The uplifts, at least as far as the 1500 ft. plateau, preceded the deposition of Tertiary sedimentary rocks which are now found solely in valleys eroded in the uplifted plateaux and Western type country, i.e., in the Midlands type country. It is clear that there has been much erosion and resorting of these sediments, and at present we cannot say that the Tertiary deposits did not cover the plateaux prior to elevation. The most we can say is that they are not found on the plateau sides or, except in tiny patches from which no stratigraphical data has yet been gleaned, on the plateaux tops. The point is of great importance, as some Tertiary beds contain fossils and beds which provide a lithological correlation. The question is whether these beds were formed prior to the plateaux uplift or later than this event. The palaeontological evidence supplied by the Tertiary fossils would date the uplifts, but unfortunately reliable data for this correlation is not yet to hand.

The Tertiary deposits themselves have been most admirably described by R. M. Johnston (1888), to such an extent that little further details have been accumulated in the 50 years which have elapsed since his work. Practically no work has been done on these rocks since then.

Johnston recognized a lower and upper stage for which he used the terms Palaeogene and Neogene respectively. This nomenclature is useful, and it is a pity that it has fallen into disuse. Johnston, however, did not appreciate the extent of the Pleistocene deposits in unglaciated areas. I include the whole of Johnston's Neogene in my Pleistocene (Lewis, 1935). Johnston's Palaeogene extends from Miocene to Pliocene, probably including the whole of these periods. It appears to me that Johnston's correlations throughout Tasmania are difficult to sustain and he has not stressed sufficiently the effects of erosion and resorting of these sediments. The basalts (as will be discussed later) are now considered to represent at least two, and probably many, volcanic stages separated by long time intervals. In a word, the Tasmanian Tertiary and Recent rocks represent a more complex sedimentation than Johnston appears to visualize, and the problems presented by these rocks are now seen to be far more complicated than they appeared 50 years ago. I cannot accept Johnston's idea of lakes of very considerable area and depth, although lacustrine basins certainly existed. I visualize these as local in area and limited in time. With these exceptions, I confirm Johnston's remarkable work.

Since Johnston wrote, important descriptions of Tertiary deposits have been recorded by P. B. Nye (1924) in southern Tasmania. I can only confirm his observations, although with the same comments as those in Johnston's correlations (see also remarks by the same writer (1923) on the Waratah Tertiaries, and by

A. M. Reid (1923) on the same area). These accounts, however, do not carry us further than Johnston's more detailed descriptions. Some brief remarks on the Tertiaries of the Ringarooma Valley are also made by Nye (1925).

In this paper, I confine myself to observations on the correlation between the deposition period and the plateau elevations. The most useful key is the basalt, which must be considered with the Tertiary deposits, as both are comparatively contemporaneous and in most places the basalt has largely contributed to the preservation of the older Tertiaries. The materials of the Tertiary conglomerate have not been adequately studied. I have already noted the prevalence of pebbles of quartzite and other Lower Palaeozoic rock types in lower beds of Tertiary conglomerate and the absence of dolerite pebbles. I am in some doubt as to whether I did not place too much reliance on this factor, and my identification has been somewhat shaken by a determination that the 'quartzites' at Millbrook Rise or in the terraces exposed by the excavations at Boyer are very largely of sands metamorphozed by basalt occurring higher up the Derwent, i.e., 'Greybilly' pebbles, and not Lower Palaeozoic from the western country. This does not apply to many of the South Esk valley deposits. There is a possibility that, prior to the plateau uplift, there were considerable accumulations of conglomerate beds consisting of pebbles derived from Western type country subsequently to the elevation of that area, but owing to resorting and the absence of reliable petrological data it is dangerous to build any correlation on this fact yet. It should, however, be borne in mind.

The basalts would present the most useful correlation but, unfortunately, it appears that there have been more than one series of eruptions separated by long time intervals and, to date, agreement has not been reached on the relative age of the more important flows. R. M. Johnston and P. B. Nye also dealt with the basalt in its relation with the Tertiary deposits. More recently, Dr. Austin Edwards (1939) has contributed a comprehensive study of this point. All these writers have recognized the difficulties of correlation, and the accounts clearly show, in consequence, some deduction.

The difficulties in correlation between the Tertiary sediments, the basalts, and the plateaux uplifts may be stated thus—

Basalts range in altitude from 2000 ft. at Waratah and perhaps 2500 ft. at Guildford to sea-level. They traverse the whole north coast from 600 ft. to sea-level and extend at similar elevations through the Midlands, Derwent, Jordan, and Coal River valleys. In all these cases they are to be seen overlying the older Tertiary sediments, some of which are of Miocene age. Along the north coast they frequently overlie Western type country which has been peneplained prior to the eruptions. Elsewhere they occur in valleys eroded in dolerite and Triassic sandstones and which had reached maturity. All these occurrences fit in well with each other, and the evidence of the origin of the physiography derived from all other sources. Then in the middle of the terrain affected by these eruptions there stands the Central Plateau. Here basalts are found from 3500 ft. to 2500 ft. with a widespread distribution down the centre until they are cut off at about 2000-1500 ft. by an obvious post-basaltic uplift. South of this fault zone they are continued in the lower Derwent valley from about 750 ft. contour and thence to sea-level. (The official Geological Survey map does not show these basalts as nearly as extensively as they actually occur.) A further considerable occurrence exists on the lower steps from Lake Sorell southwards, as described by Edwards. Round Hobart we see basalt on Mt. Wellington at 4000 ft. and a line of eroded occurrences resembling a flow down an old river valley now broken by faults and extending from High Peak at 1400 ft. and Cades Hill (1120 ft.) to below sea-level at Margate and Tinderbox. On both sides of the Clarence Hills there are remnants of much eroded higher-level basalts with visible bases at 200 ft. (Risdon), 100 ft. (Droughty), 450 ft. at Cremorne, 200 ft. (Breakneck Hill), 100 ft. (Cambridge), and 200 ft. (Acton). A similar high-level basalt occurs at Melton (Mt. Vernon), with its base about 100 ft. above the present level of the Jordon valley.

Then there is another suite running down the Jordan valley from Pontville to the Derwent estuary, and a similar occurrence in the Coal valley and at Sorell and also at New Norfolk and Boyer, with the base well below sea-level (over 100 ft. in the few occurrences which provide data).

If these basalts were all of the same age, the problem would be simple. They are certainly post-Lower Miocene, because they overlie beds containing fossils which can reasonably be assigned to a Miocene age. The age of the basalts could be Pliocene on this evidence. They are cut by post-basaltic faulting, and this faulting produced valleys which have been invaded by Pleistocene glaciation. The basalts must therefore be pre-Pleistocene. So far, so good. But it appears certain that the basalts are not all of the same age and that eruptions occurred from Lower Miocene to Lower Pleistocene times. No petrological key to age or relative date of occurrence is forthcoming.

Therefore, instead of being able to use the basalts as an easy key to physiographic history, we have to turn to physiography to give us a solution to the basalt problem.

If the basalts of the Waratah area, the Great Lake area, and the Macquarie-South Esk valleys were contemporaneous, they must have preceded the plateau uplifts or at least the latter half of the stages of that uplift. The same applies to the Mt. Wellington and Derwent basalts. Palaeontological evidence shows that the Midlands valley has existed since Miocene times, and as will be discussed later. It is necessary to put at least some of the elevation at least as far back as Miocene or early Pliocene to provide time for the work that has been accomplished by the rivers. Thus the age of the basalts would be Miocene. This, however, is not conceded by a number of authorities (e.g., Edwards). If the basalts are post-uplift, then there must have been separate occurrences, some confined to the valleys and coasts and some to the centre of the plateaux. This opens up an interesting tectonic problem.

But the immediate sub-basaltic sediments at, e.g., Waratah (1750 ft.) and Geilston Bay (just below sea-level), are the same and of the same age and both are lacustrine deposits which could not have been formed in their present localities. Again the valleys of the Nive (Tarraleah) and Ouse (Waddamana) have cut 1000 ft. below the base of the river down which the basalt flowed. While in the Derwent, and on the north-west coast at many places basalt flowed down river valleys which have since been submerged below sea-level. Therefore, I postulate an uplift of considerable tracts of country in post-basaltic times, and an age for much of the basalt as no younger than the close of the Miocene period. I also postulate depression to at least a few hundred feet in other localities. This necessitates a period of earth movements in Pliocene times.

Using first the basalt eruptions as a datum time, we find the erosion of the Midlands valleys, lower Derwent, Coal, Jordan valleys and the coastal plains in pre-basaltic times. That there are definite erosion valleys and erosion implies something to erode. Therefore, I postulate the 1500 ft. uplift as occurring in pre-basaltic times. This erosion was completed prior to the deposition of Miocene sediments and I therefore place the 1500 ft. uplift as pre-Miocene and sufficiently so to warrant dating it as Oliogocene. The most extensive basalt flows, i.e., those in the Midlands, lower Derwent valley, and along the north coast have been protected from erosion by their location at (relatively) base-level. The Tarraleah-Waddamana-Lake Sorell basalts are definitely cut by the uplift to 2500 ft., and are therefore pre-uplift. It is reasonable to correlate these with the basalts which overlie Miocene sediments, and so we can date this uplift as late Miocene or Pliocene. The north-western basalts occur as a relatively thin sheet overlying Palaeozoic (including Permian) strata exposed by previous uplifts. The basalt is broken in numerous steps from Guildford (2400 ft. to sea-level), and under the basalt lies similar Miocene sediments. We therefore have a 2500 ft. uplift along an axis running east and west through Guildford and Middlesex.

In immediately pre-basalt times (Miocene) there were extensive developments of lacustrine and marine conditions at places now appearing at different levels (Macquarie Harbour, sea-level; Guildford and Waratah, 2400-1750 ft.; Marrawah and Wynyard, sea-level; Longford to Tunbridge, 600-750 ft.; Lower Derwent valley, 100-500 ft.). This development indicates tectonic movements, probably slightly negative, in immediate pre-basaltic times. Subsequently to the eruptions, the sediments and their protective basalts have been elevated as indicated. If this post-basaltic elevation is accepted, the present difference in levels can be thus explained. The Midlands type country seldom shows basalt at over 1000 ft. elevation, and this holds good for the north coast. The basalts cut by the Ouse and Nive rivers stand roughly at the same height as those of Guildford and Waratah, 2500 ft.

We now come to the greatest objection to the above sequence. Dr. A. B. Edwards' opinion that the Central Plateau basalts are later than the age I have afforded to them and may be middle Pleistocene. I admit the strength of Dr. Edwards' arguments, but we have the Marrawah and Bulmers Hill basalts which are placed as pre-Miocene-Oligocene (Nye and Blake, 1938, Edwards, 1939). We have the Tarraleah-Waddamana basalts cut by late Miocene-early Pliocene uplifts. In the Derwent valley and elsewhere there are at least two eruptions separated by long-time intervals, as will be described later. Some of these basalts are considered to be Pleistocene. We have the further difficulty that the basalts do not appear to have been affected by glaciation. This may be due to poverty of observation, but, as far as I can see, the Guildford basalts at 2500 ft. were not glaciated, while ice reached sea-level at Zeehan—twenty miles away. The Great Lake basalts, similarly, do not appear to have been glaciated. The probable explanation is that we have a post-Malanna (Middle-Pleistocene) basalt volcanic phase. This appears certain from evidence around Hobart. To such a phase can be assigned at least the Great Lake and Lake Sorell basalts and many of the coastal occurrences.

Here, I can do no more than stress that basalt, as R. M. Johnston recognized, has been erupted in Tasmania at widely separated intervals over most of the Tertiary period. The basalts described by Dr. Edwards at the Great Lake are probably not referable to the same eruptions as those at Waddamana and Tarraleah. The separation of the different basalt flows on any particular area is a matter warranting detailed study.

These eruptions must have been the result of tectonic influences, and it appears that most, even the most recent, have been slightly broken by faulting, indicating earth movements to some extent during Middle Pleistocene times. These will be discussed later.

It appears, therefore, that we first had a middle Tertiary uplift to 1500 ft. more or less. This may have been the result of the same series of movements that produced the elevation of blocks and subsequent erosion of which gave us Permian strata on the surface. It could equally be a somewhat later phase. In any case, it is noteworthy that the principal areas in which Permian rocks appear on the surface are near the coasts. These plateau uplifts were, as already stated, always gentle and appear to have been in steps—with 200 ft. as about the average. The pressure was unequally exerted and the result has been that there is a considerable difference in resulting elevation. This is more marked on the Central Plateau.

SUMMARY

In general, there was a period during which Tasmania was squeezed by pressure from the east and south-east against the west or against pressure from the west and south-west. This pressure lasted from Cretaceous to Pleistocene times. The pressures were not continuous, but produced small uplifts which released the pressure, and a considerable time-interval elapsed before the accumulation of stresses again overcoming the natural resistance of the rock masses. Although I have spoken of uplifts to 3000 or 1500 ft., all the evidence points to a gradual uplift in definite and very small stages to this average height. So with the plateau uplifts. The evidence simply becomes more detailed as we approach present time and so the movements appear to be more complicated, but, in fact, there is no evidence of any major disturbances since the dolerite intrusions. At the same time we have to explain the various patterns of areas of rocks of different ages with the collorary that more recent rocks have been elevated and eroded.

Lacustrine deposits were elevated and a little later, as a result of the pressure basalt, was squeezed out in certain areas. The elevation resulted in an older plateau highly eroded into mature valleys. Later the higher plateaux were elevated in even smaller cubes out of areas previously elevated. Basalt eruptions continued and then later elevations cut and separated flows of the earlier basalt.

These movements extended into Pleistocene times, but the effects became gradually less intensive in both area and vertical effect. At the time of the onset of the Ice Age, tentatively assigned to Lower Pleistocene times, we see the plateaux to be much the same physiography as we now know—wide valleys eroded to base level and largely covered by basalt.

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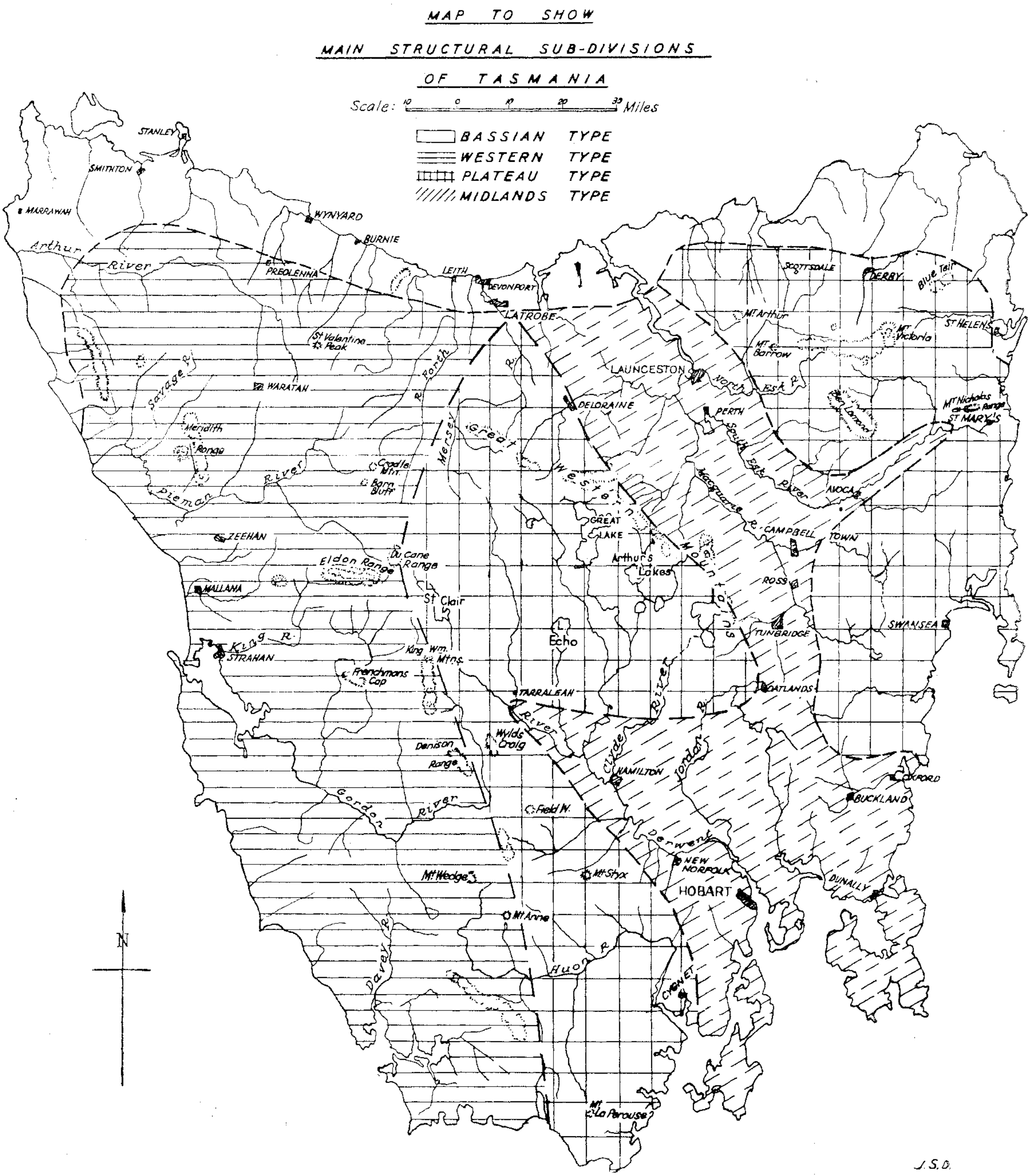

MAP TO SHOW
MAIN STRUCTURAL SUB-DIVISIONS
OF TASMANIA
Scale: 10 0 10 20 30 Miles
BASSIAN TYPE
WESTERN TYPE
PLATEAU TYPE
MIDLANDS TYPE
STANLEY
SMITHTON
MARRAWAH
WYNYARD
BURNIE
Arthur River
PREOLENNA
LEITH
DEVONPORT
LATROBE
St Valentine Peak
WARATAH
Savage R.
Meredith Range
Pieman River
Cradle Mtn.
Barn Bluff
Mersey
R. Porth
Great Western Mountains
ZEEHAN
Du Cane Range
Eldon Range
MALLANA
St Clair
King R.
STRAHAN
King Wm. Mtns.
Frenchmans Cap
TARRALEAN
Wylds Craig
Denison Range
Gordon River
Field W.
Mt Wedge
Mt Styx
Mt Anne
Davey R.
Huon R.
CYGNET
Mt La Perouse
LAUNCESTON
North Esk R.
DELORAINE
PERTH
South Esk River
Macquarie R.
GREAT LAKE
Arthurs Lakes
L. Echo
Clyde River
Jordan R.
Derwent
HAMILTON
NEW NORFOLK
HOBART
SCOTTSDALE
DERBY
Blue Tier
Mt Arthur
Mt Barrow
Mt Victoria
ST HELENS
Mt Nicholas Range
ST MARY'S
AVOCA
CAMPBELL TOWN
ROSS
TUNBRIDGE
OATLANDS
SWANSEA
ORFORD
BUCKLAND
DUNALLY
N
J.S.D.

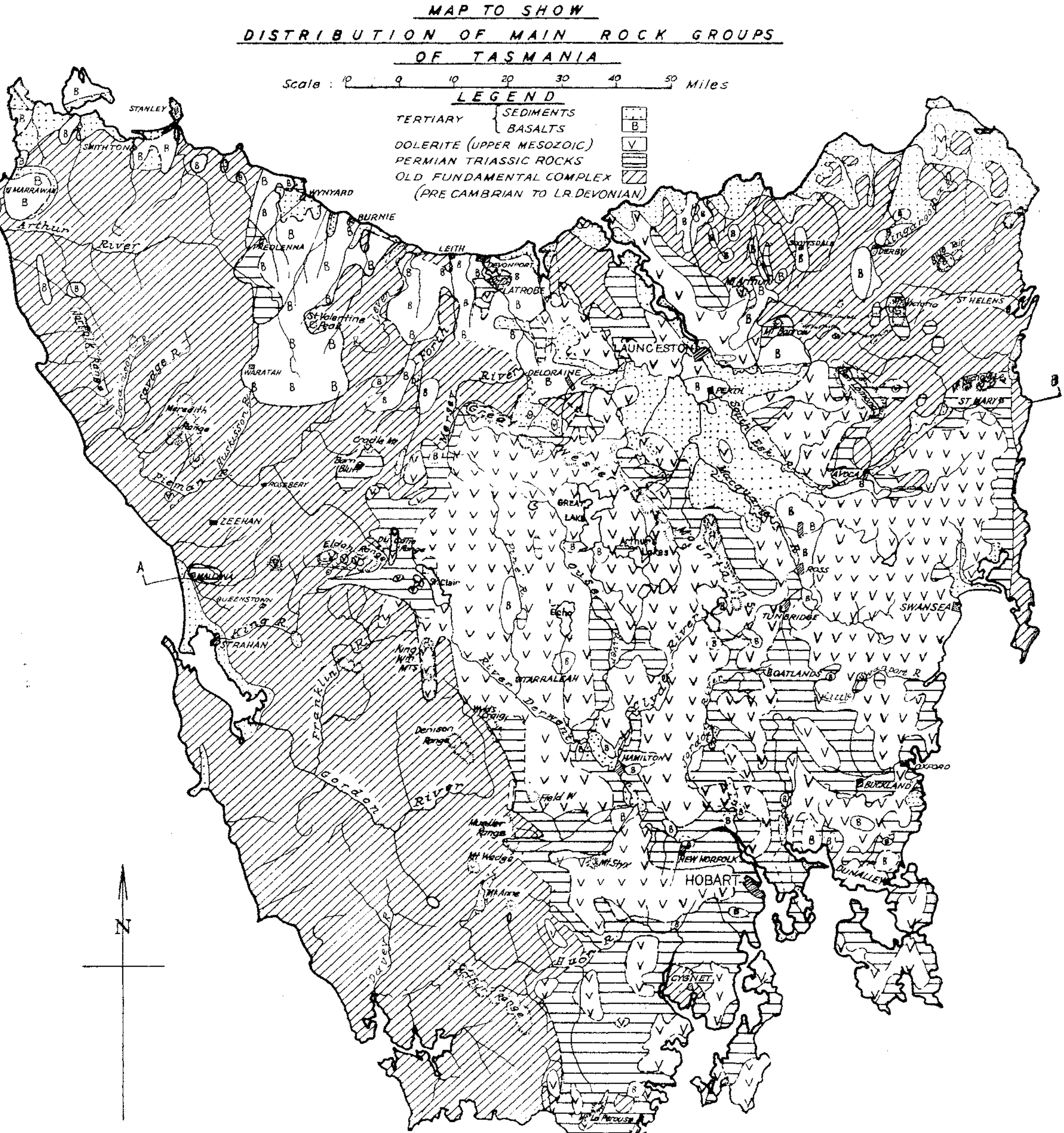
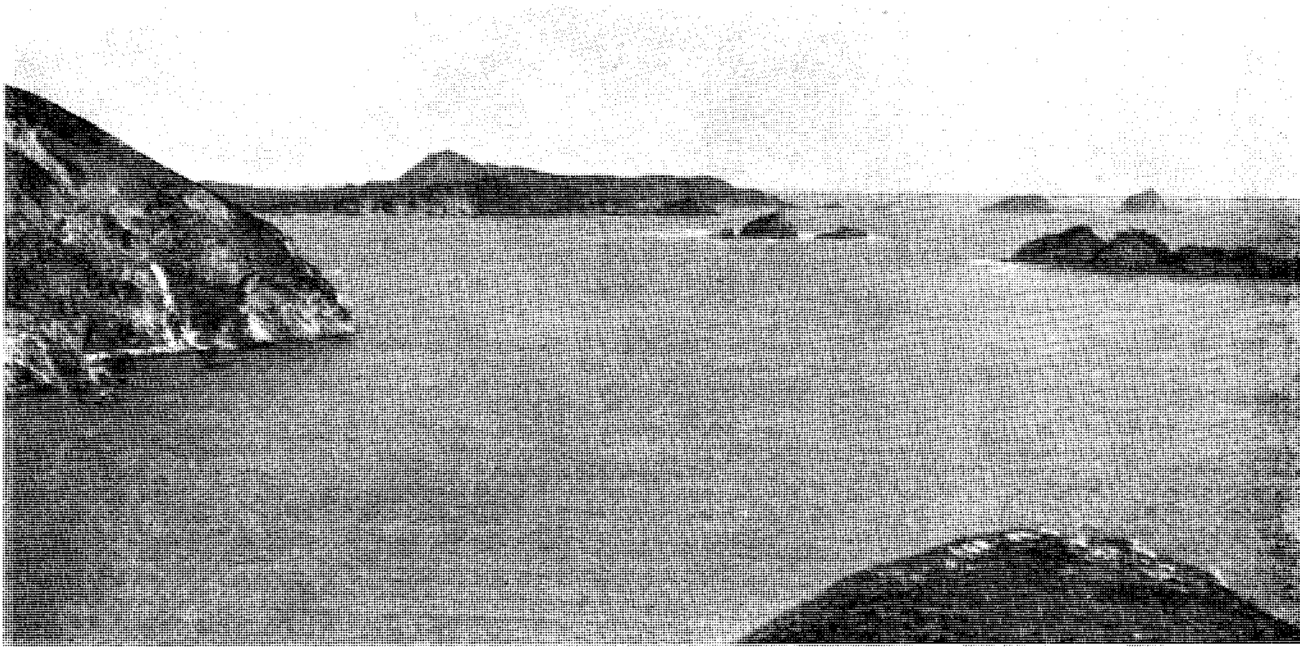

MAP TO SHOW
DISTRIBUTION OF MAIN ROCK GROUPS
OF TASMANIA
Scale : 10 0 10 20 30 40 50 Miles
LEGEND
TERTIARY { SEDIMENTS
BASALTS B
DOLERITE (UPPER MESOZOIC) V
PERMIAN TRIASSIC ROCKS
OLD FUNDAMENTAL COMPLEX
(PRE CAMBRIAN TO LR. DEVONIAN)
STANLEY
SMITHTON
WYNYARD
BURNIE
LEITH
DEVONPORT
LATROBE
LAUNCESTON
DELORAINE
WARATAH
ZEEHAN
ROSEBERY
QUEENSTOWN
STRAHAN
SCOTTSDALE
DERBY
ST HELENS
PERTH
AVOCA
ST MARYS
ROSS
TUNBRIDGE
SWANSEA
OATLANDS
TARRALEAH
HAMILTON
NEW NORFOLK
HOBART
BUCKLAND
DUNALLEY
CYGNET
N
A
B
J.S.D

PLATE IV

FIG. 1.—Entrance to Port Davey, Tasmania. Showing steep-sided slopes, and relatively shallow entrance to inlet.

FIG. 2.—Bramble Cove, Port Davey, Tasmania.

(Photos by courtesy of the Tasmanian Tourist Bureau.)



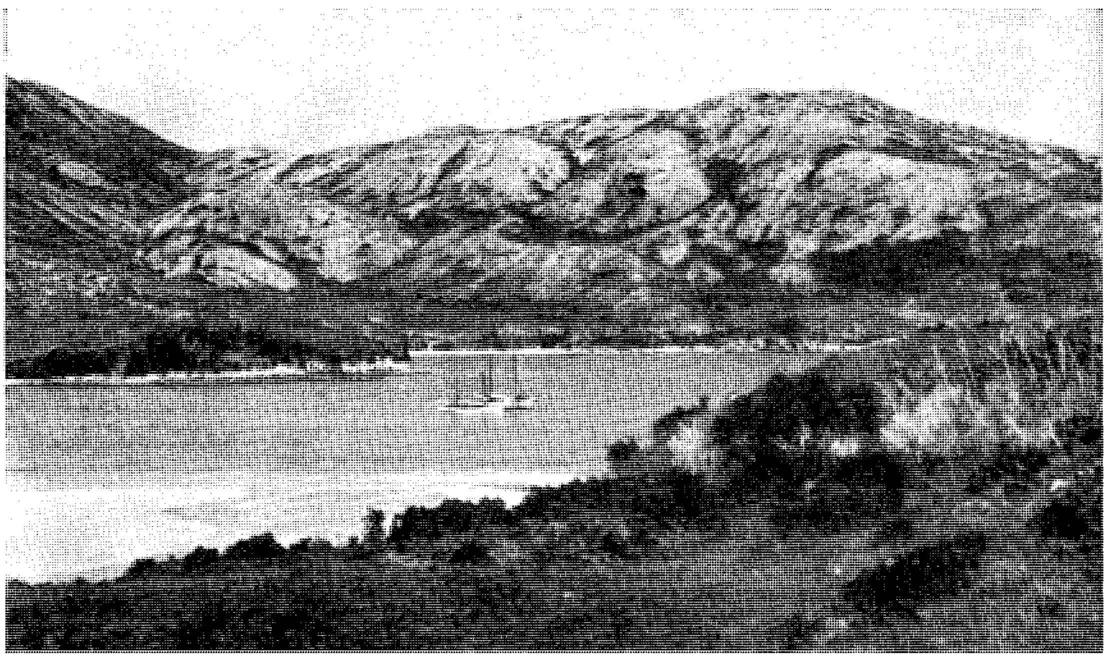


PLATE V

Looking across Bathurst Harbour from height above New Harbour, Port Davey, South Coast of Tasmania. Showing dissected nature of country and typical flat valley floor characteristic of the Button Grass Plains.

(Photo by courtesy of the Tasmanian Tourist Bureau.)