A FURTHER ACCOUNT OF THE GEOLOGY OF THE CATAMARAN COAL FIELD.

By

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Part I.

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GENERAL GEOLOGY OF AREA.

1. INTRODUCTORY.

Geology is to the miner what the Intelligence Service is to the soldier. It gives the plan of the terrain upon which the operations are based. In a general conception, it provides a guide for developmental policy, and in a special aspect it provides the tactical plan upon which each problem must be attacked. But the complete geology of a mining field is usually only apparent after fullest pure scientific research and practical investigation has been made, a result only achieved, if at all, when mining operations are concluded. Then the details of structure and the sequence of cause and effect may be known, and information of the greatest value to pure science and perhaps of economic value to those opening up other fields may be available.

But if geology is to be of practical use to the miner in opening up his own mine, it must supply its data in advance of operations. Its use is to tell the miner what his pick is going to strike. To do this, detailed knowledge of the whole stratigraphic province in which the field lies must be obtained. The geology of no 640-acre lease can be worked out within its boundaries, and even before an area is selected for a lease wide problems of policy must be considered. As a guide for all this, as accurate a mental picture of the whole district as can be obtained is vital.

The obtaining of this picture—this locality plan—entails such an amount of labour that in practice it must be built up gradually but to expend money without it is merely

Plate XXV.

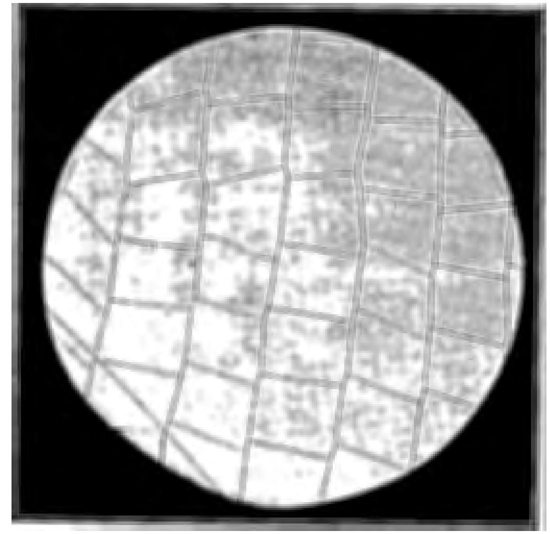

Fig. 8. Meshes in the web of *Cyrtophora parnasia* (L. Koch).

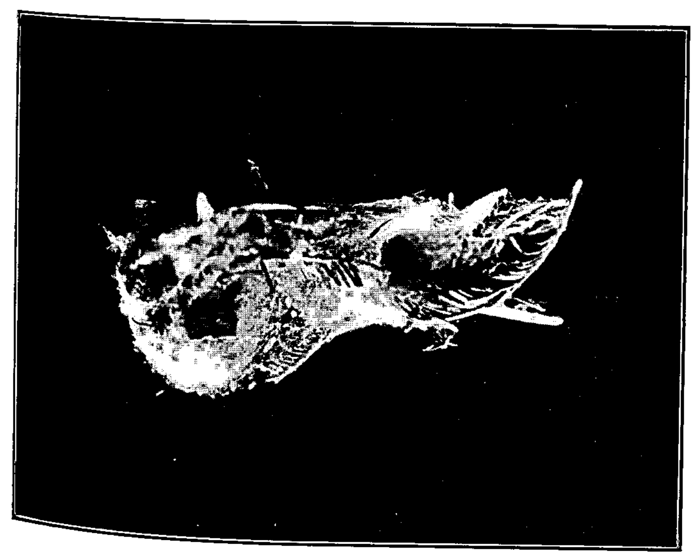

Fig. 7. Nest of *Cyrtophora parnasia* (L. Koch).

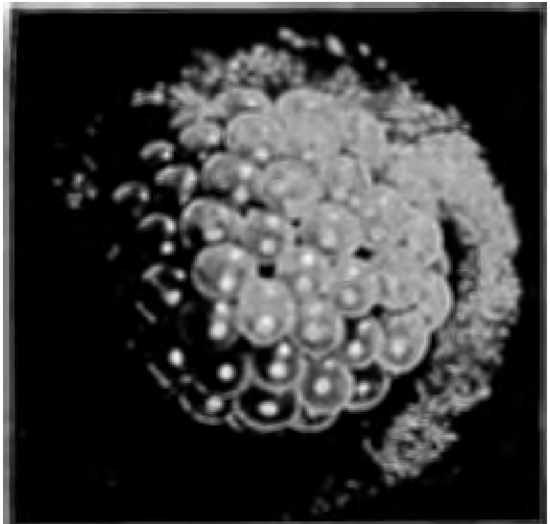

Fig. 9. Eggs of *Cyrtophora parnasia* (L. Koch).

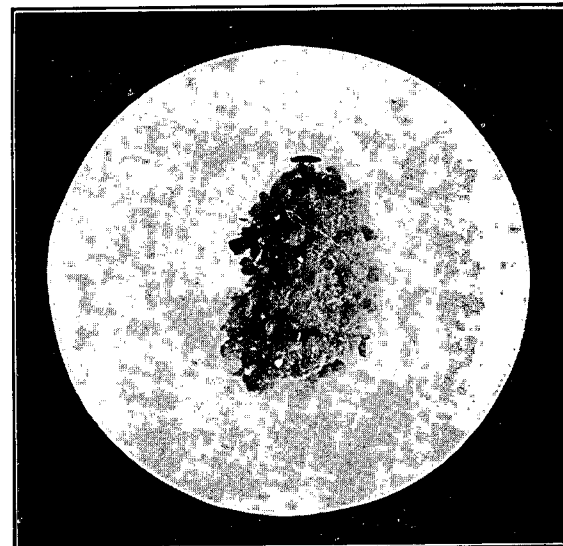

Fig. 10. Dark coloured tufts of silk on egg sac of *Cyrtophora parnasia* (L. Koch).

to repeat the tragic story of so many of the wrecks with which Tasmania is dotted. It is strange how many men who would never dream of building a house before their land was surveyed and marked will cheerfully spend thousands in opening a mine without the slightest idea of where they are or what is ahead of them. The story of money lost in Tasmanian mining has been largely the story of failure to recognise that a plan is necessary and that the Geologist can provide this plan.

Nowhere can these truths be better exemplified than in the past history of the Catamaran and other southern coal fields. The story of past efforts to open up these deposits has been a succession of chapters of blind expenditure of money without plan and of immediate resignation to fate on meeting difficulties which an appreciation of the geology of the area would have shown to be surmountable. Not only this, but when the importance of geology was recognised by the practical miner (Mr. E. C. Tregear must be given the credit for this on this field), its problems were insoluble until the telescope was used to aid the microscope—until the whole district was studied as one coal province.

Much has yet to be done before a complete geological map can be constructed. The difficulties of exploration cannot be imagined by anyone who has not attempted it, and even when all the surface data have been collected only boring operations can prove conclusions. But enough information is now to hand to warrant the construction of a "Policy Map," and it is well that this information be published as a guide to investigators in neighbouring and even distant fields, and to persons desiring to form a true estimate of the value of the field in question.

This paper aims at giving a general survey of our present knowledge. We cannot yet present a full detailed account of the geology of the field. The importance of this area has long been recognised and a wealth of literature has grown up about it, but since the last account was published so much information has come to hand from the boring and other exploratory activities of the Catamaran Collieries Ltd. and associated groups during the past three years, extended and co-ordinated by trips undertaken by the writer over the area in question and the surrounding districts, that it is necessary to recast our conception of the geology of the field and possible to make public a reasonably accurate general account of the geology of this portion of Tasmania.

2. PREVIOUS LITERATURE.

Attention is directed to the following articles on the area, and the reader is recommended to study them, as the information there set out is not repeated in this paper.

The first report of the existence of coal in the district is contained in the diary of Captain James Kelly dealing with his famous boat voyage round Tasmania. This navigator saw the seams of coal and carbonaceous shale outcropping in the cliffs bounding South Cape Bay, and referred to later in this paper.

In 1847 Joseph Milligan, who was brought from England by Sir John Franklin to report on coal in Van Diemen's Land, made a careful investigation of the area, and his report is to be found in the Papers and Proceedings of the Royal Society of Tasmania, 1848.

As the writer there remarks, coal had been mined at South Cape Bay many years previously to his visit.

In 1915 the late W. H. Twelvetrees made a survey of the Catamaran, Strathblane, and South Cape areas, and the results of his investigations are set out at length in Geological Survey of Tasmania Bulletins No. 20 (The Catamaran and Strathblane Coal Fields) and No. 24 (Reconnaissance of the Country between Recherche Bay and New River).

In 1921 Mr. A. McIntosh Reid continued the investigation, and his report is contained in *The Coal Resources of Tasmania*, chapter 7.

The area dealt with in the present paper adjoins that dealt with by myself in my account of the Mt. La Pérouse Range (Papers and Proceedings of the Royal Society of Tasmania, 1924, pp. 9-44), and may be considered as a continuation of the work there recorded.

3. GENERAL GEOLOGY.

(a) Physiography.

Looked at in detail, the physiography of this corner of Tasmania is most complicated, but in a general way it resolves itself into a coastal plain bounded on the east by D'Entrecasteaux Channel and on the west by the La Pérouse Range. Spurs descend from this range across the plain almost to the sea and divide it into a series of basins separated by rough and forest covered hills. The physiography of the western range has been fully described by the present

writer, and in this regard there is nothing further to add (see Lewis, 1924). The physiographical features of the rest of the area may be described in a few words.

About three miles south of the Lune valley a considerable spur runs eastward from Moonlight Flat. After a steep descent for several hundred feet, sufficiently sharp to define this spur from the general north and south trend of the main range, the spur rises into a considerable hill about 1,000 feet above sea level. This hill is succeeded, after a high saddle, by Sugarloaf Hill, the highest point on the spur (about 1,600 feet high), and standing some mile and a half from the edge of the main range and forming a bluff on the end of the spur. From this hill the spur drops in a series of steep, heavily wooded steps to the main road a mile or so farther east.

Between this spur and the Lune River lies a flat, even buttongrass plain, known as the Ida Bay Plain. This stands at an elevation of 100-300 feet above sea level, and from its southern and western edges the mountain spurs rise steeply. The land between the road and Southport Bluff is very little higher but somewhat seamed by small gullies and ridges thickly covered with low dense scrub.

The Sugarloaf spur is very narrow from north to south and drops quickly to the south to another basin—the Leprena Plain. This is a similar flat, regular, buttongrass plain about 250-350 feet above sea level through which runs the D'Entrecasteaux River and its several branches. To the north, the side of the Sugarloaf spur descends steeply. To the west, this plain merges into the D'Entrecasteaux cirques of La Pérouse. To the south-west, the ground rises steeply again to the Leillateah spur—an elevated saddle connecting Mt. Leillateah with the summit ridge of La Pérouse and terminating in a fine outstanding conical hill 2,630 feet above sea level, known as Leillateah [1]. The top of this peak stands some 4-5 miles back from the shore line of Recherche Bay. The country drops very steeply from the summit of Leillateah to the eastward, and after an almost sheer drop of 1,000 feet or so the spur is continued by a lower ridge

(1) I have considered a change in the cartography as given in my La Perouse paper is necessary. This is the hill most commonly known locally as Leillateah. As this was the aboriginal name for Recherche Bay it appears more appropriate to keep the name for the mountain which absolutely dominates that bay and its settlements. In 1793 Captain John Hayes named the peak I previously called Leillateah, Pindar's Peak. This is the first and original name bestowed, and is very appropriate. I have, therefore, restored it. See also note P. and P. Royal Society of Tas., written in collaboration with myself.

which has a considerable extension southwards, projecting well into the Catamaran valley. This ridge also has a wall-like side to the east, and it is succeeded by a low line of wooded hills stretching to the shore line between Leprena and Catamaran. It is in these lower extremities of the Leillateah spur and their seaward basins that the Catamaran Colliery is now working.

In succession to the south comes the Catamaran Plain (2). This is another flat tract of ground some 150-250 feet above sea level and covered in this instance with cutting grass and low scrub. It lies almost entirely to the south of the Catamaran river which flows between it and the Leillateah spur, but the most convenient access to the plain is to be gained from the river. To the west, the plain merges into the Catamaran cirque and the slopes of the main La Pérouse range. To the south-west it is bounded by the sharply descending spurs of Pindar's Peak, which terminate in a fine outstanding and almost isolated hill known as Mt. Misery, which juts out a mile or more into the plain. To the east, the plain is separated from the shore by a range of broken dolerite ridges, about a mile broad and perhaps 600 feet high at their highest point. These run right down to the shore line between Catamaran and Cockle Creek and form, in the same line, the western boundary of Cockle Creek Plain. At roughly right angles to this line a similar line of hills skirts the northern shore of South Cape Bay and obviously a further plain to the southward has been flooded by more or less recent earth movements (see Twelvetrees, 1915 (ii.)). East of Cockle Creek Plain, which is under a mile wide, is a small area of elevated country around Bare Hill (909 feet) and extending to Whale Head.

(b) Stratigraphy.

The stratigraphical succession of the rocks in this area presents few difficulties. The oldest rocks represented are Silurian quartzite conglomerates succeeded by limestones of the same age. The present writer has no further observations to add to those of Mr. Twelvetrees (Twelvetrees, 1915 (i.), pp. 8 and 33-37). In 1911 the present writer saw abundant fossils in the limestones near one of the Ida Bay Caves in the vicinity of the present quarry being worked for the Electrolytic Zinc Co. These corresponded with the series

(2) Mr. Twelvetrees called this Manuka Plain, but Catamaran Plain seems to be generally employed locally, and there are sufficient "Manuka Plains" scattered round Tasmania.

illustrated in R. M. Johnston's Geology as Silurian. Some doubt has since risen as to the correct age of these beds, but for the present there appears to be no reason for changing Johnston's determination.

The quartzite conglomerate boulders extend right across the western edge of the D'Entrecasteaux plain, and disappear under talus and soil at the foot of Leillateah at an elevation of 500 feet but beds lying *in situ* have not yet been found. In the valley of the D'Entrecasteaux they apparently are to be seen as low as 300 feet above sea level but have been here obviously much eroded. The limestone which occurs above them and forms the upper two-thirds of Sugarloaf Hill does not extend across the valley. There appears to be a marked unconformity between the conglomerate and the limestones, the former covering more than twice the area of country covered by the latter and being succeeded towards the south by Permo-Carboniferous and Triassic sediments without the interposition of the limestones. However, in the time at the writer's disposal no clear junction section between the conglomerate and either the limestones or more recent sediments could be found. The occurrence in the D'Entrecasteaux plain is marked by accumulations of great boulders evidently eroded *in situ* and no positive occurrence of the parent beds could be found although almost certainly they occur at no great depth below the surface detritus and soil of the hill sides.

The coast line of the area is most indented. Southport, with its inner and outer harbours to the north, Southport lagoon in the centre, the double indentation of Recherche Bay towards the south cut deeply into the coastal plain. These are all typically submerged river mouths, the sea following the extremities of the steep sided valleys in tortuous arms. The coast is mostly low but rocky. There are occasional sandy beaches but great masses of dolerite boulders and low cliffs of the same rock occupy the shore line for most of its extent. South Cape Bay and South-East Cape show more rugged features, but even here the cliffs seldom stand a hundred feet high. The whole coast is marked by innumerable reefs, submerged rocks, and islets, and presents a constant series of perils to navigation.

From occasional boulders in the Catamaran River, to be found with increasing frequency from three miles above its mouth, limestones of this age may outcrop in the valley of this river, but these boulders are probably derived from Permo-Carboniferous limestone beds known to occur there.

However, the fact of the occurrence of similar beds at Sugarloaf Hill and on the south coast (see Twelvetrees, 1915 (ii.)) gives an indication that possibly there may be an outcrop of this rock in the valley of the Catamaran River, but the writer has been able to find no such outcrop and is of the opinion that none occurs.

Next in succession come the marine sediments of Permo-Carboniferous age. These are common round Southport and extend high on to the flanks of the La Pérouse range south of the Lune valley and outcrop again on the coast near South Cape. They outcrop in the valley of the Catamaran River in cliffs on the S.E. face of the broad hill east of Leillateah about 2 miles S.W. of the mine workings. These are continued to the S.E. by glacial basal conglomerates. The dip would account for the appearance of these rocks below the Triassic sediments. The zones represented appear to correspond with the basal conglomerates and lower marine series as described from other parts of Tasmania. They are exposed only where the combined action of faulting, river and cirque erosion has permitted gorges to be cut deep enough into the heart of the mountains. A few occurrences of lower marine limestones are to be found on the western edge of the Leprena Plain, and succeed the glacial conglomerates in the Catamaran valley.

Ross sandstone of the lower Triassic has not yet been definitely located in the area. It should succeed the Permo-Carboniferous rocks where they occur, and appears to do so on the north-east edge of Moonlight Flat at about 2,000 feet above sea level. However, this assumption is tentative, and the coal measures appear to descend to 500 feet or thereabouts farther south. A determination of these beds is very important as they mark the lowest known limit of the upper coal measures. Any one engaged in exploration for coal should be acquainted with their general characteristics, although it is often difficult to distinguish them from sandstone beds included in the coal measures, and the present writer is by no means satisfied that he has not so confused beds of sandstone on the higher slopes of La Pérouse (Lewis, 1924). Composition is not a certain criterion as, although the Ross sandstones are predominantly quartzitic and the coal measure sandstones predominantly felspathic, these features are by no means absolutely constant. In many layers it is difficult to tell which constituent predominates, and layers of purely quartzitic sandstone are frequent in some beds of coal measures. But Ross sandstones can usually be dis-

tinguished by a massiveness seldom seen in the coal measures and by a more regular and deeper colouring and the frequency of cross bedding, which can only be seen well in massively bedded strata. It is, however, most probable that Ross sandstones will be ultimately identified in the area.

Succeeding the Ross sandstones naturally come the felspathic sandstones containing the coal measures. Nowhere on this field has the base of this series been observed, and one of the most urgent pieces of work to be undertaken is this locating of the junction of the economic beds with some underlying series. Until this is done definite knowledge of the stratigraphical position of the exposed beds in the system is difficult to obtain. The coal measures have been somewhat fully described (see Twelvetrees, 1915 (I.), and Reid, 1922) but much work remains to be done.

It would be useful to know what is the relation between the coal bearing beds to the underlying Permo-Carboniferous or Triassic sediments. The solution of this problem should give an indication of their stratigraphical position in the Triassic period—a point of vital importance in the correlation of neighbouring beds. The La Pérouse section will give this and its solution is only a matter of exploring the face of the mountain.

The fossil evidence is abundant and deserves the closest study. By this means, perhaps, many difficulties will be solved, and the whole field zoned. The coal measure fossils have never been sufficiently studied in Tasmania. Species have been identified and thanks to Dr. Walkom (Walkom, 1924, 1925), sufficient is now known of the classification of the Mesozoic flora, but little has been done in the way of studying the field occurrences. To date—beyond a certain vague empirical grouping the details of which rest in the minds of Mr. A. M. Reid and Mr. P. B. Nye—all these fossils are grouped together as Mesozoic species. What is wanted is information as to whether any one or more species or any constant groupings are typical of any particular beds in the coal measures. Detailed research in this branch may provide a key which would solve many difficulties. It is hoped that this matter will be undertaken as opportunity presents itself.

The two shafts now sunk by the Catamaran Colliery Co. have opened up fine fossil beds and some opportunity has been thus afforded to study in detail the relationships of at least two coal seams occurring in the locality. One of these fossil beds lies immediately over what is termed in the mine the shaft seam, and the other immediately underlies what is known as the anthracite seam. The fossils in both cases are wonderfully abundant and remarkably well preserved, and warrant the closest study. The writer hopes to record further conclusions on this topic in a future paper.

The shaft seam is characterised by absolutely predominant *Johnstonia coreacea*, accompanied by rarer *Thinnfeldia odontopteroides*, *T. feistelmantelli*, *Cladophlebis australis*, and *C. tasmanica* (perhaps with *Phlebopteris alethopteroides*) and with very rare *Phœnicopsis elongatus* and *Linguifolium diemenense.*

The anthracite seam is characterised by plentiful *Cladophlebis australis* and *Phœnicopsis elongatus* with rarer *Johnstonia coreacea*, *Thinnfeldia*, and *Linguifolium.*

The result of these observations will make it easy to verify the relationship of other seams with these.

The fossils underlying the anthracite are easily traceable in the lower bands of the coal itself. This does not occur in the case of the shaft seam. It is easy to see that such would be more probable with a band of fossils underlying a seam than with one overlying the coal.

Speaking generally, the fossil evidence finally and definitely terminates any idea that these are not typical Triassic measures. It was thought vaguely possible by the mine staff that the quality of the coal was evidence of a different horizon, and the existence of earlier measures at Ida Bay lent colour to this theory. But the Catamaran coal measures are typically Triassic and the grouping of the fossils corresponds most closely with that given by R. M. Johnston for Mount Nicholas.

I must here mention a further point. In 1893 R. M. Johnston gave his opinion that the Ida Bay coal seam was lower than the Upper Mesozoic measures. He says:—"It "would seem probable, therefore, that the Southport and "Ida Bay formations supply an important link in the chain "of plant life, connecting the close of the Permo-Carbonifer- "ous period with the beginnings of the Mesozoic period," and in the accompanying table he puts these beds between the Adventure Bay bed and what we now know as the Ross sandstones. (Johnston, 1893.) Mr. Reid adopts this view. (Reid, 1922.)

I desire to express the opinion that the discovery of Vertebraria must be conclusive. No examples of this plant are to be found associated with the Catamaran seams and they cannot be lightly tossed aside. The Ida Bay seam is not now approachable to check observations, but personally

I have never found R. M. Johnston in error in a direct observation. We must, therefore, support his determination of the stratigraphical position of the Ida Bay seam.

The next event in the geological succession was the intrusion of the dolerite (diabase), and the solution of the problem of these intrusions is the most important piece of economic geology to be undertaken in the area—if not in all Tasmania. As Mr. Twelvetrees has said:—"The Geological "mode of occurrence of this rock has long been a subject of "controversy but it must be correctly understood before the "prospects of coal fields can be gauged." He then proceeds to elaborate his theory of its occurrence (Twelvetrees, 1915 (i.), p. 18). The importance of this object of research is so great that all Tasmanian Geologists have made some contribution towards its solution, but unfortunately with widely conflicting results. The present writer has summarised his views in a recent paper (Lewis, 1926), views which are strongly supported by evidence collected in this area, and although it is too much to hope that these will be the last word on the subject, it is sincerely hoped that they are based on a correct appreciation of the field evidence and will in due course be confirmed by others.

The occurrences in this locality may be grouped into (1) the coastal dolerite, (2) the Catamaran sill, (3) the La Pérouse dykes and sills.

(1) *The Coastal Dolerite.*

This mass extends from South-East Cape northerly along the shore of D'Entrecasteaux Channel past Recherche Bay to Southport and is evidently closely connected with occurrences farther north.

It forms Bare Hill and the promontory between Recherche Bay and South-East Cape, and also underlies Cockle Creek Plain and forms the line of hills extending for about a mile west of this plain and running northward to the valley of the Catamaran River. The settlements of Catamaran and Leprena are built on it, and it forms the several capes along the western side of Recherche Bay and the occurrences north of Sullivan's Point and south of Southport. It is, even in hand specimens, of a characteristic coarse grained holocrystalline structure with frequent veins of gabbroid nature and is relatively hard and massive and free from cracks and secondary crystalline minerals. It appears to be a typical transgressive mass of unknown depth and definitely limits the coal-bearing strata to the eastward, except to the east of Recherche Bay and towards Southport Lagoon.

(2) *The Catamaran Sill.*

This occurrence of igneous rock is the one which has caused the trouble on the mining field and in the bores, and its isolation is the most useful piece of pure geology to be worked out on the field. At its southern extremity this outcrops as a dyke-like mass at Little Island in South Cape Bay and there has been fully described (Milligan, 1849, and Twelvetrees, 1915 (ii.)). A clear section can there be seen in the cliff face. It is apparent that this body of igneous rock rose as a dyke with a well defined wall-like eastern edge. It is here about 100 yards wide and of unascertainable depth. Farther west it appears to arch over sedimentary deposits which are exposed on the beach and after about 100 yards to descend to sea level again and continue thus for about 50 yards—probably this is a local coalescence of two dyke-like masses ascending in close proximity to each other. The dyke proper is thus about 250 yards wide. It then assumes the form of a sill commencing to the east with a thickness of about 200 feet and rapidly thinning to about 50 feet and gradually feathering out some 400 yards or so from the dyke.

Coal definitely exists under the sill and continues right to the edge of the dyke. It was mined some years prior to 1848 and the entrance to the old tunnel mentioned by Dr. Milligan (Milligan, 1849, p. 22) is still visible. This coal seam is definitely under the sill. Mr. Twelvetrees made a curious mistake when he ridiculed the shaft sunk here (Twelvetrees, 1915 (ii.), p. 7), and his error can only be accounted for by supposing that he did not descend the cliffs. On the cliff face referred to the coal was mined by a shaft under the "diabase" and not only "to people of that day" but to a geologist of to-day "would it be the most natural thing "to suppose that by sinking through the diabase rock coal "would be reached below." Since it can be seen that the diabase is only 50 feet in thickness and coal lies not 50 feet below it.

The coal measures and seams have not been metamorphosed for more than a few inches—extending to a few feet locally—and beyond a slight alteration in angle of dip, perhaps due to faulting, the sedimentary beds have been barely disturbed by the igneous intrusion. This only bears out observations made in many places in Tasmania that neither extensive alteration nor dislocation necessarily follows these intrusions. This occurrence is definitely intrusive and of a later age than the sedimentary series.

The Rocky Boat Harbour track crosses the junction between the igneous rock and the sandstones, about half a mile inland. The edge of the igneous rock was located as accurately as possible, and a bearing was taken from this edge to the edge of the occurrence at Little Island. This gave a reading of roughly 40° E. of mag. N., and when it was plotted on a chart the result gave a line through the eastern edge of the occurrence in the Catamaran field and of that to the west of Leprena with such a degree of accuracy—allowing for minor irregularities in the edge of the sill—that the interpretation was forced on the writer that this occurrence represents the outcrop of a fairly regular sill, a little broken, perhaps, by subsequent faulting.

The eastern edge is a roughly regular outcrop, and the sill then feathers out to the westward through the coal measures, rapidly decreasing in thickness and varying in its westward extension. Bore results give the authority for this statement. This sill has been cut with faults. The two dolerite hills—one behind the hill seam and one on the south coast—are uplifted portions of it and apparently in present evidence coal measures extend below the igneous rock. The outcrop is very irregular, being a succession of sharp rises separated by curved saddles. At the coast the top of the sill descends to sea level, but much may have been removed by erosion. It then rises quickly to about 400 feet and forms the backbone of Coal Hill. A mile or so inland it rises into a pointed conical hill capped with boulders and almost bare of trees, clearly visible from Cockle Creek Plain and Catamaran Plain, and the only hill in the vicinity not densely covered with forest. This hill must be between 800 and 1,000 feet in height.

The surface of the sill then drops quickly down below 200 feet, and passes under the Catamaran Plain, appearing at the surface toward the eastern edge of this feature, although here it becomes confused with the coastal dolerite. It passes under the coal measures of the Catamaran basin, emerging at about 280 feet in a tiny outcrop just west of the anthracite outcrop here and again at 400 feet as the top of the hill at the back of the hill seam. It then passes under the sedimentary rocks of the Leprena Plain and is cut by the D'Entrecasteaux River at about 150 feet above sea level about a mile west of Leprena. Farther north it has not yet been investigated, but the basalt occurrences between Leprena and Ida Bay appear curiously to be in the same general line.

In the nature of the texture of the rock this sill is immediately distinguishable from the coastal dolerite. It is of the closest grain, without crystals apparent to the naked eye, and it is seamed with cracks and zoolite veins. Its structure is constant throughout its surface occurrence and its depth as far as explored by bores and on the coast. According to strict petrological classification it is a basalt, and it is often so called by the miners locally who invariably distinguish it from the coastal dolerite. Milligan called it "basalt" and distinguished it from his "greenstone" of the Whale Head occurrence. Mr. Twelvetrees did not distinguish it from his generic diabase. It is—from observations of hand specimens—similar to the chilled-margin rock of dolerite intrusions elsewhere and is to be tentatively grouped with the Mesozoic intrusions. It is easily distinguishable from the olivine basalt occuring north of Leprena. But it is so obviously a different rock from the normal dolerite, that a separate name should distinguish it. The fact that these intrusions have been grouped under the name of "diabase" (dolerite) and the Tertiary flows as "basalt" should not obscure the fact that this is a true "normal basalt," although presumably of Mesozoic age. To avoid confusion with the olivine basalt and in respect to usage the writer suggests the name "Basa-dolerite." Its correlation with other dolerite intrusions must be determined in the future.

This occurrence exercises a controlling influence on the economic coal measures and study and mapping of its outcrop and extensions are of vital importance to a knowledge of the field. For the present it seems that, although it cuts right through the field and will in the future be a source of trouble, it by no means limits the area of possible coal-bearing strata. The width of the outcrop appears to be only some 200-400 yards and westward extensions appear to be in the nature of sills. On the coast unaltered coal exists beneath this sill which feathers out in a few hundred yards. There appears to be no reason to fear the rock in the coal field. Probably it only interrupts the coal for a few hundred yards, if at all, and elsewhere overlies and underlies seams. There seems to be little doubt that the shaft seam dips under the sill and the anthracite overlies it. Only mining operations will show whether the seams have been materially affected. In any case there must be several miles of possible coal-

bearing country between this occurrence and the mountain ranges although the possibility of other dykes and sills must be considered. Contacts between the dyke and the coastal dolerite should be searched for carefully and may yield valuable information, and any possible relation between it and the Tertiary olivine basalt to the north should be studied.

(3) *The La Pérouse Dykes and Sills.*

This occurrence has been fully described (Lewis, 1924), and there is little new information to add. Leillateah is capped by a mere 50 feet of dolerite—a fragment of an eastward feather edge from the La Pérouse dyke. This sill has been eroded away between Leillateah and the dolerite peak immediately east of La Pérouse, and everywhere coal measure sandstones may be seen protruding from below it. The main dyke across the front of the mountain seems to be over 2,000 feet in depth in the vicinity of the Hippopotamus—although it is not 400 yards in horizontal width. This may be a zone of up-welling of the original magma.

South Cape Range and the dolerite hills behind it appear to be portion of the same occurrence as that of Pindar's Peak (the Leillateah of my previous paper) and to extend from the summit in a roughly south-easterly direction—the difference in elevation being due to tectonic faulting.

The rock under La Pérouse and in the sills and dykes exposed in that mountain corresponds in texture with that of the Catamaran sill described above, while that of Pindar's Peak is typical holocrystalline dolerite. All the present evidence points to a possible correlation between the La Pérouse sill and the Catamaran sill, the sills having been broken by a fault of about 3,500 feet.

The writer cannot stress too strongly the view advanced in his previous paper that the slopes—both eastern and western—of the La Pérouse range present such remarkable sections that they cannot be neglected by those interested in practical mining in this field. Further study on these slopes is one of the urgent necessities as a preliminary to a thorough understanding of the coal measures.

Continuing the geological history of the area, the next rocks in succession are the Tertiary olivine basalts, but their exact age is not yet definitely established. These rocks occur at Leprena—astride the loco-railway line, and extend for about 500 yards westward. Metamorphic contact with shales is apparent from scattered surface pebbles. Then come many small deposits of sediments of a more or less modern age. Mr. Twelvetrees groups these sediments as Tertiary and Quaternary. The present writer is of the opinion that the sand dunes on the seaward half of Cockle Creek Plain are of recent age, and the remaining sediments belong to the Pleistocene and represent glacio-fluviatile deposits from glaciers during the period of maximum flow as the ice melted. Leprena Plain and the country between that settlement and Southport Lagoon is covered with such deposits, but they do not appear to be exactly morainal.

Further research necessitates a recasting of the views expressed in the writer's previous paper (Lewis, 1924, p. 43) on the subject of the extension of the Pleistocene glaciers in this area. Erratics of Triassic grits and conglomerates from summit of ranges are definitely to be found on Leprena Plain, e.g., about 1 mile east of shed at end of railway line, that is near eastern boundary of plain and about 300 feet above sea level.

Further, several ridges composed of a jumble of angular blocks of dolerite, sandstone, and quartzite conglomerate occur, notably about half a mile south of the end of the southern branch of the new Leprena mill tram line, and this plain was definitely under ice during one phase of the glacial epoch. It is now covered with morainal till and outwash apron deposits. The "rubbishy mixture" referred to by Milligan on the south coast is due to land slips and not to ice action.

The Catamaran Plain is relatively free from sediments, but between Recherche Bay and the workings at Catamaran recent deposits abound. However, these appear to be due to surface erosion and great accumulations banked up by frequent changes by the Catamaran River in its course. The boulders have given trouble in some of the bores, although I am not sure that some of these are not glacial or glacio-fluviatile. Accumulation of quartz pebbles have been derived from weathering of Trias-Jura grits on mountain range. Sometimes these are quite angular, but usually water worn. Their arrangement shows alternation of flood and slack waters. They occur in both valleys. No evidence could be found of raised beaches or invasion of the land by the sea in Tertiary or Quaternary times.

4. HISTORICAL SEQUENCE OF THE DEVELOPMENT OF THE PRESENT TOPOGRAPHY.

Physiography is too often regarded as an elementary branch of geology and of little practical importance. No greater mistake could be made. The physiography of a region, correctly interpreted, provides a key to earth movements, and the results of these in turn, when accurately plotted, indicate the whereabouts of any beds the miner desires to locate. Especially is this so in the case of Tasmanian coal measures, since time has not yet effaced the influence of subsequent earth movements on the present topography.

The present writer has already elaborated his views on the development of the main features of Tasmanian topography (Lewis, 1924, pp. 27-31, and Lewis, 1926), and there is no occasion to repeat these opinions. The further study of the area has only confirmed the succession of events set out previously. It is not necessary to quote all the examples which have come to light.

As suggested above, research into the geographical conditions during the deposition of the coal measures would well repay investigation, but one point is certain—the very long Permo-Carboniferous-Triassic period of sedimentation came to an abrupt end, and in this field the top of the coal measures appears to have been lost by subsequent erosion. Earth movements raising the level of the land were probably responsible, and these were followed from isostatic causes by the dolerite intrusions. It seems at present that at any rate the coastal dolerite and the Catamaran sill are different intrusions. No evidence is yet forthcoming as to which was the earlier, but the writer suggests that the Catamaran sill is a true example of an intrusion of chilled-margin magma following a tectonic fault and that the coastal dolerite is either the top of the magma which has stoped its way upwards or been injected at a later stage when crystallisation had proceeded much farther. The La Pérouse occurrence is more difficult to interpret but probably may be grouped in much the same way as these other occurrences.

The absence of Tertiary sediments indicates sub-aerial conditions during that long period and that this area has not been below the sea since Jurassic times. The fact that these very soft coal measures have not been eroded in the very long interval since their deposition in spite of the absence of covering indicates that they have rested stably not very much above sea level since their original elevation.

For the reasons given previously it appears certain that the La Pérouse range and the mountains to the north are the results of block faulting and the main outline is due to what the writer has termed "late Tertiary tectonic faulting." The date appears to be immediately pre-glacial.

Further research is necessary before the actual relation of the Sugarloaf spur to the remaining country can be satisfactorily explained. It is safe to presume that the limestone stands stratigraphically some 6,000-8,000 feet below the coal measures of the Leprena Plain. To-day it stands topographically 1,000 feet higher than these beds. It appears so out of place in its surroundings that its position may be due to pre-coal measure faulting and the coal measures may abut against it. Whether this is so or not warrants investigation as throwing important light on the economically possible limestone reserves.

The removal of the limestones over the quartzite conglomerates of the Leprena Plain was effected prior to the uplift of the La Pérouse Range, as the post-faulting erosion here has done little more than remove the overlying coal measures in the D'Entrecasteaux valley. If, as appears to be the case, the coal measures of Leillateah are proved to overlie this quartzite without the intervention of the Permo-Carboniferous and Ross sandstones series, a fact will come to light with a very interesting bearing on the tectonics of the sedimentation period. Namely, that through the earlier period these Silurian rocks stood out as an island. Later as the mass sank into its magmatic foundation it was submerged below the coal measure lagoons, etc., giving proof to the assumption of a landsurface remaining at the same level, while some 5,000 feet of sediments were deposited on the basal rock gradually sinking in response to added weight.

D'Entrecasteaux Channel must be regarded as a flooded portion of the coastal plain. Soundings show that the same general features are produced below the water as exist on the plains near the coast. A fault line may govern the coast, but it would be of no magnitude when compared with the great tectonic faults five miles inland. Recherche Bay and Southport are the flooded mouths of the rivers now emptying into those estuaries and the older courses of these rivers are clearly shown by the soundings (see Reid, 1922, Plate XXII.). A post glacial rise in sea level of under 100 feet would explain all the coast features. There appears to be no evidence of ocillation of strand level or of Quaternary land movements.

South Cape Bay out to the Eddystone and Pedra Branca must be considered a submerged portion of Tasmania as Mr. Twelvetrees states. The topography of this portion is probably governed by a fault running roughly east and west —probably through a point about two miles south of Cockle Creek. The submerged portion represents a plain similar to the Leprena and Catamaran Plains, and the range of high hills fringing the coast from Coal Hill to Cockle Creek Plain appears to correspond to the Sugarloaf and Leillateah spurs. The line of rocks and reefs from the Mewstone to Pedra Branca and Eddystone may represent a further spur to the south, and South Cape Range seems to be a portion of the Pindar's Peak dolerite intrusion dropped by this great block fault. Sea erosion of the soft sedimentary rocks has been rapid since the submergence of this block and has been responsible for minor details of the coast line at South Cape Bay. This agency is scarcely felt in the sheltered waters of the Channel.

Cockle Creek Plain, Bare Hill, and the rough country towards Whale's Head are a separate feature. Here the coastal dolerite is highest and widest. Bare Hill seems to be merely a residual of dolerite exposed by erosion. In spite of diligent search no evidence could be found of a marine invasion of Cockle Creek Plain as suggested by Mr. Twelvetrees. Cockle Creek Plain presents superficial resemblance to a glacial valley, but no grounds could be found for assuming that it was ever under ice. Again the gradual rise to the south coast, and the abrupt drops there to the beach and the nature of the coast make it difficult to believe that this area could have been elevated by a recent minor block fault and supports the following theory, viz., that it is the valley of an ancient river which drained the now submerged plain to the southward, and of which the South Cape Rivulet may have been a considerable branch. This old river has been destroyed by the South Coast fault already described, and its whole drainage captured by the submerging of its basin and the subsequent northward erosion of the sea. The valley between Cox's Bight and Port Davey is susceptible of a similar explanation.

We now come to a consideration of the origin of the Leprena and Catamaran Plains and the intervening Leillateah Spur—the vital area from an economic standpoint. There seems to be no doubt that the Leillateah Spur is the result, at least, as far west as the north and south ridge half a mile or so east of the summit of Leillateah, of a series of faults at an angle to the main line of break that gives the mountain range its outline. This ridge has been part of the uplifted block, and this has protected the country between it and the sea from erosion sufficiently to form the divide between the D'Entrecasteaux and Catamaran Rivers. In addition it seems that a fault runs along the eastern portion of this ridge forming a break between two great blocks of country. Hill Seam ridge presents a more or less gentle escarpment 300-400 feet high on the south-eastern slope and a sharp escarpment of over 600 feet on the side of the Leprena Plain to the north-west. The ridge itself is isolated by a double fault—an east and west elevated block and a fault separating it from both plains. The Leprena block is a separate feature. The ridge is to some extent protected by a portion of a dolerite cap. This seems to be continued on the summit of Leillateah, some 2,000 feet high, and a mile or so farther west. In general, this ridge appears to be a portion of the Leillateah Spur separated from that feature by block faulting.

Another equally plausible theory is that the Catamaran Plains and shaft block have dropped as a result of tensional stresses from the Leprena Plains and Hill Seam block. This view is supported by the dip of the strata which in the Leprena Plain block appears to be to the north-west and in the Catamaran Plain block to the north-east with a break near the eastern boundary and farther east a dip to the west indicating a drag against the coastal dolerite as this block sank.

The Catamaran Plain and the Leprena Plain have very likely been considerably extended by erosion subsequent to the faulting, but this does not affect the general proposition as to their ultimate origin. The existence or otherwise of these controlling faults must exercise a vital influence on the policy of mining in the district.

The great La Pérouse tectonic fault as modified by these Leillateah deviations bounds the two basins to the west. The uplift of the mountain block was probably gradual and streams flowing in pre-existing valleys continued their courses until they reached the edge of the scarp. Here they cut great gorges, and later resumed more or less their original course across the unaffected blocks of the plains. To the seaward side of these plains occurs the belt of dolerite already described. This has presented a hard bar at the mouths of the streams and has materially contributed to the preservation of the soft coal measures behind although the low level of these is their greatest protection.

The history of the basins since the period of major block faulting has been a very slight and gradual erosion of the sedimentary beds behind the coastal dolerite as the rivers have cut down through this hard bar. Tributaries have been pushed behind it and their erosion has caused the dolerite to stand out in a series of ridges.

As has already been indicated, ice extended for considerable distances beyond the mountain névés during at least the maximum period of Pleistocene Glaciation. The discovery of moraines and erratics at 300 feet above sea level on the Leprena Plain indicates the possibility that ice reached sea level in South-Western Tasmania. To-day the rainfall at Catamaran averages 60 inches. It is infinitely higher at Port Davey. It seems to the writer, therefore, to be a reasonable assumption that during the Pleistocene glacial epoch there was an extension of ice in South-Western Tasmania to a greater extent than elsewhere, and that absence of definite moraines is no ground for stating otherwise.

Finally, the sequence of rise and fall of strand level during post-glacial times presents problems of great interest. Professor Sir Edgeworth David has called attention to the erosion of troughs by streams in glaciated valleys on the West Coast (David, 1926), and the same features are observable, although not so well marked in this area. Every river crossing a button-grass plain has entrenched itself. This is most strongly marked in the case of the Catamaran which even enters the sea between two moles, the remnants of a dolerite spur into which it has cut its channel. For over five miles this river flows in a winding course between cliffs from twenty to fifty feet high cut in the coal measures on the northern side of the Catamaran Plain. Similarly, the D'Entrecasteaux River flows in a trough not quite so marked or so persistent as that of the Catamaran but otherwise very similar and also on the north side of the Leprena Plain. The Lune does the same on the north side of the Ida Bay Plain.

This at first sight suggests a rise of the land but no raised beaches are discoverable with the one exception of this finest example of a shore platform the writer has ever seen. This lies on the east centre quarter of South Cape Bay and runs over a hundred yards out from the cliffs. It has been eroded out of soft horizontal coal measures, and stands at about high water mark. It appears to the writer to represent a recent slight rise of strand level to the extent of not more than ten feet. On the other hand, the mouths of every river have been flooded by the recent rise of the sea, and the discovery in the Catamaran mine and neighbouring bores of several old courses of the Catamaran River adds further difficulties.

The explanations suggested by Sir Edgeworth David in regard to the Strahan district appear, however, to be confirmed in this area. A slight recovery of the land on the melting of the ice, exceeding in rapidity the recovery of the waters of the ocean, seems to be the reasonable explanation. To this must be added the increase in degree of slope given by submergence of land surface to the east and south. The dry valley of Cockle Creek indicates that the submergence took place in the very recent past and the topography of the valleys of the Catamaran, D'Entrecasteaux and Lune point to its having occurred when the plains were under ice. Thus, these rivers have been able to deepen their beds to an extent beyond all proportion to the time such a process would normally have taken.

5. THE LA PEROUSE RANGES AS A SOURCE OF HYDRO-ELECTRIC SUPPLY.

The writer professes no qualifications as a civil engineer beyond those given by common sense and a knowledge of the terrain in question. On the La Pérouse Range, especially on the spur running south-east from Pindar's Peak (the Leillateah of the writer's former paper), there exist high level glacial lakes. There are small catchment areas, good sites for storage dams at a high elevation, an enormous rainfall, and from 1,000 to 2,000 feet drop, according to the location of the various portions of the scheme. The problem is whether sufficient storage could be obtained at an economically possible outlay to tide over the maximum possible rainless period. As to this the writer can only give some observations, and detailed investigations by a qualified engineer would be necessary before the slightest considerations could be given to the possibilities of such a scheme.

First, as to rainfall—no data exist as to this and it would be as well to start a series of readings at least at Catamaran with a view to possible future developments. If the rainfall in Catamaran is 70 inches—which seems to be a fair estimate—the rainfall on the La Pérouse ranges should be in the vicinity of 100 inches, with an average maximum period without rain of 21 days.

Lake Margaret with a watershed of 7 square miles, average storage head of 16 feet, static head of 1,100 feet, and average annual rainfall of 150 inches develops an 8,000 horse-power. The La Pérouse range should provide a simple scheme with a watershed of 2 square miles and a more extensive costly scheme with a watershed up to 4 square miles. The storage head could be developed to any economic height. It should prove easy to obtain a static head of from 1,500 to 2,000 feet and the average annual rainfall may prove equal to that at Lake Margaret. It is probable that 2,000 horse-power could be developed, but the question of costs may make such a scheme impracticable. It is certain that a scheme would be far more costly here than at Lake Margaret as the natural facilities are inferior.

Should La Pérouse ever be considered, the writer's outline suggestion for a scheme is: (1) A storage dam across the branch of South Cape Rivulet which drains the lakes south-east of Pindar's Peak; (2) the water to be drawn thence to a service reservoir at the site of the lake above the Catamaran Valley to the north of the lakes above referred to; (3) open courses to be run round the side of the Catamaran Cirque to the lakes at its head and so augment the supply by tapping these streams—this may be carried round the south-eastern face of La Pérouse but probably the results would not warrant the very high costs of this work; (4) the water to be drawn from this reservoir down a straight drop to a power station in the Catamaran Valley.

An alternative scheme would be to utilise the Picton Valley as a site for the power station and obtain the benefit of the larger catchment area—including the Reservoir Lakes —which is available on this site.

The writer would not have broached this topic had it not been freely discussed as a possibility by the Catamaran Mine Staff. The writer's own opinion is that it would be far more economical to bring the power from a larger scale scheme and that any possibility of a scheme in the La Pérouse ranges is prohibited by the smallness of the catchment areas and the heavy overhead cost which would be placed on any small scheme. This opinion, however, can only be confirmed by a competent engineer. A point that must always be borne in mind in such an investigation is that any possible site for a dam in this locality is highly glaciated. This gives frequent rock bars—as at Lake Margaret—which make excellent foundations for any works, but the country is littered with moraines, which are impossible as a foundation for anything of weight.

APPENDIX.

List of Works referred to in the Text.

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