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THE PHYSICAL AND GEOLOGICAL STRUCTURE OF LORD HOWE ISLAND.

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I.—Physical Structure.

The geographical position of Lord Howe Island has been already described, and it has been shown that under this name are included a number of outlying rocks. Chief amongst these are the Admiralty Islets to the north; Mutton Bird Island to the east; Rabbit or Goat Island, within the Lagoon, on the west; and the solitary pinnacle, Ball's Pyramid, away to the south-east.

The outline of Lord Howe Island itself is roughly crescentic, or, as very appropriately termed by Mr. H. T. Wilkinson, J.P., "boomerang-shaped."* The length, as the crow flies, is six or seven miles, or, taking into consideration the inequalities of the surface, probably nearly double that distance. The average width is one mile, but at the southern end of the island it is considerably more. The island has been estimated, by Mr. Charles Moore,† to contain 3,220 acres, 2,000 of which would be capable of cultivation. Personally I do not think that much more than a third of this amount will ever be fit for the agriculturist, and then only under certain conditions.

On approaching from seaward its bold, and in many places, rugged outline becomes apparent; whilst the close and intricate growth of the vegetation on the hill slopes obscures its really heavily timbered condition.

Lord Howe Island is practically formed of three high volcanic ridges, the most striking physical features of which, says ‡ Mr. H. T. Wilkinson, "are the mountains known as Mount Gower and Mount Ledgbird. The former rises in cliffs from the sea to an altitude of 2,840 feet and the latter to a height of 2,504 feet, together forming the southern and south-eastern portion of the island and presenting a coast-line of rugged cliffs inaccessible from the sea." The most northerly of these masses forms the northern extremity of the island, and is known as the North Ridge; the central mass forms Mount Lookout; and the southern, and by far the largest is composed of the two large hills before mentioned, with a few subsidiary eminences, such as the North Hummock and Intermediate Hill. These form the back-bone, as it were, of this most interesting spec of oceanic land, aptly termed the "Madeira of the Pacific," § and are visible at sea for a distance of at least fifty miles. The intermediate depressions are formed of low undulating rises; and the shore frontages, when not precipitous, are flat and usually open, but sometimes like the low rises densely wooded. Nearly two-thirds of the west coast, or the concave side of the boomerang,

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* Report on the Geology of the Island, *Lord Howe Island. Report on Present State*, &c., p. 4.

† Hill's *Lord Howe Island, Loc. cit.*, p. 17.

‡ *Op. cit.*, p. 4.

§ The Island of Lord Howe. "The Madeira of the Pacific." By "Linnæus" (12 mo. Sydney, 1882).

to follow out Mr. Wilkinson's simile, is protected by a fringing coral-reef, extending from Phillip Point on the north, to the foot of Mount Ledgbird on the south.

The North Ridge is broken up into a series of semi-detached peaks, presenting a bold face to seaward, rising from soundings of ten and eleven fathoms in precipitous vertical cliffs, of from 600 to 700 feet, without the intervention of any beach. The north-east end of this ridge terminates in the North Peak, or "Pools-Lookout," a well rounded hill of 714 feet. Following the cliffs along to the westward, over successive minor rises, a peculiar semi-isolated hill is approached, standing in majestic solitude, and known as Mount Eliza. It has all the appearance of a conical hill cut vertically in half, concave or hollowed out towards the sea, and presenting to the eye, as viewed from a distance, a curved crescentic outline. It has been exceptionally well described by "Linnæus," who says, "resembling a divided cone with a peaked top." This rugged promontory terminates to the north-west in a bold craggy headland, running north and south, the northern extremity being known as Phillip Bluff, and the southern, Phillip Point. Under the precipitous cliffs of this end of the island, soundings are obtained varying from seven to fifteen fathoms, but there are no gulches or gullies running up from the sea-level. The only indentation is near Phillip Bluff, where a short but deep water-way runs in under Mount Eliza. Along the face between the two points mentioned above, one or two sea-washed caves exist, but no opportunity of exploring these was afforded to our party. Two spurs tending in a southerly direction, are given off from the North Ridge. The boldest and most precipitous is an off-shoot of the North Peak, and overlooks Ned's Beach Bay on the east coast. From the smaller isolated peaks of this spur, one of the most beautiful views on the island is visible. Looking south the entire length is laid out before the eyes of the observer, across the tops of Mount Lookout and Intermediate Hill, or on the other hand, over the Lagoon, along the nearly vertical sides of Mounts Ledgbird and Gower. An excellent photograph, taken from a water-colour drawing, has been published by the Government Printer of this view, and is the best general panoramic view of Lord Howe Island.

The second spur proceeds from near the centre of the North Ridge, and projects as a well rounded sloping promontory into the Lagoon. Between its western side and Phillip Point is enclosed the North Bay, forming the most northerly arm of the Lagoon, and well protected from the heavy south-west seas which at times break upon this part of the island, by one shore end of the coral-reef. On the eastern side of this promontory is a sub-marine depression in the Lagoon, known as the Boat Pool.

Between the North Ridge and the main mass of the island is a narrow connecting neck of land, principally formed of the second volcanic mass, known as Mount Lookout, surrounded by at least two-thirds of the only undulating and flat ground on Lord Howe. Mount Lookout is a conspicuous and rather conical hill on the east coast, overlooking the northern end of Blenkinthorpe Bay, 414 feet high, and commanding an uninterrupted view to the sea horizon in nearly every direction, the only exception being to the north and south. Slightly separated from Mount Lookout is a more or less flat table-land extending diagonally across the island at its south-west extremity, forming a low point, overlooking as near as possible the centre of the Lagoon. Two prominent headlands are thrown out from Mount Lookout; that to the north-east is called by the inhabitants Clear Place Point, but on the Admiralty chart is marked Observatory Spot. The coast-line between this point and the southern off-shoot, which forms the northern termination

of Blenkinthorpe Beach, is formed by high steep slopes and overhanging cliffs, but not to the same extent as those of the North Ridge. Clear Place Point is one of the few, if not the only spot, from whence a complete view, looking north-west and south-east, can be obtained of the Admiralty Islets, and Ball's Pyramid, about eighteen miles away in the ocean, at one and the same time.

Between the elevated ground of Mount Lookout, and the North Ridge, the surface is either flat, or rises in undulating heights, densely wooded. The highest point is a more or less flat-topped hill overlooking the south side of Ned's Beach Bay, and by rough barometrical measurement is 200 feet above sea-level. This hill, which I have called Wilkinson's Promontory, is of the greatest importance from a geological point of view, as being the highest point to which the Coral-sand rock, to be afterwards described, has been traced. The intervening flat ground extends along the shore of the Lagoon, forming to the south of Mount Lookout, Moseley's Flat; and to the north, the flats fringing and running between the hills previously mentioned. The most important are those at the Old Settlement under the North Peak, and that extending from the landing place near Thompson's Point across the island to Ned's Beach. Ground of this description is either open and grassed, as Moseley's Flat, and the Old Settlement, with patches of low stunted vegetation; or undulating and densely wooded like the slopes of Wilkinson's Promontory and the tract across to Ned's Beach. The vegetation here is extremely dense, comprising some of the finest trees, especially the magnificent Banyan (*Ficus columnaris*, Moore). Speaking generally, many portions of these flats are but a few feet above high-water mark—this is particularly applicable to Moseley's Flat, which is protected at its eastern side by sand hummocks.

From the southern end of Moseley's Flat to Point King, the projecting headland at the final base of Mount Gower, the island is formed by the largest of the three volcanic masses. To all intents and purposes, it forms at least half the superficial area, and is at the same time the most precipitous and grandest half. The ground by degrees rises from Moseley's Flat, sometimes by a gradual ascent, at others by steep and sudden jumps to a height of 2,840 feet, the top of Mount Gower. This portion of Lord Howe consists of four separate hills, grouped two and two. Those at the northern extremity are the least important, North Hummock, and Intermediate Hill, the latter said to be 647 feet. It throws off a spur seawards, forming Mutton Bird Point, attached only by a narrow neck of land, and which after a few years more denudation will become an islet. It is in a direct line with Mutton Bird Island, doubtless separated from the main island at a comparatively recent geological epoch. From this point the coast-line southwards is bold and precipitous in the extreme, and is only known to a few of the more adventurous of the Islanders. The deep valley between Intermediate Hill and the northern extremity of Mount Ledgbird is traversed by the Deep Creek, probably the most important rivulet on Lord Howe. It takes its rise in the various gullies, furrowing the sides of Intermediate Hill, and the saddle formed by a low spur from Mount Ledgbird. After much tortuous winding, and with its banks covered with a dense sub-tropical vegetation, it discharges itself into the southern part of the Lagoon. As the valley is descended it gradually opens out into a well marked alluvial flat, circumscribed by a spur of Intermediate Hill on the north composed of the Coral-sand rock, and the foot of Mount Ledgbird on the south. The edges of this flat, and the course of the creek are noticeable for the number and size of the Pandanus trees

distributed along it. The latter marks also the inland track to the southern high grounds, a continuous ascent taking place until the divide at the head of the Deep Creek Valley is reached, the track crossing it at a point called the "Smoking-tree," 430 feet above sea-level. On the further side of this ridge a descent takes place into a subsidiary valley, the track gradually ascending again on to a direct spur of Mount Ledgbird where the crossing place is known as the "Half-way Root," or "Red-clay Saddle," about 550 feet high. Beyond this point the traveller becomes committed to the rugged and almost inaccessible spurs and gullies, with which the eastern flanks of Mount Ledgbird are seamed. The latter are in many places deep, invariably steep, as a rule well watered, and frequently interrupted by steep walls of rock, over which the water-courses must run at certain seasons with great rapidity and force. The sides are strewn with basaltic boulders, varying from a hundredweight to many tons, masses of loose rock and general *débris*, intermingled with fallen timber, and dense and in many places impenetratable foliage. So much have the hill sides become covered with fallen material that rock *in situ* is seldom seen except in the beds of the gullies, or as steep and impassable walls in their courses, or on the spurs between them, and which have to be invariably circumscribed before the travelling line can be regained. To add to the difficulty of locomotion the slopes are in places covered with large expanses of sheath-grass and palm scrub, but the gullies are at times beautifully shaded with large tree-ferns. Such is the general aspect of the eastern slopes of Mount Ledgbird, up to the foot of the immense precipice known as "The Wall," at an elevation of about 1,000 feet—a perpendicular face of basaltic rock, above which the sides of the mount, both here as well as on the west and north, rise in a series of high perpendicular step-like terraces, to a height of 2,504 feet. A little north of the summit of Mount Ledgbird, a line drawn east and west represents the broadest part of the island—about one and a half miles as the crow flies. On the eastern side this line would terminate on the peninsular of East Point, having three well-marked indentations of the coast line. So far as I have been able to ascertain, this is the least known portion of Lord Howe. Even Mount Ledgbird is not as frequently ascended as Mount Gower, and its topography is less known. On its western side, overlooking the Coral Reef, the slope is steeper than on the east, and practically inaccessible, rising in sheer vertical precipices of great height one above the other. The mode of progression along the eastern flanks of Mount Ledgbird is graphically described by Mr. R. D. Fitzgerald, then Deputy Surveyor-General, who accompanied Cloete's expedition to Lord Howe. He says: "The track gets worse and the faces more frequent, with water pouring over them. The ferns grow thicker, and the orchids are in flower, but the path is steeper, and often the roots of the 'forked trees,' that grow down like soldiers' piled muskets, have to be cut through with a tomahawk, being too close for the traveller, though the guides may writhe through them, and Ned stops now and then and declares the 'face' to be impassable, when a descent has to be made with reluctance, for an ascent has to be made to make up for it; and so 'face' after 'face'—which become very frequent towards the end—are passed, and at length 'the saddle,' *par excellence*,* or backbone of the camel between its humps,† is gained, and the day's work is over.'"‡

At its southern end Mount Ledgbird throws off two spurs. That towards the south-east descends to form the connecting saddle with Mount Gower,

* The divide between Mounts Ledgbird and Gower.
† Mounts Ledgbird and Gower.
‡ Hill's *Lord Howe Island, loc. cit.*, p. 40.

and must be passed over in following the tract for the ascent of the latter. From this spur a very magnificent view of the south-east side of Mount Gower is obtained, and, on a clear day, Ball's Pyramid, away in the ocean. We were fortunate enough to traverse this part of the island on such, and were well rewarded for our exertions in climbing to this height.

The second spur stretches to the south-west, and almost overhangs the sea in a series of wall-like terraces. Below the lowest wall is a much shorther, but very dangerous track to Mount Gower, which rises from the beach a little beyond the shore end of the Coral Reef, and, after passing under the spur, skirts the north side of Erskine Valley. This track, called the Lower Road, was partially traversed by Mr. Thorpe and the writer, under the guidance of Mr. W. Nichols, and afforded a good opportunity of examining the horizontal basaltic rocks of which the wall is formed. Here again I cannot do better than quote the description by Mr. Fitzgerald, who explored the whole of this path:—"The summit of the precipice, one of the flanks of Mount Ledgbird, facing the sea . . . . . was at length reached . . . . Then began a very rapid descent over loose rocks and crumbling basalt, and the guides spoke of a 'bad bit' . . . . Down and down, till a thousand feet from the ridge was reached; when, on turning a rock, they got the first glimpse of the 'bad bit,' and a '*bad bit*' it was—a track across the face of the precipice . . . The precipice rose on the right hand sheer and naked, perpendicular as a wall for a thousand feet; then a little rubbish, with here and there a stunted plant. Then the track, not more than two feet wide, and then down 500 feet to the palms. . . . What a treasure those little bushes are; but there are places where there are none, where there is nothing to grasp but the roughness of the perpendicular rock; and there are places—'gulches'—where the path itself is gone, and foot holds have been cut with a pick in the rock or gravel. . . . In all that dangerous track the rounding of the angles is the worst, when you cannot see where you are going, and grasp at anything with one hand, reluctant to let go the other, and the other is sidled on *over nothing*. But the last angle is turned, and they stand again upon the talus of the precipice, and it is grand—oh, wonderfully grand to look upon it—1,000 feet of grey perpendicular basalt, the very highest mass of which overhangs the base."*

The apex of Mount Ledgbird is formed by what Mr. E. S. Hill terms, "a dome-like eminence, rising out of, but at no great height from its centre, and having precipices of from 100 to 200 feet sheer down from its base." There are, in fact, three apices to this hill, and according to the published charts the centre is the most elevated.

Mounts Ledgbird and Gower are separated by Erskine Valley, or the "Between Hills," a deep and wide depression, running down to the south-west coast. Its descent is very rapid and steep, with more or less permanent water, the sides of the valley being everywhere covered with boulders and volcanic *débris*, interspersed amongst the densest possible vegetation. The saddle at the head of this declivity, forming the connecting neck between the two hills, is very narrow, probably not more than twenty to thirty yards, covered with large boulders, and supporting a low, stunted vegetation, and much under-growth, bearing testimony in the twisted and gnarled condition of the trees to the heavy squalls and gales which pass across it, and of which we had a vivid personal experience during the night we were camped in this otherwise charming spot. Erskine Valley acts, in fact, as a kind of funnel,

* Hill's *Lord Howe Island*, *loc. cit.*, p. 43.

and reminded me much of the deep, long gulches with which the Island of St. Helena is cut up. The saddle cannot be far short of 2,000 feet above sea-level.

The further ascent of Mount Gower from this divide is one long, steep, and in places almost vertical climb. The sides of this hill are much less broken up into terraces than is the case with Mount Legdbird, the immediate scarp or wall below the summit being of great height and grandeur. The latter, as compared wirh other portions of its surface, is flat, of about half a square mile in extent. Mr. John Duff remarks that "the top of Mount Gower is probably 150 or 200 acres in extent, chiefly flat, with numerous creeks and ravines across its centre. The soil is composed of sphagnum (moss) and other decayed vegetable substances. All the trees on it are stunted in growth."* Mount Gower rises to a height of 2,840 feet

Taking the coast line of Lord Howe Island generally, it may be said that from Phillip Point on the north-west to Ned's Beach on the north-east; and again from Mutton Bird Point on the east round the south end of the island to Erskine Valley on the south-west, it is more or less inaccessible. The chief breaks in its continuity are the following:—To the north-east of Phillip Bluff a short narrow inlet occurs, almost at the base of Mount Eliza, and known as the "Gulch." A comparatively small depression of the island would cause the waters of the North Bay within the Lagoon to join with those of the open sea through this gut-way. Immediately at the north-east corner of Lord Howe Island is the pleasant Ned's Beach Bay, protected by a long ledge of rocks, in six and seven fathoms of water, and encircling the point of the North Peak, and terminating at the Sugar-loaf, a basaltic mass between the point and the Admiralty Islets. Some distance round the south headland, enclosing the before-mentioned bay, are a series of rocky inlets, terminating to the south in Middle Beach Bay. This headland is a prolongation of the Coral-sand rock plateau previously referred to, and, both from its importance, and lacking a name, I have termed it Wilkinson's Promontory.†

Middle Beach Bay is a snug little harbour, and has the good repute of being the only landing-place which can be depended on in all seasons and weather. A narrow calm channel exists between two sunken rocky reefs, in which the water, from two to nine fathoms, no matter how it may be raging outside and around, is always calm and comparatively still.

From Middle Beach, following the coast-line round Observatory Point and the rocky flanks of Mount Lookout, Blenkinthorpe Bay is approached, terminating to the south-east in Mutton Bird Point. This bay is the most pleasant coast recess on the island, and is the only instance of sand accumulation in any way approaching the dune, or rather hillock formation. Beyond the previously mentioned headland to a point opposite the southern extremity of Mount Ledgbird, the shore is much broken up into cliff-girt harbours, only one of which, Boat Haven, appears to have received a name. From the point just indicated the coast follows an unbroken line to King Point, the southern extremity of Lord Howe.

On the west coast the great feature is the Lagoon, about three and a quarter nautical miles in length, with an average breadth of half to three-quarters of a mile, but narrowing very much towards its southern end. The shore line south of Thompson's Point is generally uniform, the only project-

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* Report on the Vegetation of the Island.—*Lord Howe Island, Report on Present State, &c.*, p. 10.

† After the late Mr. H. T. Wilkinson, J.P., of the Department of Mines, Visiting Magistrate at Lord Howe.

ing point being opposite the south-west roadstead entrance. The head or deepest portion of the bay washes the shore of Mosley's Flat. A further description of the Lagoon and its enclosing reef will be found in the previous Zoological Report.

Ned's, Middle, and Blenkinthorpe Bays each have fine expanses of sandy beach, backed at the first by low sand hummocks, and at the last by incipient dunes; but neither of these is to be compared to the fine stretch of sand extending for one and a quarter miles along the Lagoon, from Thompson's Point to the southern boundary of Mosley's Flat.

The creeks on Lord Howe Island are, strictly speaking, unimportant, and such one would anticipate from the small area of the island, A short water-course exists at the Old Settlement and receives the drainage of the gullies traversing the amphitheatre of the east end of the North Ridge. No other creek is met with until the flat ground between Intermediate Hill and Mount Ledgbird is reached. Here occur the Deep Creek and its branch, the Soldier's Creek, which drain the extensive area formed by the flanks of Intermediate Hill, the connecting ridge as high as the Smoking Tree, and thence round the precipitous north-west side of Mount Ledgbird. A short distance further south is the Fresh-water Pool, a rocky gorge cutting through the western terraces of that remarkable hill. The two former creeks have small sand bars at their mouths, and communicate with the Lagoon only during freshets or at high tides. In each case, after leaving the higher ground, their water-courses meander through small alluvial flats, formed by the detrital matter brought down by them. Along the edges of the flat at the Soldier's Creek, and up the course of the Deep Creek are to be found many fine examples of the Pandanus (*Pandanus Forsteri*, Moore). The gullies in which these creeks terminate are invariably steep, assuming in many cases, especially in the southern part of the island, the aspect of miniature mountain torrents. In all probability the deepest gully is Erskine Valley, although some of those on the north-east flanks of Mount Ledgbird are not by any means to be thought lightly of. On the other hand, one of the most beautiful and impressive ravines is the Valley of the Shadow of Death, already referred to in the Zoological Report, running up from Middle Beach, past the Observatory Point, and draining the plateau of Mount Look-out. Doubtless during long continued rain many fine leaps of water are to be observed on Mounts Ledgbird and Gower. In H. F. White's map is shown a swamp in a portion of what is now known as Mosely's flat, but this did not come under our notice.

The vegetation of Lord Howe is, next to its general outline, its grandest feature. "It is," says Linnæus, "peculiarly beautiful and striking, and to treat it in any exhaustive way, would require a special artist devoted to it."* On approaching from seaward, especially on the western side, its heavily clothed state is not in the least apparent, the view showing "how deceptive the appearance of foliage may be where there are no great irregularities in the growth of the trees, for when looked down upon, though of considerable size, from the evenness of the general surface they look dwarfed and stunted, which is the case in looking at them from the sea also."† To this is due the apparent rounding and non-precipitous outline of many of the eminences of the island, even including some portions of the rugged southern hills. The botany has to a great extent been already described by Mr. Charles Moore,‡

* "Linnæus," *loc. cit.*, p. 24.
† Hill's *Lord Howe Island*, p. 41.
‡ *Ibid*, p. 17.

and Mr. Duff.* The salient points brought forward by Mr. Moore clearly prove the Lord Howe flora to incline far more towards that of New Zealand and Norfolk Island than to that of New South Wales. This has a great bearing on the geological facts shortly to be communicated on. Those typical Australian families, the Leguminosæ and Myrtaceæ are barely represented, whilst the Proteaceæ are said to be wholly wanting. "The typical plants of the island are four palms," says "Linnæus," by whom the best popular account has been written, "a ficus with the habit of the Indian banyan, and several large foliaged plants of great beauty. The timber-trees are numerous, and these yield wood of great excellence for building and cabinet work. But perhaps the most noticeable feature of the vegetation of Lord Howe is the number of varieties of climbing, twining, and creeping plants, some of which are exceedingly striking."†

The flora of Lord Howe Island being of very great interest, I make no apology for extracting the following information from Mr. Moore's interesting account, and that of "Linnæus." The Orchidaceæ are sparingly represented by *Dendrobium*, and *Sarchochilus* growing on trees, but Mr. Moore is mistaken in limiting these to those growing on the hill sides. They certainly frequent the low ground timber almost as plentifully. There are four palms, and their distribution has already to some extent been referred to (p. 5). The "Thatch Palm" (*Kentia Forsteriana*), and the "Curly Palm" (*K. Belmoreana*) occupy the lower zone, ranging up to 1,000 feet, when their place is taken by the "Umbrella Palm" (*K. Canterburiana*), which covers only a limited belt, according to Mr. Moore, but "Linnœus" states that it can be traced to the top of the highest mountain, which is, of course, Mount Gower.‡ The fourth variety is *Kentia Moorei*, the "Mountain Palm," and is only found at elevations exceeding 2,000 feet. It is a dwarf form and of very graceful outline.

The trunks of the "Thatch Palm" are used as the main timbers for building purposes, and when split form battens, whilst the fronds are utilized for thatching purposes, hence the name. The "Curly Palm" is less robust than the preceding, and has erect pinnæ, producing a striking contrast to those of the former, which are pendulous.

Equally striking in appearance are the *Pandani* or "Screw Pines," of which Mr. Moore believes there are two species. The "Tent Tree" (*Pandanus Forsterii*, Moore) grows both on the flat ground and on the hill-sides to an elevation of 2,000 feet; but, so far as my own observation went, only where the soil is of a volcanic nature.

As previously stated, the tree of the island is the Banyan. "It marks distinctly an inner zone of vegetation, being protected on every side by belts of trees of various descriptions. It possesses, to an extraordinary degree, the branching characteristics of the famous "Banyan" of India (*Ficus indica*). From its high wide-spreading branches adventitious roots are produced, which descend to the ground, then rapidly enlarge, and become in the course of time huge stems, drawing nourishment from the earth, for the support and increase of the parent branch, which, as it extends, produces similar root stems; the tree by this means covering a very large space of ground.§ . . . This interesting tree appears to be new and confined to the island, its column-like stems suggesting the specific name, *columnaris*,

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* Report on the Vegetation of the Island, *Lord Howe Island, Report on Present State, &c., loc. cit.*, pp. 8–11.

† "Linnæus," *loc. cit.*, p. 21.

‡ *Ibid*, p. 22.

§ Some of these trees cover at least half an acre of ground.

proposed to be given to it. In character it is allied to *Ficus microphylla* of this Colony; but the smaller size of the fruit and foliage, and its numerous root-stems, at once distinguish it from that species."*

One of the most conspicuous trees is the *Hemicyclia australasica*, Mueller, to which attention is at once attracted by its red-coloured plum-like fruit. The trees of most frequent occurrence are *Hibiscus Patersoni*, the "Juniper," *Myoporum acuminatum*, Br., and a tree supposed to be the "Manchineel" mentioned by Ball—*Ochrosia elliptica*. They occur always near the coast, and form the outer or protecting belt of trees. Epacridacious plants are represented by the large *Dracophyllum Fitzgeraldii*, found in Erskine Valley. It reaches as much as forty feet high, with a trunk at least two feet in diameter. It is allied to indigenous species of New Zealand and New Caledonia. There is a Mistletoe-like parasite *Viscum opuntioides*, Forster, but is restricted, Mr. Moore says, to *Hemicyclia* and *Elæodendron*, and kills the timber upon which it grows. It is also found in Norfolk Island. A cane-like climbing plant, *Flagellaria*, completely uniting surrounding trees; and the "Tulip Tree," *Fugosia Pattersonii*. We had very unpleasant experience of a most offensive plant, which appears to be generally distributed over Lord Howe, called the "Stink Plant," *Coprosoma putida*, Moore and Mueller, emitting a smell from its bruised leaves or branches not easily forgotten, and described by Mr. Moore as "perfectly abominable." It reminded us more than anything of the odour from an ancient cesspool. Lieutenant Ball speaks of the Mangrove, but Mr. Moore says that *Ægiceras fragrans* was observed only at the mouth of a small creek from Mount Gower. We did not see it.

Many very beautiful ferns were observed; but I regret to say that the tree-ferns are not found in the profusion they appear to have once existed, except in the more inaccessible parts of the island. Mr. Moore mentions two new arborescent species of *Alsophila*, and *A. excelsa*, Br., with *Trichomanes meifolium*.

At the top of Mount Gower occur another fine species of *Trichomanes*, *Lomaria capensis*, and *Hymenophyllum tunbridgense*, where they grow in great profusion.

The general set of the currents is from the north and north-east, but the local currents around the island appear to be very variable. The most important one is that running through the Sugar-loaf Passage, between the main island and the Admiralty Islets. The larger number appear to be one knot currents.

The tide rises and falls about six feet. There are two good anchorages, one on each side of the island. That on the east lies off Ned's Beach in 16–18 fathoms, and is known as the North-east Roadstead. The second is called the South-west Roadstead, and is situated outside the main middle entrance to the Lagoon, in 15–18 fathoms; and there is a temporary anchorage outside the north end of the reef. A well-defined 20 fathom line exists on the east, and supposing an elevation of this amount to take place, it would be the means of adding to the superficial area of Lord Howe in that direction, and northerly and southerly, land many times its present size.

The prevailing winds in summer are from the south-east, and during winter from the south-west, the latter at times blowing with great violence, accompanied by severe rain squalls. According to Mr. E. S. Hill, "cyclones from the N.N.W. occasionally devastate a confined area of from 40 to 50 yards wide," but these are not of frequent occurrence. The steep gullies

† Moore, in Hill's *Lord Howe Island*, *loc. cit.*, p. 21.

between the various hills afford excellent gathering places, whence heavy gusts sweep down on the surrounding sea, especially the Lagoon, in the form of miniature whirlwinds, taking up the water in masses of spray. These "wollies," as they are termed by the inhabitants, resemble the heavy winds which traverse the deep ravines and valleys of St. Helena, and are so dangerous to passing shipping. The approach of these gusts when passing over the more level portions of the island can always be detected by the loud rushing noise which heralds it.

The heaviest rain is from the south-east; but true periodical rains are said not to occur. Showers, however, are abundant throughout the year.

The temperature during summer is fairly warm; we were told that it was sometimes as much as 80°, but the winter is tolerably genial. On the whole, it may be described as more equable than that of the general sea border of New South Wales.

The Admiralty Islets are eight in number, six in the main cluster, and two more or less detached representing North Island, some little distance removed from the former. The central and largest is nearly half-a-mile long, exceedingly steep, and, like Lord Howe, precipitous on its eastern side. It is probably about 300 feet high. An elevation of ten fathoms would place these islets in communication with the main island.

Mutton Bird Island is a rather quadrangular, rocky, and inaccessible islet, seven miles east of Blenkinthorpe Beach, 265 feet high, and with a central dome-like eminence. It lies within the 20-fathom line. Both it and the Admiralty Islets can only be approached in the finest and most settled weather, a landing at any other time being quite impossible.

Close to, but separated from King Point, the southern extremity of Lord Howe, is a small circular islet, known as Gower Island, with deep water immediately outside it.

The only other islet contiguous to Lord Howe is Goat or Rabbit Island, within the Lagoon, an oblong piece of land 114 feet in height. Its outer or western end gives attachment to a portion of the fringing reef.

By far the greatest interest, however, centres itself in the isolated and mysterious Ball's Pyramid, situated some eighteen miles to the south-south-east of Lord Howe. In outline it is described as pyramidal,* rising, without a break, 1,816 feet abruptly from the ocean. Mr. H. T. Wilkinson states that its base is but sixty chains long and twenty-five chains wide. A landing can only be effected, and with the greatest difficulty, on the north-east side.

Three maps of Lord Howe Island are extant. The earliest, by Mr. Surveyor H. F. White, is dated 1835 (Pl. IX). As a separate map this has never appeared, but a reduction was published by Mr. E. S. Hill†. We are indebted to Mr. E. Twynam, Deputy Surveyor-General, for tracings of Mr. White's original chart, and for permission to publish it. The map bears the following title, "Survey of Lord Howe Island, in latitude 31′ 30″ S, longitude 139° E. H. F. White, Assistant Surveyor, 7th January, 1835." It is on a scale of half-an-inch to one mile, and gives the outline of the island in a remarkably accurate manner, especially at the northern end. The map is, however, particularly interesting to the geologist from the statement that the Coral-reef is a "bar of sand," and the entrances one fathom in depth. I shall have occasion to refer to this matter when dealing with the Geology. Mr. Twynam has also furnished us with a tracing of the original chart (Pl. VIII) of Lieutenant Henry Ledgbird Ball, the discoverer of Lord Howe Island. The map bears the following inscription, which is worth quoting:—"There is no danger in

* H. T. Wilkinson, Geological Report, *loc. cit.*, p. 6.

† *Lord Howe Island*, *loc. cit.*, frontispiece.

approaching Howe's Island. The 'Supply' anchored there in thirteen fathoms sand and coral; but there lies about four miles from the S.W. part of the Pyramid, a dangerous rock which shows itself a little above the surface of the water, and appears not to be larger than a boat. Lieutenant Ball had no opportunity of examining whether there is a safe passage between them or not. The island is in the form of a crescent, the convex side towards the N.E. Two points, at first supposed to be separate islands, prove to be high mountains on the S.W. end, the southernmost of which was named Mount Gower, and the other Mount Ledgbird; between these mountains there is a deep valley which obtained the name of Erskine Valley; the S.E. point was called Point King, and the N.W. point, Point Phillip. The land between these two points forms the concave side of the island, facing the S.W., and is lined with a sandy beach, which is guarded against the sea by a reef of coral rock at the distance of half-a-mile from the beach, through which there are several small openings for boats; but it is to be regretted that the depth of water within the reef nowhere exceeds four feet. They found no water on the island, but it abounds with cabbage palms, mangrove, and manchineal trees, even up to the summits of the mountains. No vegetables were to be seen. On the shore there are plenty of gannets, and a land bird of a dusky brown colour*, with a bill four inches long, and feet like those of a chicken; these proved remarkably fat, and were very good food; but we have no further account of them. There are also many very large pigeons and white birds resembling the guinea-fowl†, which were found on Norfolk Island, were seen here also in great numbers. The bill of this bird is red and very strong, thick, and sharp pointed. Innumerable quantities of very fine turtle frequent this place in the summer season, but at the approach of winter they all go northwards. There was not the least difficulty in taking them. The sailors likewise caught plenty of fish with a hook and line. Ball's Pyramid lies about three leagues S.E. of Mount Gower, and may be seen about twelve miles off, from this there are dangerous rocks, extending about four miles S.E. and S.W., those to the S.W. not showing above water. There are also rocks extending four or five miles from the N.E. and N.W. ends of the islands, which are of a moderate height. Within the N.W. point lies a rock with eleven fathoms water close to it, and there is a passage between it and the island. Mount Ledgbird may be seen about twenty leagues off."

On the reduction of White's map, published by Mr. E. S. Hill, a number of names are given to bays and islands, not on the later maps, and which do not appear to be used now. These, however, are not given by White on his map, but have been taken from Lieutenant Ball's chart. Thus, the North Bay on the latter's chart is called Callam's Bay; the bay now unnamed at the Old Settlement is Hunter's Bay; that portion of the Lagoon impinging on Moseley's Flat is called Prince William Henry Bay; whilst Blenkinthorpe Beach, on the opposite side, is marked Ross' Bay. The island within the Lagoon is spoken of as Blackborne Isle, instead of Goat or Rabbit Island, the names under which it is now known. The Admiralty Islets have the alternative name of Roach Islands, and some advantage would be gained by employing this appellation, as distinguishing these insignificant rocks from the true Admiralty Islands to the north of New Guinea.

A more detailed survey was made by H.M.Ss. "Herald" and "Torch," and the chart published in 1853, on a scale of three inches to a geographical mile. The general execution of this map, as a specimen of cartography, is rough in

* Probably *Ocydromus sylvestris*, Sclater.

† The White Galinule *(Notornis alba)* is evidently referred to here.

the extreme, but the interior topography is simply useless. The coast and sea details are, however, given with great exactness. The third map with which I am acquainted, was published in connection with the Hon. J. Bowie Wilson's Report on Lord Howe Island in 1882. This, entitled "Lord Howe Island and adjacent Islets and Reefs," is on a scale of three and a quarter nautical miles to one inch, seems to be an improved edition of the former map as to the execution, with much greater topographical detail. In one particular, however, the two charts do not agree, the heights of the principal elevations. The greatest discrepancy exists between that of Intermediate Hill. In the "Herald" and "Torch" chart the height of this is given as 841 feet, but in the 1882 map as 647 feet, a difference of 194 feet. The latter map was used by Mr. H. T. Wilkinson as the basis of the geological map accompanying his Geological Report on Lord Howe Island in 1882 (Pl. X).

II.—Geology.

The general geology of Lord Howe Island is extremely simple, but the details are more complicated. The island consists practically of two formations only—the volcanic rocks forming the general mass, and the stratified beds resting on them. The time at my disposal, through numerous other duties claiming attention, rendered a study of the whole in detail an impossibility, and such a proceeding, indeed, did not come within the scope of my instructions. An examination of the volcanic rocks sufficiently to permit the writing of a memoir on them would occupy much time, and could not safely be performed by one observer. I was not even able to solve many problems connected with the stratified deposits, and other very important points must still remain open, a settlement of which would have materially assisted the conclusions attempted to be drawn from the geology, so far as known to me.

1. *Volcanic Series.*—Two thirds of the island is composed of volcanic rocks, comprising the three isolated masses already mentioned. The only sections visible from the densely wooded nature of the ground, and rounded outline of the eminences, are along the coast, and on the precipitous sides of Mounts Gower and Ledgbird. As seen from the water, the exposed volcanic rocks present a stratified structure, having the appearance of those of sedimentary origin, "but a close inspection shows them to be made up of different horizontal beds of volcanic rock."* In no place is this more apparent than on the westerly faces of Mounts Gower and Ledgbird. An excellent section may be examined by ascending the steep foot of the latter, from the beach, for 300 feet or thereabouts, to the "Lower Road," which runs for a portion of its more accessible course, more or less horizontally parallel with a magnificent exposure of volcanic agglomerate, which is overlain by a vesicular basalt, and this in its turn by an apparently harder stratum of closer texture. So far as measurements with the eye alone can be relied on, these beds appear to be from 15 to 30 feet thick. A somewhat similar succession is again seen at the "Black Rocks," at the west sea-foot of Mount Ledgbird, where a very fine agglomerate is followed by a vesicular basaltic rock. In no part of the island is this stratification seen to better advantage than along the sea face of the North Ridge, as viewed from the water below. There a section, 700 feet high, can be scanned at a glance, showing what certainly appears to be a successive alteration of beds of

* H. T. Wilkinson, Geological Report, *loc. cit.*, p. 4.

agglomerate, and a harder and denser rock, seamed in all directions by dykes and veins, a number of which are quite vertical, and run up the face of these magnificent cliffs like so many ladders.

The rock so frequently spoken of as an agglomerate consists of a reddish-brown, or otherwise darker base, containing fragments of other volcanic rocks from a few inches in diameter up to a hundredweight. Amongst the best exposures of this rock I may mention the headland immediately to the north of Ned's Beach, and between the Clear Place and Observatory Point on the eastern side of the island. At the former place many of the contained blocks are of an immense size, and, from weathering lighter than the base, give to the whole a remarkable appearance. This agglomerate rests upon a vesicular and somewhat scoriaceous rock full of small crystals.

At the latter locality the agglomerate forms a rugged and dangerous beach, and is here again associated with a scoriaceous basaltic rock and is much traversed by dykes, having a general north-easterly and south-westerly direction. A dense dark greenish-brown basalt also occurs here, but time did not permit me to satisfy myself of its relation to the general series, but it seemed to be an interbedded rock.

This basalt was said to contain tin, and about thirty tons were illegally removed some years since to Auckland, N.Z. It was reported to have yielded 40 per cent. of tin, but on an official assay of the material being made in Sydney it was found to be quite destitute of the metal. As it was still asserted on the island to be stanniferous I brought typical samples away with me, but on treatment in the Geological Survey Laboratory by Mr. J. H. Mingaye, they were again found to be worthless.*

This rock has been petrographically examined by Mr. T. W. Edgeworth David, of the Geological Survey Branch, who finds it to consist of a ground mass of triclinic felspar, granular augite, and dendritic aggregations of magnetic iron, and grains of olivine.

On the east coast of Robbin's Point occurs a light blue or greenish gray basalt, also apparently an interbedded deposit. It contains veins and scattered crystals of iron pyrites, and, according to Mr. T. W. Edgeworth David, is a hard dense diabasic basalt. He believes it to be one of the oldest rocks on the Island. Mr. H. T. Wilkinson states that a somewhat similar rock is met with on the east coast of Boathaven. The pyrites from this locality yielded 3 dwt. 14 gr. gold, and 3 dwt. of silver to the ton. Samples brought from Robbins' Point by myself did not yield either of the metals on assay by Mr. Mingaye.

In a small bay, intermediate between Wilkinson's Promotory and Middle Beach I observed a beautiful exposure of a brick-red volcanic deposit, very much resembling an ash, and forming a moderately high cliff. It was associated with an agglomerate, and traversed by dykes.

The latter form a most important feature in the geology of Lord Howe, and are well worth a study simply in themselves. They were observed varying in width from 6 inches to as much as 18 feet, and many must even be much wider. They are usually denser and finer in texture than the rocks in which they immediately occur, and, as a rule, stand forth like walls, usually weathering into square or oblong blocks, and presenting a somewhat concretionary structure. Excellent examples may be examined at the Black Rocks, at the west sea-foot of Mount Ledgbird; and again the rocky shore of the Lagoon between Boat Pool and North Bay is seamed with them,

* For full particulars of this case and the parties concerned, see Legislative Assembly Papers, 1883, No. 11.

running in a general direction of N. 130° W. One in particular, on the eastern side of North Bay, is very noticeable, traversing the shore-line just at high-water mark for nearly the whole depth of the bay.

At the north-east point of Ned's Beach a cellular basalt occurs, containing augite and olivine. The vesicular cavities are filled with a zeolite, which Mr. David places in the chabazite group. At the same locality there is also present a lateritic amygdaloidal basalt, the amygdules consisting of aragonite.

No traces of any recent lava streams, or other phenomena of the kind, were noticed, nor was a crater observed. It must, however, be borne in mind that the geological examination I was able to make of the volcanic rocks was but a very limited one. Probably the most interesting parts of the island, the extreme southern end and south-eastern portions, were not reached through lack of time, and the same may be said of the north-west headland. If any traces of a crater be ultimately discovered it would not surprise me to find it at or near the peculiar fractured hill previously described under the name of Mount Eliza.

From a microscopical examination of the rock specimens collected by ourselves and Mr. Alexander Morton, Mr. T. W. Edgeworth David concludes that all the Lord Howe igneous rocks belong to the Basalt Group. Those of the diabasic type are probably Pre-Tertiary, and perhaps Palæozoic; whilst the non-diabasic basalts are not older than Tertiary, and some may even be Post-Tertiary. And, finally, that a vast period of time must have elapsed between the eruption of the two.

The only minerals observed were zeolites in the scoriaceous basalt at the northern point of Ned's Beach and at Mutton Bird Point on the east coast.

During Mr. Wilkinson's visit in 1882, the drift in several of the water-courses draining from the mountains was prospected, and no trace of gold or other metallic ore was found.

2. *Red Clay Bed.*—Immediately overlying the volcanic rocks, and between them and the succeeding Coral-sand rock series, occurs a bed of stiff unctuous red or yellow clay. This bed, although exposed in rather inaccessible spots, does not appear to have escaped the notice of Mr. Fitzgerald, who remarks, "The stratified coral passes into a very red clay as it approaches the trap."* The significance of this remark did not strike me until I accidentally came across this clay *in situ*. Its superficial area has not been traced out; but, assuming that it continuously underlies the Coral-sand rock, having been detected at three separate places, its distribution must be considerable. The most important exposure is at one of the small rocky bays on Wilkinson's Promontory, to the east of Ned's Beach. Here the beach, between tide marks, is composed of a coarse volcanic agglomerate. The clay, which is of a chocolate colour and very stiff, is visible in the cliff immediately reposing on the agglomerate and four feet in thickness. In its turn it is overlaid by thick masses of the Coral-sand rock, extending to the summit of the hill.

The next section is visible in Fern Glen, behind Captain T. Nichols' house, where it is a few feet in thickness, but probably less than at Wilkinson's Promontory, and contains fragments of basalt rock. The third exposure which came under my notice was on the low banks of the Deep Creek. Now it is exceedingly probable that a diligent search along the course of the gullies draining the plateau of Mount Lookout and the Deep Creek Valley would bring to light a number of additional sections of this interesting bed. I can only regret that time did not permit of a thorough

* Hill's *Lord Howe Island, loc. cit.*, p. 44.

investigation of this deposit. I am, however, inclined to the opinion that it may be found concurrent with the Coral-sand rock, and that wherever sections can be exposed, showing the junction of this with the volcanic series, then the red clay will perhaps be met with also. So far as my observation went it is unfossiliferous.

3. *Coral-sand rock Series.*—The thin-bedded calcareous rocks included under this name have been deposited either on low basaltic spurs or against the flanks of hills of that nature. For all practical purposes it may be said to form the narrow neck of land uniting the North Ridge with the southern basaltic uplands, except Mount Lookout. Associated with younger deposits it forms all the flat ground of this part of the island and some of the lower hills, such as Wilkinson's Promontory, and extends, in an unbroken sweep, from the Old Settlement on the north to and inclusive of Moseley's Flat on the south. Two other patches exist, one at the head of North Bay and the other in the valley of the Deep Creek. On Mr. Wilkinson's map it is represented at the former locality as forming two horns running up between the hills, the westerly one forming the depression connecting North Bay and the Gulch. I had no opportunity of following out the boundaries in detail, but at the point where the boundary approaches the shore it is most certainly erroneous. This is probably due to the faulty topography of the map, already referred to. The hill-shading at this point represents the slope of the hill as descending to the shore, whereas in reality, immediately rising from the latter is a low hill composed of Coral-sand rock, circumscribed on its other three sides by shallow gullies, which from the boundary line between the Coral-sand rock Series and the volcanic rocks forming the general mass of the North Ridge. On the low rise are situated two caves, excavated in the former. Time did not permit of my following out the boundaries of the second patch, that at the Deep Creek, except at its southern termination along the Fresh-water Pool. Here the Coral-sand rock has, on the map, been carried up the flanks of Mount Ledgbird, but I was quite unable to trace it beyond the creek edge, which again appears to form the boundary.

Mr. H. T. Wilkinson describes the extent and boundaries of the deposit in these words:—"Following the coast line northerly from the western base of Mount Ledgbird, the formation flanking the hills consists of blown sand as far as a point 10 chains south of Robbins' Point, where a basaltic spur from the North Hummock comes down to the sea. From Robbins' Point we have again the blown sand rock, which here forms the central rock of the island between West Beach and Blenkinthorpe Bay. About a mile further north, the west spur from Mount Lookout reaches to the beach, and immediately beyond this the coral-sand rock forms the whole width of the island as far as the north point of Ned's Beach on the east, and Boat Pool on the west. A small area of the sand rock again appears between North Bay and the Gulch."

The only eminences of any importance formed by this deposit are Thompson's Point at the north end of the Lagoon, from 30 to 40 feet high; the cliff at Robbins' on the west flank of North Hummock, about 30 feet; the cliff immediately to the north of the Deep Creek mouth, and above all Wilkinson's Promontory. At each of these spots the Coral-sand rock may be seen in excellent sections, when not obscured by its own *débris*; these will be described separately later.

Over the surface of the lower flat grounds, back from the shore line, this peculiar deposit is met with outcropping in small patches, and forming small scarps along the crests of gentle slopes. Excellent examples of this feature can be seen between the Old Settlement and Thompson's Point, around the

residences of Messrs. Wm. Nichols and T. B. Wilson. Even on the low ground of Moseley's Flat such outcrops are visible, proving that although large areas may be hidden by a deposit of soil, or younger alluvium, the Coral-sand rock is not far below. Furthermore, where the soil is deeper and more plentiful, and from the colour of the latter, it would be difficult to assert that the subjacent rock *in situ* would be coral-rock or basalt, pieces of the former are constantly turning up through the operations of the agriculturist.

Lithologically the Coral-sand rock consists of minutely comminuted and completely rounded coral *debris*, with grains of volcanic substances, such as augite, magnetite, and altered lava, with occasional fragments of echinoderm plates and spines, shells, foraminifera, and particles of sand, bound together by a calcareous paste, consisting of a clear crystalline calcite, which does not, however, entirely fill the interstitial spaces, but is sufficient to cement together adjoining grains.* The grains are usually white, but sometimes stained yellow, invariably oblong in form, and as a rule, perfectly opaque. So little cohesion is there between the particles, which are of a tolerably uniform size, that it was with the greatest difficulty slides sufficiently thin could be prepared for the microscope. The disintegrated particles have been very carefully examined by Mr. Whitelegge and the writer, and we believe that a large portion are composed of fragments of nullipores, and corallines (calcareous algæ), with a moderate admixture of true coral *débris*. Speaking generally the constituents of the Coral-sand rock agree very closely with the component particles of the present beach sand at Lord Howe. One important feature of the latter, is the paucity of foraminifera. In places the Coral-sand rock becomes very loose, and the particles are easily disintegrated. At other times it is very coherently bound together, and becomes a firm solid rock. The fragments appear to owe their rounded aspect not alone to attrition, but probably partly to the solvent action which yields the crystalline calcite for the partially cementing medium. At least 90 per cent. of the component fragments appear to be comminuted coral and nullipores.

The calcareous condition of this rock is in keeping with that of many other so-called coral "sand-rocks" of comparatively recent origin, but it is not oolitic, and differs from the majority in not having the grains invested by a pellicle or husk of calcite. Thus, at Ascension, and to some extent at St. Helena, in the superficial calcareous deposit there forming, "each rounded particle of shell and volcanic rock can be distinctly seen to be enveloped in a husk of pellucid carbonate of lime."† The same phenomenon is seen in the recent coral formation at Norfolk Island,‡ and numerous other instances could be cited. In the large quantity of coral detritus, which acts as its chief constituent the Lord Howe Coral-sand rock resembles the recent limestone of the Bahamas, but essentially differs from that of Bermuda, which, although calcareous, consists of shells and foraminifera.§ It is also similar to the blown sands forming the extensive dunes of the South Australian Coast.|| Touching the deposits at Ascension and Norfolk

* The place of the calcite as a cementing medium is occasionally taken, although not often, by a dark volcanic paste of a similar colour to the included volcanic grains. The structure of this rock has already been described by Mr. T. Davies and the writer, in a paper by Sir R. Owen, "Description of the Fossil Remains of two species of a Megalanian Genus, *Meiolania*, from Lord Howe Island." *Phil. Trans.*, 1887, CLXXVII, p. 497.

† Darwin, Geol. Obs. Volc. Islands, 1844, p. 49.

‡ J. E. Carne, Ann. Report, Dept. Mines, N.S. Wales, for 1885 [1886], p. 145; T. W. E. David, *ibid*, p. 147.

§ Nelson, Quart. Journ. Geol. Soc., 1853, IX, p. 207.

|| Ten.-Woods, Geol. Obs. S. Australia, p. 182.

Islands, their description would almost embrace that at our island. Of the former Darwin says:—"Small well-rounded particles of shells and corals, of white, yellowish, and pink colours, interspersed with a few volcanic particles." Mr. Carne's description of the latter is identical, almost word for word.

A similar instance of the comingling of volcanic particles takes place in the calcareous sandstone of Rat and Booby Islands, two islets of the Fernando do Norhona Group.*

The Coral-sand rock consists almost wholly of carbonate of lime, four analyses quoted by Mr. H. T. Wilkinson, giving an average of 75 per cent. The following are the details :—

Component Elements.	1	2	3	4
Carbonate of lime	96·5	85·4	95.4	96·4
Phosporic acid	Trace.	Trace.	Trace.	Trace.
Moisture, &c.	3·5	14·6	4·6	3·6
Total	100·0	100·0	100·0	100·0

The specific gravity is 2·452, that of ordinary limestone varying from 2·6 to 2·75.

The consolidation of this rock is undoubtedly due to the percolation of water, whereby carbonate of lime is dissolved, and redeposited on evaporation, as a cementing medium, the agglutination probably going on rapidly. This process is described by the late Professor J. B. Jukes, as taking place at Raines' Inlet,† Great Barrier Reef; and excellently by Professor H. N. Moseley at Bermuda.‡

The stratification is usually very evident, and excellently shown at many places along the shore, particularly in the section at Thompson's Point, the laminæ varying from one to three inches in thickness. At times, however, it is difficult to distinguish either, from the manner in which large and small masses have been tossed about, not, I think, by any convulsions of nature, but simply by the undermining action of the waves and the faces of the sections obscured by *debris*. The Coral-sand rock is particularly susceptible to weathering, and it is even possible to distinguish in large blocks between the effect produced by atmospheric and marine denudation. In the former case very fantastic figures are sometimes produced, pinnacles, ledges, and long reef-like floors and walls, the whole surface being eaten into a minutely vesicular or honeycomb appearance. The inshore escarpments and isolated patches, weather with a much more jagged and broken aspect, the honeycomb appearance giving place to an open cavernous condition. When greatly dessicated by either of these causes, all trace of lamination becomes lost, and this highly broken-up condition renders locomotion exceedingly difficult, and, in the event of a fall, dangerous. Detached portions which have lain about near the cultivations become rounded and waterworn, and the cavities filled with the ordinary red soil of the island, when many strange outlines are produced. These irregular spaces vary from one to six and nine inches in diameter, and perhaps even more. As a rule, when the Coral-sand rock rises in low cliffs at and above high-water mark the foreshore is formed by an ordinary marine platform, flat, with a seaward inclination. Such may be seen on the south side of Prince William Henry Bay. On this Coral-sand rock platform the ba-

* Moseley, Notes by a Naturalist, 1879, p. 79.
† Voyage of the "Fly," 1874, II, p. 339.
‡ Notes by a Naturalist, 1879, p. 20.

saltic pebbles and fragments rolled down from the North Hummock become naturally cemented to the surface of the former. Denudation then setting in, the pebbles afford to the immediately underlying Coral-sand rock a certain amount of protection, and so a small pinnacle is formed, leaving the intruders perched at the top. They resemble so many miniature towers, or *roches perches*, and are either isolated or arranged in curved lines and other fantastic figures, when they give to the beach a very peculiar appearance. Pot-holes are sometimes met with also. Veins and concretionary masses of calcite are not uncommon, excellent examples of the latter being procurable in Fern and Peg-leg Gullies, behind Captain T. Nichols' house.

I have succeeded, much to my surprise, in distinguishing two distinct periods in this Coral-sand rock Series, separated by a well-marked unconformity. The four best marked sections seen on the island by me are the following; three of them show the two series *in situ*, the third only one. Taking the last first, the following sequence is visible at Thompson's Point, from above downwards :—

1. Disintegrated and perhaps blown sand, intermingled with a little earthy matter, forming the soil, 1 foot.
2. Thin stratum of red soil, containing semi-fossil *Bulimus*, 2 to 3 feet.
3. Coral-rock, thinly laminated, forming the low bluff known as Thompson's Point, and believed to be dipping north, but the face much obscured by fallen blocks and loose sand, 20 to 30 feet.

This section is some fifty yards long, and may be taken as a typical one of the Coral-sand rock when forming low sea cliffs. It will be referred to hereafter in connection with the guano deposit. An equally good but higher section is visible in the cliff to the north of the Deep Creek mouth. This, by barometrical measurement, is 100 feet above the sea-level at the highest point of the cliff, but the bed No. 2 does not appear to be present.

At the outlet of the Deep and Soldier's Creeks the lower division of the Coral-sand rock runs into the Lagoon in long shelves and reefs, much broken up by denudation, leaving isolated patches on the shore quite free of *débris*, and, above all, clearly *in situ*. Here the unconformity is visible, the lower stratification inclined, the upper horizontal, or nearly so, and the lamination in both very thin. The inclination of the lower is 11° in a direction N. 75° E., whilst the upper series when dipping at all is at about 3°, and towards the north.

The following sketch (Pl. VII), in which these features are excellently shown, is taken at the mouth of the Deep Creek,* and also exemplifies the manner in which the long ledges of coral-rock run out, reef-like, into the Lagoon.

From the fact that only portions of the lower series are visible, and the greater part of the upper has been removed by disintegration and marine denudation it is impossible to estimate the thickness. An equally clear and larger section is visible on the east coast in a conspicuous outlier of the Coral-sand rock on the shore near the northern end of Middle Beach, and which has been marked by Mr. H. T. Wilkinson on his map as a volcanic rock. By far the best, and most satisfactory section, however, is that along the south side of Ned's Beach, exposed for about 200 yards, along the cliff of Wilkinson's Promontory, above the beach. Here, whenever the face is clear of vegetation, the junction of the two sets of beds is most distinctly to be seen. Three observations of the lower inclined series gave the direction of the dip as W. 10° N., varying from 25° to 35°, the junction and unconformity being very

*From a photograph by the Government Printer, taken during Mr. Cloete's expedition.

apparent. The upper series is not, I think, quite horizontal, but has a very gentle inclination eastward and northward. This excellent section brings prominently forward two important points connected with the Coral-sand rock deposit, viz., the constantly changing dip of the lower series, and the approximate greater thickness of the upper. The direction of the dip is here quite different from that observed on the western side of the island, and the steady continuance along such an extent as here shown must be looked upon as exceptional.

From the fact that the Coral-sand rock was deposited on the denuded flanks and perhaps summits of pre-existing hills, it necessarily follows that its thickness must be very variable. I am not aware that any excavation has been sunk to prove it, but Captain T. Nichols estimates that, in the neighbourhood of Fern and Peg-leg Gullies, the Coral-sand rock attains a thickness of at least 80 feet. By rough barometrical measurement, the height of the plateau running back from Wilkinson's Promontory was found to be perhaps 250 feet. I traversed this plateau from end to end, and crossed its flanks at various points, and was unable to detect any other form of rock than the Coral-sand rock, and further I believe this to be the greatest altitude to which the latter extends. Allowing the junction of the two series, at Ned's Beach, to be between 30 and 50 feet above high-water mark (say 40 feet), it is not more, we have for the thickness of the upper beds, no less than 200 feet.

In a preliminary investigation extending over but a short time, many difficulties present themselves, which could only be solved by a regular detailed survey. On this ground some of the points now brought forward, will require confirmation. But it may be accepted with confidence that the Coral-sand rock was deposited on the flanks of basaltic islands, of much greater extent than now existing. I believe a break in this deposition occurred, whether partially or wholly so, it is difficult to say, but probably the latter. An unconformity however most certainly exists. Evidence of this, as before stated, is only visible at a few spots, what with the dense vegetation generally clothing the sea faces, and the tumbled condition of the sections. I was much puzzled at first by the everchanging dip, sometimes highly inclined, sometimes horizontal, just as the upper or lower series happened to be within view. By an inspection, however, of the sections described, this peculiarity was explained.

On a low rise, at the head of North Bay small caves are weathered out of the Coral-sand rock. One of these is about forty-five yards long by from twenty-five to thirty yards wide, and some sixteen feet high. The descent, although through an irregular half-choked aperture, is not difficult, and the roof is partially covered with impure stalactites. The second cave had become so much filled by falls that it was not worth or capable of investigation.

The Coral-sand rock is the chief fossiliferous deposit on the island. It has yielded the remains of the interesting reptile, named by Professor Sir R. Owen, F.R.S., &c, *Meiolania*, eggs of turtles, bird-bones, and recent species of both land and marine shells.

Mr. Fitzgerald states that "curious pipes pass through the stratification, which may have been formed by stems of palms; they are hollow at the centre, and the particles of coral are solidified at the circumference, so that at some places they project like short chimney-pots."* Examples of such cylindrical tubes did not come under my notice, but no doubt the description is accurate. The impressions and moulds of trees had long been known in similar deposits, and in many countries. Darwin describes them at King

* Hill's *Lord Howe Island loc. cit.* p. 45.

George's Sound,* and so does Jukes,† who believed them to be sand stalactites only; Capt. R. J. Nelson, at the Bahamas;‡ and the Rev. J. E. Tenison Woods, in the sand dunes of the South Australian coast.§ The last-named observer combats the arboreal origin of such cavities in the sand examined by him.

Whether the phenomena described by Mr. Fitzgerald are due to the decay of trees entombed, or are analagous to those pipes, which frequently traverse chalk and other similar formations, it is impossible to say without a direct examination.

Guano deposit.—The only exposed outcrop of this observed by myself was at the landing-place, at the northern end of the Lagoon. It forms a bed from ten to fifteen feet thick, and extends along the beach, a little above and between water marks for perhaps thirty yards. Mr. H. T. Wilkinson remarks, "At a point about 20 chains north of Thompson's Point, and cropping out on to the beach is a considerable deposit, consisting of calcareous earth mixed with bird's bones." It is traceable inland, having been proved in sinking wells, but probably occupies only a limited area. No doubt, after the final deposition and upheaval of the Coral-sand rock, the narrow neck of land between the landing place on the west and Ned's Beach on the east, and uniting the North Ridge with the central portion of the island, was occupied by a shallow gut-way. Mr. Wilkinson speaks of a well thirty chains (660 yds.) inland, in which this deposit was sixteen feet thick.

This old well exists in Mr. Thompson's garden, and, through the courtesy of Mr. H. T. Wilkinson, I am able to give the following particulars:—

Sand...	4 feet.
Yellow clay...	14 „
Coral sand, passing into "a kind of thick putty mud" of unknown thickness.‖	

Speaking of these wells, Mr. E. S. Hill remarks—"In sinking, occasionally argillaceous beds of fourteen feet in thickness have been cut through; these have been resting on a coral *débris*, and will retain no water."

The position of this deposit is not well defined by any boundaries, but it may occupy the whole of the low ground between the foot of the North Peak Ridge on the north, the Landing Place, and Ned's Beach, east and west; tailing off towards Thompson's house towards the south. That such is the case is probable from further remarks of Mr. Hill's on another well in this neighbourhood, which "was dug nearly through the clay," to a depth of thirty feet. The situation chosen happened to be a kind of basin in which heavy rains collected and there remained till evaporation or percolation relieved the surface. If my supposition relative to the depression is correct, then the so-called "Guano" was deposited on its flanks, and insensibly graduates laterally into the superincumbent layer of loam.

The thickness, I was informed, has been proved to thirty feet, and it does not probably extend to a much greater depth beyond this. The deposit is frequently spoken of as the "Guano"; by Mr. Wilkinson it is called "calcareous earth mixed with bird's bones." For my own part, the deposit appeared to possess a much higher argillaceous than calcareous nature.

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* Geol. Obs. Volc. Islands, 1844, p. 745.
† Quart. Journ. Geol. Soc. 1853, IX, p. 211.
‡ Phys. Structure of Australia, 1850, p. 61.
§ Geol. Obs. S. Australia, 1862, p. 167.
‖ The well could not be sunk lower on account of water, which stands at 18 in., and is not diminished or increased by pumping, or rain.

When seen on the shore it is of a dark ochreous colour, decidedly argillaceous and stiff, containing bird's bones (chiefly *Puffinus*), and pumice.

Mr. Wilkinson gives its composition as 25·1 per cent. of phosphoric acid, equal to (Ca_3 P_2 O_8) Tribasic Phosphate of Lime.

It will be remembered that the Coral-sand rock contained phosphoric acid up to fourteen per cent., and it is probable that this important and valuable constituent is to some, although small extent, derived from the disintegration of the coral deposit, which is one of its constituents as well as bird remains and exuviæ.

The formation of this phosphatic deposit, which is much too impure to be of any commercial value, is, to some extent, explained by the present mutton-bird rookery at Clear Place Point. Here, where several thousand birds are at work, excavating their burrows, sometimes in the decomposed Coral-sand rock, sometimes in the volcanic soil, intermingled with their bones and droppings, a thin but semi-phosphatic accumulation is going on.

Loam, Soil, and Alluvium.—In many places surrounding the low, scarp-like outcrops of the Coral-sand rock, but more usually covering the latter, is a deposit of loam, forming the soil of the island. It is described by Mr. Charles Moore as of a rich character, being of a dark, unctuous, loamy nature, largely impregnated with humus.* It, however, varies in composition, according to whether derived wholly from the decomposition of the basalt, or that only in part, combined with the decomposed Coral-sand rock. Decayed vegetable matter enters largely into its composition also. The analyses of three different samples are given by Mr. H. T. Wilkinson as yielding phosphoric acid equal to tribasic-phosphate of lime to the extent of 20·1 per cent., 9·1 per cent., and 5·6 per cent. respectively, but neither of these is sufficiently rich for commercial purposes as a manure. By dissolving portions in water, when of a decidedly chocolate colour, a residue of volcanic products is left. As the basaltic rock is receded from, the soil becomes more and more sandy-calcareous, until at last the loamy nature is lost, and it assumes the aspect of a calcareous, sandy soil.

Rich patches of this deposit afford the best garden sites on the island, and it is during gardening operations that the remains of *Meiolania* are usually found, lying loose, having been detached from the nearest rock during its denudation. It is in this way that the irregular holes and spaces so frequently met with in blocks of detached Coral-sand rock become filled as previously described.

I am quite unable to give any precise information as to the depth of this loam, although in places there must be a considerable thickness. It supports a most luxuriant vegetation.

The Old Settlement and Deep Creeks, at their mouths traverse small alluvial flats, formed by the detrital matter brought down by their action, Such accumulations must be regarded as quite distinct from the loam deposit, which is the result of atmospheric action on the rocks immediately underlying, and vegetable decay, and, although both may have been formed more or less concurrently, I have no data on which to base an opinon as to the thickness of these alluvial strata, but it cannot be very great. As in the case of the loam, the flats form excellent agricultural areas.

Under the term "marine alluvium" can only be included the sandy beaches of the Lagoon, Ned's Beach, Middle Beach, and Blenkinthorpe Bay which have already been referred to.

Æolian Deposits.—Along the shore frontage of the Old Settlement, the Lagoon south of Thompson's Point, and Ned's Beach are low sand hummocks,

* Hill's *Lord Howe Island, loc. cit.*, p. 17.

caused by the wind's actions on the beach sand. They extend from high-water mark a short distance inland, and are covered with coarse grass and creepers, whilst a fringe of Thatch Palm (*Kentia Forsteriana*) marks their inland boundary. Ned's Beach is a very good example of this feature. At Blenkinthorpe Beach the sand hummocks are replaced by incipient dunes, which protect the low-lying Moseley's Flat from the inroads of the sea, which would certainly more or less take place were it not for their presence. Speaking broadly, these little dunes are some fifteen or twenty feet above sea-level, inclined with a rather steep slope seaward, and more or less abrupt on the land side overlooking the flat. There are no dunes in the precise and true sense of the word.

Sand and Shingle Beaches.—The sandy beaches have already been referred to in the physical description of Lord Howe. Shingle beaches do not exist; but at the western foot of Mount Ledgbird, and again on the western side of North Bay, a large quantity of coral and basaltic boulders is collected, forming the beach, and piled up along high-water mark in a low terrace.

Land-slips.—At the north end of Ned's Beach masses of basaltic detritus have fallen, or more properly slipped, from the higher eastern flanks of the North Peak. They consist of earth, with stones and blocks of rock, and form low cliffs of limited extent along the waters edge, with a scarf-like front from twenty-five to thirty feet high. This deposit is now in course of destruction by small rivulets coursing through it.

III.—The Geological History of the Island.

Mr. C. S. Wilkinson has remarked* that "great volcanic activity prevailed throughout the Pleiocene period," in what is now known as New South Wales. This remark may be equally well applied to the whole of Central-eastern and South-eastern Australia generally. Sir James Hector similarly says of the Pleiocene in New Zealand †:—"This formation belongs to a period when New Zealand was the mountain range of a greatly extended land area, and when, in the North Island, the volcanic forces had their greatest activity." I believe the more recent geological history of Lord Howe Island may be said to date from this period also. Lying as it does between this continent and the islands of New Zealand, it is but reasonable to suppose that the volcanic activity of one or other of these areas extended in that direction. By an inspection of sounding charts of this part of the South Pacific it will be apparent that a submerged bank, at the depth of about 1,000 feet, extends from New Zealand north-westerly to Lord Howe, but the latter is separated from Australia by deep water. This point has been already briefly pointed out by Alfred Russell Wallace‡, and it is extremely probable that Lord Howe may have been nearly the furthest extension of this old continent in the direction indicated, for, quoting§ Sir James Hector again, "there is no clear evidence of its (*i.e.*, New Zealand) having been connected during Tertiary times with Australia, lying to the westward."

If we now follow up the evidence afforded by soundings, we find a confirmation of these statements in the work performed by the "Challenger"

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* Notes on the Geology of New South Wales, 2nd edit., 1887, p. 85 (4to, Sydney, 1887. Government Printer).

† Handbook of New Zealand, 4th edit., 1886, p. 30.

‡ Stanford's Compendium of Geography and Travel, Australasia, 1879, p. 576.

§ Ind. Col. Exhib., London, 1886, New Zealand Court. Detailed Cat. and Guide to the Geol. Exhibits, 1886, p. 40.

Expedition between New Zealand and Sydney. In the narrative of the voyage* it is said, "From these soundings, it is evident that a bank extends some 200 miles west of Mount Egmont, and may possibly reach Lord Howe Island." Again, "a reference to the general chart seems to indicate that a bank of soundings, of less than 500 fathoms, extends a considerable distance west of the north cape of New Zealand."† This bank is exceedingly well shown on the general chart. Following the track of the "Challenger" from Cook Strait towards Sydney, the first bank beyond the 150-fathom shore line, occurs at depths varying from 275 to 400 fathoms, and extends for about two-thirds the distance in the direction of Lord Howe. The second bank, and apparently that referred to in the previous quotations, ranges to a depth of 1,100 fathoms, and it is on this that Lord Howe stands, the bank extending sufficiently far in a northerly direction to include Middleton Shoal and Elizabeth Reef. Between this 1,100-fathom line and the east coast of Australia occurs the "deep oceanic depression," described by the Rev. W. B. Clarke,‡ and varying in depth from 2,000 to 3,000 fathoms.

How far this old land surface extended to the north it is difficult to say, but a very noteworthy fact presents itself if a chart of this part of the South Pacific Ocean is carefully examined, and the 160th meridian of east longitude followed up from Lord Howe. There, a little to the east of this line, we find soundings at intervals represented by the following shoals going northwards.§

Lord Howe Island.....	S. lat., 31° 36′ 30″.	E. long., 159° 5′ 10″
Elizabeth Reef	S. lat., 29° 56′ 0″.	E. long., 159° 4′ 50″.
Middleton Shoal	S. lat., 29° 27′ 40″.	E. long., 159° 4′ 17″
Bellona Reefs	S. lat., 21° 47′ 20″.	E. long., 159° 35′ 1″.
Chesterfield Reef & Islets.	S. lat., 19° 58′ 30″.	E. long., 158° 30′ 0″
Bampton Reef.....	S. lat., 19° 1′ 19″.	E. long., 158° 27′ 3″.

It is therefore possible that an old land connection of Lord Howe with New Zealand may have extended even as far north as the three last reefs off the west coast of New Caledonia. The connection thus shown to exist between Lord Howe and New Zealand is borne out in a very marked manner by some points in the avi-fauna of the former. The birds common to the two, whether species or genera, have already been mentioned (*antea*, p. 17), but the occurrence of so purely a New Zealand genus as *Ocydromus*, and the former existence of the White Gallinule, *Notornis alba* are facts not to be overlooked in a discussion such as the present. The latter bird, as before stated, was known to live on Norfolk Island, and the opinion has even been ventured that this island also was connected with New Zealand. Mr. Wallace referring‖ to the latter, states, "it has probably been much more extensive than it is now, and has included the Auckland and Chatham Islands, and perhaps even at some remote period the Kermadec Group and Norfolk Island." Again, speaking of the birds of Norfolk, he says,¶ "but there are three others which connect this land unmistakably with New Zealand. These are the *Nestor productus*, which formerly inhabited Phillip Island, but is now said to be extinct; a fine parroquet, *Cyanoramphus Rayneri;* and a remarkable white rail, *Notornis alba*. All these are peculiar New Zealand forms, and two of them would be quite unable to pass over

* Narrative I, pt. 1, p. 466, Diagram 2, and Physical Chart of the World.
† *Ibid*, p. 467.
‡ Journ. R. Soc. N. S. Wales for 1876 (1877), p. 75.
§ Findlay's S. Pacific Ocean Directory, 1884, 5th Edit., p.p. LIV, and LV.
‖ Australasia, *loc. cit.* p. 564.
¶ *Ibid*, p. 575.

any great width of ocean, while the Australian birds are mostly such as fly well, and might easily have emigrated to the island. This sufficiently explains why, although the great majority of its birds are Australian, yet naturalists consider this group of islands to belong really to the New Zealand zoological district."

I think, on the whole, therefore, there is reason to believe that Lord Howe Island originally formed a portion of the New Zealand volcanic area, and certainly dates back to the Pleiocene period, perhaps further; but of this we have no definite proof at present, although the diabasic basalts, according to Mr. Edgeworth David, may be Palæozoic, at any rate they are probably Pre-Tertiary. On the other hand his conclusion that all the non-diabasic basalts are not earlier than Tertiary will tend to support the hypothesis suggested here.

Evidence has been adduced to show that Lord Howe formerly consisted of three or more but little separated islands, and, assuming the Coral-sand rock to be of æolian origin, that it was not until after its accumulation that any further depression took place; but these minor changes did not to any great extent alter its configuration from what we now see it, beyond rounding the general contour and deepening the gullies. The separation of portions of its surface one from the other probably conveyed to the mind of Mr. E. S. Hill the expression that, "at one time, it appears to have been a chain of atolls, linked together by the coral insects."* There is not the faintest trace whatever of any condition of things, so far as my own observations went, which could be likened to that of an atoll; nor did any evidence of submergeance other than the facts derived from a study of the Coral-sand rock present themselves to our notice.

A very important statement, however, has been made by Mr. Fitzgerald. When speaking† of the Coral-sand rock he mentions that "it even seems to cap the tops of the mountain." This appeared to me so improbable that I communicated with that gentleman, who very kindly replied as follows:‡—"The first time I went to Howe's Island I did not succeed in reaching the top of the mountain, but was informed that it was composed of the same kind of rock as the low parts of the island (coral), and as it appears to be flat from below, I thought it might be the case; but on my second visit I found that the top was not flat but deeply furrowed, and showing no coral or coral-rock. I refer to Mount Gower, but have no doubt that Lidgbird is exactly the same."

The supposition that Lord Howe, as we now know it, was composed of a few small islets is based on the fact that it would require a depression of but comparatively few feet to return it to this condition. This granted, we have but to imagine a slight upheaval, and circumstances favourable for the accumulation of the Coral-sand rock would at once exist. It is possible that this may have resulted to some extent from the destruction of pre-existing fringing reefs, bearing in mind the formation of the calcareous deposit at Norfolk Island, described by Carne. The destruction of a coral shore invariably gives rise to calcareous sand such as we have now before us. Finally, the presence of nullipores, which play so conspicuous a part in the construction of some reefs, such, for instance, as Keeling Island, must not be overlooked. "There," says Darwin, "the nullipore bed has a thickness of two or three feet, and a breadth of twenty feet."§

When first I examined this deposit *in situ*, I regarded it as of aqueous deposition; but after due consideration of all the facts for and against, I

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* Hill's *Lord Howe Island, loc. cit.* p. 54. † Hill's *Lord Howe Island, loc. cit.* p. 44.
‡ Letter, dated May 26, 1888.
§ Dana, Corals and Coral Islands, 1872 (Engl. Edit.), p. 137.

have abandoned this view in favour of an æolian origin. The equal and minute size, and the complete rounding of the particles; the abundance of bird bones and land shells, with the more or less perfect preservation of the latter; and the occurrence of turtle-eggs, is strong confirmatory evidence. Under the influence of wind far more friction takes place than when small particles are triturated in water, and their edges become rounded to a much greater degree, giving rise to the appearance presented by the Coral-sand rock of Lord Howe. The occurrence of such fossils as the above in a similar deposit at St. Helena caused Darwin to ascribe a like origin to it.* On the other hand, marine shells were not frequently observed in the Lord Howe rock, but when present were well preserved, and in some traces of colour were still apparent. The presence of turtle-eggs, although not found in nests as described by Jukes on the islets of the Great Barrier, may still be taken as evidence tending in the same direction; and equally so is the palm impression seen by Mr. Fitzgerald, who says: "In the inclined stratified coral, in one place, very distinct impressions were observed of palm-leaves 10 or 15 feet long."†

Irregular stratification, and false bedding‡ were not observed, although it is often asserted that they are features in æolian rocks; but they are as often seen in aqueous sediments, the result of ever-changing currents. Indeed, it is not imperative that false bedding should be present, because Professor H. N. Mosely mentions the entire absence of it in the calcareous sand-rock at Raine Island.§ He says:—The deposit is "closely similar to that at Bermuda, except that it is remarkably evenly bedded." It would have been much more satisfactory could I have adduced evidence of one of those temporary growth stages of vegetation sometimes met with in æolian deposits, and represented by beds of lignite, or some form of carbonaceous matter. Mr. C. S. Wilkinson has described one in the consolidated sand dunes between the Parker River and Cape Otway, Victoria.|| Another instance is recorded by Mosely as seen at Bermuda in a dockyard excavation, where a bed of lignite occurs forty feet below sea-level in the sand rock of the island.¶ And lastly, Tenison Woods records an excellent case in connection with the Wide Bay sand hills.** No such instances as these have been seen at Lord Howe, although it is not impossible they may occur.

The balance of evidence may, I think, be said to weigh in favour of the æolian origin of the Lord Howe Coral-sand rock; and it is remarkable how well Dana's description†† of deposits termed by him "Drift Sand-Rock" tallies with it. "Still another kind of beach formation is going on in some regions through the agency of the winds in connection with the sea * * * and proceeds from the drifting of the sand into hillocks, or ridges, by the winds. The drifts resemble ordinary sand drifts, and are often quite as extensive * * * These sand-banks, through the agency of infiltrating waters, fresh or salt, become cemented into a sand-rock, more or less friable, which is frequently oolitic. The rock consists of thin layers or laminæ, which are very distinct, and indicate, generally, every successive drift of sand which puffs of wind had added in the course of its formation." As regards the height to which the Coral-sand rock extends, it in no way exceeds the known

* Geol. Obs. Volc. Islands, 1884, p. 88.
† Hill's *Lord Howe Island, loc. cit.* p. 44.
‡ The dip, although variable, is too steady over considerable areas to represent this.
§ Notes of a Naturalist, &c., 1879, p. 347.
|| Report on the Geology of the Cape Otway District. Report of the Director, Geol. Survey Vict., June, 1863—Sept. 1864. [1864—65], p. 25.
¶ Notes, *loc. cit.*, p. 21. ** Jour. R. Soc., N. S. Wales, 1882, xvi, p. 60.
†† Corals and Coral Islands, *loc. cit.*, p. 154.

altitude of Sand Dunes. I traced it to a level of 200 feet, or more, above the sea, which compares favourably with the height of the dunes along the Cape Otway coast, where Wilkinson* ascertained them to attain 200 feet. Similar dunes were observed by myself about Anderson's Inlet.

Neither does the dip of the Coral-sand rock, where inclined, exceed that of the known inclination at which blown sand rests. The mean of the dips taken is 28°, whilst, from observations made by Mr. C. S. Wilkinson and myself at Cape Otway, it was found that the faces of the dunes stood at from 30° to 35°.

Having endeavoured to account for the accumulation of the Coral-sand rock chiefly through the agency of the wind, it now becomes necessary to offer some remarks on the apparent unconformity visible between different portions of this deposit. I have to candidly confess that, without a further and more detailed examination, I could not venture on any absolute explanation. It is possible, of course, that after the accumulation of the lower or inclined series (Pl. VII), a partial change of level took place, giving rise to the tilting of the beds, after which the upper or horizontal series was brought together in a similar way to the former. One point, however, is very clear, a submergence took place after the final accumulation of the Coral-sand rock, as evinced by the fact that it now forms the fore shore, and bottom of the Lagoon, and is itself in course of denudation. To bring about the necessary physical change to effect this, a general sinking of the island must have taken place, and it is probable that it is from this period that the present fringing reef dates its origin. A significant fact in support of this is the statement on White's map that the entrances to the Lagoon were only one fathom deep at low water. Now, from the most recent surveys, we find that the water in the two main or navigable channels varies from three and a half to five in the North Entrance, and from four to seven in the South Entrance. If White's soundings are to be depended on it looks as if we were here in face of an historical depression!

To sum up, it may be briefly stated that a marked break occurs in the Coral-sand rock series, but whether this is due to depression and re-elevation or to the known peculiar physical changes which Æolian rocks undergo is not at present clear; that after its final accumulation depression undoubtedly did take place, resulting in the present geological and physical aspect of Lord Howe Island.

To regard the Coral-sand rock as of sedimentary origin is requisite the assumption of a series of changes, for which there is no evidence, including a direct depression of some 200 feet. That no elevation has taken place since the present physical aspect was assumed is, I think, apparent. On some of the Pacific Islands patches and blocks of coral, more or less semi-fossilized, are found at high altitudes, clearly proving that emergence had taken place whilst the present configuration of those islands was in course of formation. Such an instance was observed by Stutchbury, at Tahiti, where on one of the higher mountains he observed a bed of semi-fossil coral.‡ So far as observed, no facts of this nature have been revealed at Lord Howe Island. It is possible that the severance between the latter and New Zealand took place during the subsidence spoken of by Dana—"between the New Hebrides and Australia, the reefs and islands mark out another area of depression which may have been simultaneously in progress."§

R. ETHERIDGE, JUNR.

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* Report on the Geology of the Cape Otway District, *loc. cit.*, p. 26.

† Trans. R. Soc. Vict. 1876, XII, p. 3. ‡ Darwin, Geol. Obs. Volc. Islands, p. 28.

§ Dana, Corals and Coral Islands, *loc. cit.* p. 329.